# Chinese Orthopedics:

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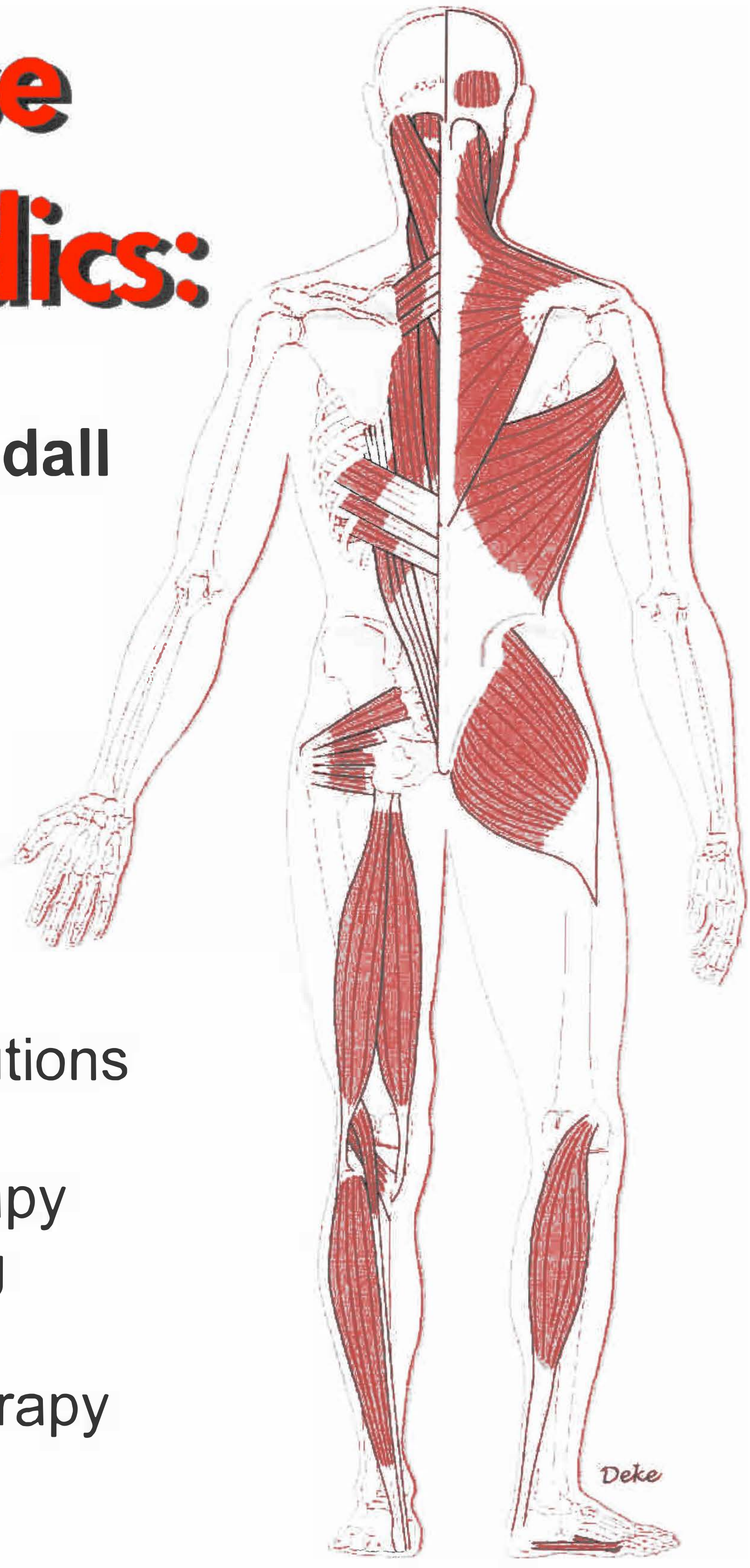


- Muscle Distributions
- Assessment
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- Mobilization

Posterior Lateral Foot
Muscular Distribution

# Chinese Orthopedics

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# Forward

Chinese orthopedics is a unique approach to the assessment and treatment of pain and musculoskeletal conditions commonly affecting the general population. It is based on a modern science-based understanding of needling therapy as well as the longitudinal organization of the musculoskeletal system. Both of these original discoveries where made by the Chinese in ancient times. Marco Polo's may have been the first European to witness the practice of needling during his stay in China from 1275 to 1292. European Jesuits visiting China some two centuries later wrote their reports in Latin and introduced the term "acus punctura" to explain what the Chinese called "needling therapy." The term acupuncture only means to puncture something with a needle and gives no hint as to its therapeutic usefulness. By the early 20th Century, new but metaphysical ideas were promoted in the West that acupuncture was based on energy and blood circulating by means of invisible meridians, instead of blood vessels originally described by the ancient Chinese. These impossible ideas have permeated the Western training programs for both lay practitioners and medical professionals alike.

Failure to provide evidenced-based training in the assessment and treatment of pain and musculoskeletal problems, that affect some 70% of the population, has resulted in many acupuncturists not being able to adequately serve the public's needs. This has been unfortunate in California where the acupuncture law recognizes needling to be a physiologically based process and requires students to be trained in primary care competencies. Acupuncturists have been marginalized by lack of this training and are not able to communicate with the medical community. The author, along with a few others, recognized very early on for the need in science-based training in applying acupuncture in treating pain and common orthopedic problems. Few acupuncturists have been interested in pursuing this type of training. However, those that have participated in this program are very successful in helping a significant number of patients to resolve their problems.

Fortunately, the Chinese provided the world with the unique treatment modality of needling therapy that is based on known anatomical relationships and physiological processes of the body. These facts have been scientifically verified by a significant body valid research which has been basically ignored. Instead, the Western world is still trying to confirm the existence of invisible meridians which has wasted an enormous amount of time and research funds. The other critical part of the story is the original Chinese discovery in how the body is longitudinally organized. This involves spinal axial pathways with segmental level dominance. The Chinese understood these relationships ca. 200 BCE based on observing certain phenomena including propagated sensation along longitudinal routes provoked by needling, and organ referred pain. The ancient Chinese also performed post mortem dissection studies as well.

Roots of Chinese medicine date back to the Neolithic period of human development but the unique practice of needling therapy may have only occurred during the latter half of the Zhou Dynasty (ca. 500 BCE). Millenniums before this the ancient Chinese therapeutically used small stone points to prick and bleed certain locations on the body. This gave the Chinese a very long period of time to figure out what locations or nodes on the superficial body were most effective. Since they were bleeding these nodes it allowed them to develop a keen appreciation for the distribution of superficial blood vessels. Metal needles were first described in the Chinese text called the "*Huangdi Neijing (Yellow Emperor's Internal Classic*" complied sometime before 200-100 BCE; usually referred to as the *Neijing*. The oldest metal needles recovered so far date to 150 BCE.

The *Neijing* provides the world's first description of the lymphatic system along with the first complete description of continuous cardiovascular blood circulation of inhaled air and absorbed nutrients by means of a branching system of out flowing arteries and return flowing veins. All of the main longitudinal and collateral blood vessels to the internal organs, extremities, head, brain, and trunk are described. The skeletal muscles are also described in terms of six longitudinal distributions of the arm and legs on each side of the body. Numerous approaches in treating pain and orthopedic conditions are also provided in the *Neijing*. This includes needling therapy, massage, including hot water massage, exercise, guided stretching, breathing exercises, manipulation, mobilization, pressure methods, traction, heating for some conditions, and cupping.

Purpose of this text is to provide updated translations, by the author, on key aspects of the *Neijing* that are consistent with modern anatomical and physiological science. Perhaps it would have been an easier approach to use existing Western texts to train lay and medical acupuncturists in orthopedics except for the fact of the unique Chinese discoveries with regard to the longitudinal body organization. This information is presented for all of the muscles including the kinesiology involved in the articulation of each joint. Needling therapy protocols are provided as well. Joint mobilization, manipulation, and exercise rehabilitation are also provided. Orthopedic assessment provided herein is consistent with present day Western standards and methods including: strength testing; range of motion; neurological assessment; and use of diagnostic imaging and laboratory tests.

American acupuncturists have been schooled in the common use of Chinese pīnyīn (拼音) Romanization pronunciation guide syllables in place of the actual Chinese characters. These terms are only used to teach non-Chinese in how to pronounce Chinese characters, including their tone, much like the phonetic guides that are used in English dictionaries. Pīnyīn (拼音) terms are nonsensical in absence of the actual Chinese character. This text is basically for individuals that are either learning or practicing Chinese needling therapy and therefore the most commonly used pīnyīn (拼音) terms are provided in Chapter 1 along with their corresponding characters to better understand the Chinese concepts. The goal is to phase out the practice of using pīnyīn (拼音) terms and solely rely on modern medical and scientific terminology.

D.E. Kendall, 2009

# 1

# Introduction and Principles

Principles of Chinese orthopedics involve the assessment and treatment of musculoskeletal conditions from the perspective of the ancient Chinese understanding of the muscular system longitudinal organization along with modern orthopedic assessments. This information is presented in modern Western terminology and pathology affecting the musculoskeletal system, consistent with primary care medical training and evidence based standards. This is essential to assure that practitioners are able to communicate with mainstream medical providers and services, including possible specialist referral, to best serve the interest of their patients. Emphasis is on developing a 21st century understanding on the key anatomical and physiological findings of the ancient Chinese. They performed postmortem dissections as early as the Spring and Autumn period (770 BCE - 476 BCE) of the Zhou dynasty. Early physicians mapped out the entire cardiovascular system and identified all the main arteries and veins supplying the superficial and internal body regions. They correctly understood the role of the internal organs except for the spleen which was assigned digestive and metabolic activities; since 1889 these have been proven to be pancreactic functions.

Ancient Chinese identified twelve specific longitudinal regions on each side of the body with six associated with each arm and leg. Neurovascular nodal pathways (acupoints),[a] blood vessels, and skeletal muscle distributions were specifically identified for these longitudinal regions. The brain and spinal cord were identified and they had a rudimentary understanding of peripheral nerves. From this basic understanding the Chinese discovered spinal cord longitudinal organization with segmental dominance. Use of metal needles was introduced around 500 BCE. This led to the development of the effective and repeatable practice of "needling therapy" (zhēn 针[b] needle: zhì 治 to cure, to heal). Assessment and treatment protocols for orthopedic conditions presented herein are consistent with the Chinese longitudinal muscle distributions and spinal relationships.

Orthopedics in Chinese is usually referred to as "straight bones (zhènggǔ 正骨)" but is also referred to as "orthopedics and traumatology (gǔshāng kēxué 骨伤科学)" which literally translates as "science specialty of bones and injuries."[1] The word "orthopedics" was first used in the West by Nicolas Andry (1658-1742), derived from the Greek root "orthos," meaning "straight," and "pais," meaning "child." Andry believed that skeletal deformities were the result of muscular imbalances that occurred during childhood. His treatise, *Orthopedics or the Art of Preventing and Correcting in Infants Deformities of the Body*, was first published in 1741.[2] He defines an "orthopedist" as a physician who prescribes corrective exercise. Andry's definition is far from what is now

[a] The ancient Chinese referred to the needling sites as nodes or critical junctures (jié 节) where collateral vessels branched from the longitudinal vessels involving both nerves and blood vessels and best described as "neurovascular nodes." Nodal sites are also referred to as: slight depression, cave, or hole (xué 穴).
[b] Chinese characters provided herein represent the simplified character set of China and their pīnyīn (拼音) pronunciation guide syllables and tone indicator.

practiced, however, many of his ideas are similar to movement and exercise approaches promoted some 2,000 years prior by the ancient Chinese.[3]

## Chinese Orthopedics

In addition to movement therapy including (tàijíquán 太极拳), guided stretching (dǎoyǐn 导引), and exercise for rehabilitation (kāngfù 康复),[4] the Chinese developed a wide range of treatment modalities to address pain, musculoskeletal, and orthopedic conditions which were common among ancient people just as they are today. These treatment methods include the use of: needling therapy; mobilization; manipulation;[5] massage (tuīná 推拿);[6;7] pressure methods; heat application; diet; breathing exercise (qìgōng 气功),[8;9] stress management; lifestyle counseling and electroneedling (EN) (See Appendix A).

Needling therapy is usually referred to as "acupuncture" in the West. This term was coined by early Jesuit missionaries to China from the Latin "*acus*" (needle) and "*punctura*" (to puncture) to describe their observations of needling therapy. Unfortunately, "acupuncture" only denotes puncturing something with a needle and provides no clue to a highly sophisticated and effective therapeutic system. Marco Polo (1254-1324) may have been one of the first Europeans to observe needling therapy during his stay in China from 1275 to 1292 some two centuries before the first Jesuits arrived. Supposedly he referred to it as "needles that cure" in a now lost letter from the Venetian archives to the Doge of Venice. This information has not been verified and Marco Polo did not mention Chinese needling therapy in his *Travels*. Medical instruments of ancient Chinese referred to as needles included probes, pricking devices, and knife-like devices that may have been used for reducing abscesses and minor surgery.

Chinese orthopedics employs the use of standard assessment methods for evaluating orthopedic conditions. Muscular conditions are viewed in terms of the unique Chinese view on the longitudinal organization of the skeletal muscular system.[10,CH 12] Twelve longitudinal muscle (jīngjīn 经筋) pathways are considered to distribute along each side of the body with six starting on the feet and six on the hands. Once assessment is complete the condition is then treated with Chinese medical modalities. Most important treatment approach relies on needling therapy (acupuncture) using the well established neurovascular nodes (acupoints) discovered by the ancient Chinese. Needling is applied consistent with established physiological mechanisms.

Needling protocols take advantage of spinal cord axial (longitudinal) relationships as well as segmental dominance along with distal nodes usually on the terminal extremities. Some proximal nodes are considered as well. In some clinical conditions electrostimulation is applied to selected inserted needles (electroneedling: EN; See Appendix A). Candidate treatment protocols are provided in Chapters 6 through 17 for conditions affecting all joint articulations in the body. Perhaps the most important aspect of Chinese orthopedics treatment and assessment is reliance on the longitudinal organization of the musculoskeletal system as described by the ancient Chinese (See Chapter 2).

## Application

Problems addressed with Chinese orthopedics are often concerned with soft-tissue lesions that result in dysfunction and pain in the muscles and joints of the body. Lesions to muscles, tendons, tenosynovial sheaths, joint capsules, ligaments, and bursae typically arise from environmental, inflammatory, degenerative, and traumatic conditions. Although these situations are quite common, they are often not adequately evaluated and treated. Through the process of proper history taking, keen observation, and careful clinical examination, the source of the problem can be localized so proper treatment and management of the case can bring about a possible successful resolution. These same assessment strategies can also be applied, using proper guides, to evaluate various degrees of potential disability and impairment in situations where the problem cannot be resolved by further medical intervention. In this situation the patient is considered to have reached their maximum medical improvement (MMI).

Orthopedics can also involve the treatment of acute fractures, dislocations, infections, tumors, and other abnormalities. In the West, Chinese medicine practitioners are not presently trained in surgery, bone setting, or resolving dislocated joints, as is done in China. Consequently, these traumatic conditions need to be handled in modern emergency care facilities. Likewise, significant infections and tumors are not normally treated by needling therapy techniques. However, practitioners need to have sufficient knowledge of these conditions to understand when a case must be referred to the proper medical specialist. Specific treatment of these conditions is not covered in this text, however, post recovery or post surgical treatment is a normal part of Chinese medical orthopedics.

## Patient Care Responsibilities

The most important responsibility of a practitioner is to provide the best care possible within the scope of their training and experience while respecting the patients' sensitivities as well as all other ethical and legal aspects of practitioner-patient interrelations. Critical to fulfilling the responsibilities of properly addressing patient needs requires a present-day understanding of anatomy and physiology as well as competency in the practice of needling therapy. In addition it requires employment of an organized system of collecting and summarizing clinical findings, examination results, laboratory results, diagnoses, treatment details, recommendations, and progress. Properly collected data then permits assessment of clinical trends and effectiveness of various treatments. The purpose of Chinese orthopedics training is to develop the necessary skills and competencies in the assessment and treatment of orthopedic conditions including pain and musculoskeletal problems. Specific objectives include:

- Understanding of orthopedics consistent with the historic Chinese theories and current medical science
- Concentration on present understanding of anatomy and physiology of the musculoskeletal system, including assessment and standard evaluation methods as well as treatment strategies using needling therapy
- Understand the medical and legal obligations of maintaining records, referral to other specialists, and need for laboratory tests or other studies

- Help practitioners integrate into mainstream medicine and improve communication skills with other health care professionals
- Prepare practitioners to be able to work within multiple disciplinary clinics

## Early Beginnings

Chinese culture is very ancient dating back to the Neolithic period of human development. Sometime around 9000 BCE the people moved north from the middle Yangzi river valley to settling along the great basins of the Yellow River of China. Transition to an agrarian society brought many challenges associated with living in fixed locations that had an impact on health. Disease became prevalent resulting in the need to develop a wide range of treatment modalities over time including the use of: herbal remedies, heat packs (some that contained herbs), radiant heat, moxibustion (direct heat on skin or much later on needles), cupping, therapeutic bathing, diet, medicated diet, exercise, movement therapy, guided stretching, breathing exercises, relaxation techniques, pressure techniques, manipulation. massage, bone setting and splinting, and limited surgery.[10,CH5] Present day practitioners in China still reduce and splint all types of bone fractures. Neither bone setting nor surgery of any kind has yet to be included within the scope of modern needling therapy practice in the West.

Ancient Chinese physicians also pricked the skin with small stone points called "biānshí (砭石)" to therapeutically release a few drops of blood. Stone points were used for bloodletting, and also for reducing abscesses.[3] The small points were employed for several millenniums before the metal needles were introduced. This gave the Chinese a very long time to acquire a detailed understanding of the longitudinal pathways of main blood vessels, skeletal muscles, spinal cord, and nerves. It also allowed them to also identify the most effective neurovascular nodes along these pathways for pricking to address pain, orthopedic conditions, and internal organs problems.

### Blood Vessel Theory

Sometime around the middle of the Zhou dynasty (700 BCE-500 BCE) the Chinese developed a keen interest in studying the human body. Eventually this led to postmortem dissection studies. One of the main interests was the understanding of the blood vascular system and its critical role in bodily function and sustaining life.[10] The earliest reported account of continuous blood circulation, including a description of human conception and fetal developmental including that of the internal and sensory organs, is found in the *Guanzi* (ca. 375 BCE) in the essay on Water and Earth:

"Earth is the root source of all things and the foundation of all life and luxuriant growth... Water is the blood (xuè 血) and breath (qì 气) of earth in a similar manner to blood and breath circulation through blood vessels and muscles."

From this time period forward, Chinese physicians participated in a text-based alignment of knowledge eventually leading to detailed medical manuscripts. Oldest of the ancient texts recovered so far were retrieved in 1973 from tomb 3 at Mawangdui near the city of Changsha, Hunan Province, China dated to 168 BCE. These medical manuscripts were part of a large collection and provide the first detailed information about the Chinese blood vessels (mài 脉).[3,11] Similar vessel texts were also found in 1983 at

Zhangjiashan in a tomb dated to 150 BCE. Collectively, these texts provide the first universal model of pathology based on the blood vessel theory. Neither Chinese needling therapy nor neurovascular nodes/acupoints (jié 节/ xué 穴) are mentioned in these particular texts.[3,p39,p.87]

## First Comprehensive Text

The most important ancient text on Chinese medicine, including the first information on needling therapy, is the *Huangdi Neijing (Yellow Emperor's Internal Classic)*. It is often referred to as the "*Neijing*" and the date of its origin is unknown but other information suggests it may have been compiled around 200-100 BCE. The *Neijing* is obviously a compilation of texts written much earlier but none of the originals have survived to date. Efforts to place a fair copy of the *Neijing* in the Han Dynasty court library was initiated by Liu Xiang after 26 BCE and completed by his son Liu Xin.[12] Liu Xin was also an author and astronomer and famous for having calculated the period of the solar year by analyzing moon phases over a 19 year period. His value for the solar year only differs from the present value by 14 minutes. The earliest recorded mention of the *Neijing* is found in The *History of the Former Han Dynasty* by Ban Gu (32-92 CE). He simply lists the *Neijing* as consisting of 18 scrolls without comment.

By the 2nd and 3rd Century CE the *Neijing* was viewed in terms of the *Suwen (Common Conversations)* and the *Zhenjing (Needling Classic)* containing nine scrolls each.[13;14] The *Neijing* was then lost until 762 CE when a Tang dynasty minister named Wang Bing set out to restore a recovered copy. He added text to the *Suwen* (*SW*) and renamed the *Zhenjing* the *Lingshu* (*LS*) (*Center of Knowledge*).[13;14] Commentaries were also made in 1056-1066 CE during the Song Dynasty by Gao Baoheng.[13;14] Additional commentaries on the *Suwen* continued up to the 19th century.[14]

This incredible work provides a compilation of Chinese medical concepts that demonstrate a profound understanding of anatomy and physiology that was superior to the ancient Greek ideas of the same time period. The Chinese information is 80 to 90% consistent with modern understanding including the first detailed description of the entire cardiovascular system specifically identifying all the major arteries and veins of the internal and superficial body.[10] They also identified the brain, spinal cord, some peripheral nerves, heart, pericardium, lungs, stomach, spleen, liver, gallbladder, kidneys, urinary bladder, lymphatic system, and the membrane systems of the thoracic, abdominal, and lower abdominal cavities (sānjiāo 三焦); but, never specifically identified the endocrine glands.

Reason for this level of knowledge is the fact that the ancient Chinese conducted postmortem examinations to obtain quantitative information noted in *LS 12* as follow:

"With regards to a person, even 8 Chinese feet tall (about 6 feet), they can be examined by a trained practitioner providing that the skin and flesh are still intact. Externally the body can be completely measured in accordance with established standards. In case of death, a dissection study can be performed to examine the condition of the internal organs to determine the firmness or fragility of the viscera and the size of the bowels and contents of the digestive system. The length of the vessels can be measured and whether the blood is either clear or deep and thick. The total air content of the body can be determined as well as the ratio of blood to air in the 12 main longitudinal vessels. It can also be determined if the body contains considerable blood and air or if there is a lesser amount of both. Quantitative measurements can be derived for all of these parameters."

The *Neijing* gives a complete description of the cardiovascular blood circulation of: 1) a critical component in inhaled air (qì 气) now known to be oxygen, absorbed in the lungs and distributed in the arterial blood supply (*LS 10*); 2) nutrients (yíng 营) from food stuff and water broken down in the stomach and absorbed by the small intestine fine veins (*LS 81*) and directed to the liver by the portal vein; 3) defensive substances (wèi 卫) (immune cells) that can leave blood circulation to mount a defensive action and then drained back into the blood supply via the lymphatic system (*LS 18*); and 4) refined substances of vitality (jīngshén 精神) which mediate emotions (hormones and other biologically active substances) (*LS 8*). The venous blood returns to the heart and lungs, now known to transport cellar respiratory carbon dioxide ($CO_2$) which is exhaled along with the nitrogen ($N_2$) in the lungs as air (qì 气).[10] It was clearly understood that the inhaled air and nutrients were critical to sustain life.

## Cardiovascular Blood Circulation

A detailed and correct discussion of the entire cardiovascular system involving all main blood vessels supplying the internal body as well as those supplying the extremities, head, and brain is provided in the *Neijing*. Vessel pathways are accurately described along with the length of the longitudinal vessels.[10, CH9,CH10,CH11] The three main deep singular vessels (jīmài 奇 脉) of the internal trunk were distinguished from the 12 longitudinal vessels (jīngmài 经 脉) supplying each side of the body. Deep vessels include the aorta (chōng 冲 thoroughfare vessel), vena cava (rèn 任 allowance vessel), and veins of the posterior trunk (dū 督 governing vessel) consisting of the azygos, hemiazygos, and ascending lumbar veins (See Figure 1.1). Five other singular vessels (jīmài 奇 脉) were also described which consist of superficial venous networks on each side of the body. These vessels are in addition to the six longitudinal veins (jīngmài 经 脉) on each side of the body to account for the fact that the body has 80% more veins than arteries due to the slow flow rate in veins.

The aorta receives oxygenated blood and nutrients, collectively referred to as "essential substances (qì 气 and yíng 营)," directly from the heart left ventricle. Here it is circulated to the arteries (like a thoroughfare) supplying all the internal organs and brain and a branching system of out flowing longitudinal arteries that supply the arms, legs, head and face, and the body trunk. This clearly involves heart function producing a pulse wave as noted in *LS 62* (*Pulsating Transport*):

"Essential substances leave the heart (left ventricle) suddenly, like shooting a cross bow or like a wave hitting shore."

After the pulse wave reaches the thenar region (radial pulse) it declines and reverses flow in the veins. The pulse was noted not to be able to transmit through the arterioles, capillaries, and venules (fine vessels sūnmài 孙 脉) and hence veins do not have any pulse.

The vena cava is the largest allowance vessel of the body and receives venous blood from the liver, kidneys, and the urinary bladder. Venous blood from the gallbladder, stomach, spleen, pancreas, and the intestines is directed to the liver by the portal vein and is included with the blood of the liver. The vena cava also receives blood from the return flowing longitudinal veins of arms, legs, head, brain, and face, and the body trunk, including blood from the governing (dū 督) vessels. The vena cava connects to the right atrium of the heart. Vessels comprising the governing vessels (veins) of the posterior trunk receive venous blood from the intercostal and other veins of the back and the bronchial veins of the lungs. Venous blood from the heart is drained from within the heart itself by the coronary sinus.

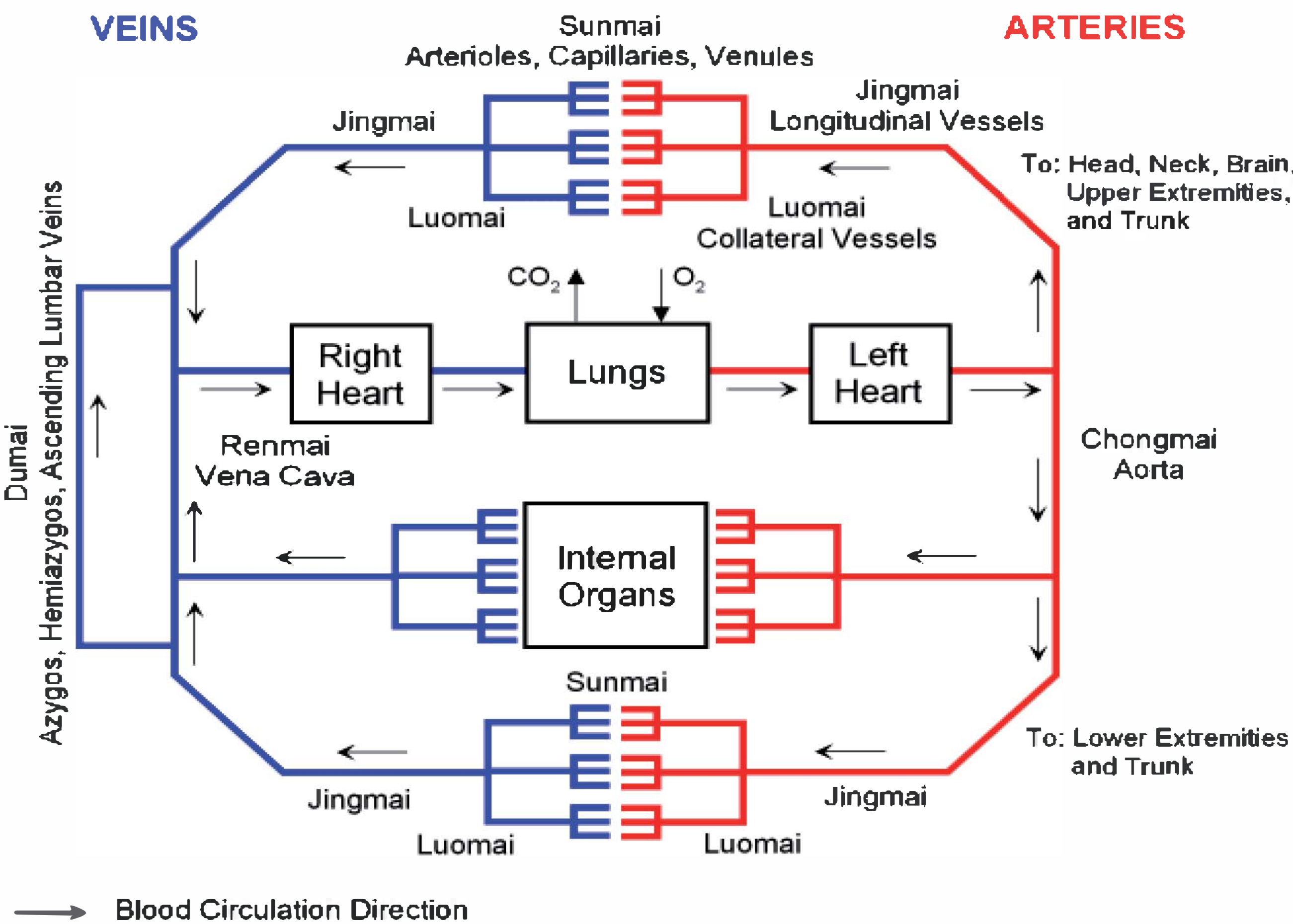


Figure 1.1. Schematic view of Chinese cardiovascular system organization and vessel branching

Pathology affecting the 12 longitudinal blood vessels (jīngmài 经脉) includes disorders resulting from blood circulation problems along each longitudinal vessel. The longitudinal vessels are thought to have internal connections with specific internal organs. Problems in circulation could result in disorders associated with the somatovisceral related internal organ. Problems also result when blood circulation of essential substance (oxygen from inhaled air, nutrients, and water) along specific longitudinal vessels is either in surplus (excess) or hollow (deficient). It is presently understood that muscular problem, including pain and chronic pain, result when blood flow is restricted.[15] In addition, restricted oxygen and nutrient flow to the internal organs results in serious problems including heart attacks. All the above conditions affecting the vessels and somatovisceral related organs are thought by the Chinese to reflect on both the radial (related by the Chinese to the lungs) and carotid pulses (related to the stomach).

There are three sets of longitudinal arteries and veins that supply and drain each arm, leg, body trunk, and head. These vessels (jīngmài 经 脉) branch into collateral vessels (luòmài 络 脉) which in turn supply the fine vessels (sūnmài 孙 脉), now known to be arterioles, capillaries, and venules, that connect the arteries to the return flowing veins.[10] This completes the circulation of blood "like a ring without end" (See Figure 1.1).

William Harvey provided the first experimental verification of continuous blood circulation in 1616. He continued teaching on the cardiovascular system and published his *Exercitatio* in 1628 but did not verify how the arterial blood flowed to the veins.[16] This problem was resolved by Marcello Malpighi (1628-1694) by discovering capillaries in 1661. The work of Harvey and Malpighi confirmed the Chinese concepts of continuous blood circulation "like and ring without end" through a complex branching system of out flowing arteries and return flowing veins postulated some 1800 years earlier by the ancient Chinese.

Despite this, Harvey's contribution is rightly considered the single most important Western discovery because it stimulated a science-based endeavor to understand the human body. Ancient works always need to be viewed in terms of modern science. Here we have a paradox where the ancient Chinese had a correct understanding of the cardiovascular system which was replaced with metaphysical concepts in the 20th century. Chinese ideas of blood circulation were replaced with the misconception of blood and energy circulating by means of invisible meridians by Georges Soulié de Morant in 1939 and 1941.[17] Adoption of this impossible "meridian theory" by the majority of European and American practitioners has virtually precluded Chinese needling therapy from being integrated into mainstream medicine.[18;19] These incorrect ideas have also impeded the development of valid treatment protocols and science-based training for Chinese needling therapy programs in the West. This present text is based on correct anatomic and physiologic terminology consistent with the ancient Chinese discoveries and present day medical science.

### Confusing the Spleen with the Pancreas

Had the ancient Chinese identified and understood the endocrine glands their comprehension of anatomy and physiology would have been nearly complete. They did assign certain vitalities and related emotions to the five main viscera that are obviously mediated by hormones (*LS 8: Root of Vitalities*) (See Table 1.1). These organ relationships are easily correlated with the main endocrine glands except for the spleen being paired with the stomach. The stomach was considered to have the major descending function of the body by breaking down food stuff and water and passing this on to the small intestine. The spleen was wrongly considered to have the major ascending function of the body by controlling digestion and absorption of nutrients via the small intestine veins. Nutrients were noted to be directed upward (ascending) to the liver via the portal vein and then onto the vena cava (rènmài 任 脉) and then heart.

Ancient Chinese, Greeks, and other cultures described diabetes being characterized with symptoms of frequent urination, sweet tasting urine, wasting of the body, and finally death. The Chinese thought the spleen caused diabetes however, Oskar Minkowski serendipitously provided experimental evidence of the pancreatic (yí 胰) origin of diabetes in 1889.[20;21] The Greek physician and anatomist Herophilus (ca.335-280 BCE) from Chalcedon in Asia Minor was first to identify the pancreas. Some four hundred years later Ruphos (1st or 2nd Century CE), an anatomist and surgeon of Ephesus in Asia Minor coined the term "pancreas" which in Greek meant "all flesh." Galen (138-201 AD), another physician and anatomist also born in Asia Minor, thought the pancreas served as a cushion or fatty pad below the stomach to protect the large blood vessels lying immediately behind the pancreas (splenic artery with branches to the pancreas). Considered the most famous physician in the World of his time, his word was not to be challenged until the 18th Century.

It is interesting to note that the ancient Chinese measured the size and weight of the viscera and bowels, and the capacity of the bowels.[10,p46] The spleen was noted in the *Nanjing* (*Classic of Difficulties*) Question 42 to weigh 2 jīn (斤) and 3 liǎng (两 = 1/16 of a jīn 斤) along with another one half jīn (斤) of distributed fat.[22;23] Weight of a jīn (斤) during the Qin and Han dynasties was 220-253 grams.[24] An average of these two values results in a weight for the spleen of 517 grams with the distributed fat weighing 118 grams. The weight of 517 grams for the spleen is actually twice the normal value while the 118 gram weight for the distributed fat is consistent with the weight of the pancreas.

The pancreas is a dual function organ that controls digestion as well as having a critical endocrine role to maintain blood glucose levels. Since the spleen has no endocrine function it would seem reasonable that the Chinese vitality of intent (yì 意) is more appropriately assigned to the pancreas (See Table 1.1). Anatomically, the spleen is located in the upper left abdominal cavity, in contact with the stomach, tail of the pancreas, the diaphragm, and the left kidney. The pancreas lies slightly below and behind the stomach to reach the descending part of the duodenum where it curves left to meet the large intestine. All these organs make intimate contact with each other which may have contributed to missing the role of the pancreas. But, the most likely problem may have resulting by the Chinese following the large splenic artery route to its final destination at the spleen and ignoring the fact that this artery supplies small critical branches to the pancreas before reaching the spleen.

The spleen is the largest lymphatic organ in the body that targets pathogens that infect the bloodstream. It also filters out and breaks down old red blood cells, recovers iron from the hemoglobin, and removes bile pigments for excretion as bile by the liver. Toward the end of fetal development the spleen manufactures red blood cells and after birth this function is taken over by the bone marrow. The spleen also acts as a blood reservoir including the storage of about 25% of the body's platelets. During stress or at other times when additional blood is needed, the spleen contracts, forcing stored blood and platelets into circulation. The ancient Chinese should have assigned the spleen to the heart which they considered responsible for blood and the vascular system.

Table 1.1. Characteristics of Chinese assigned organ vitalities and related endocrine glands.

| Vitalities | Vigor (pò 魄) | Mood (hún 魂) | Vitality (shén 神) | Intent (yì 意) | Drive (zhì 志) |
|---|---|---|---|---|---|
| Residence | Air | Blood | Vessels[1] | Nutrients[2] | Essence[3] |
| Related Organ(s) | Lungs | Liver | Heart | Exocrine Pancreas | Kidneys |
| Endocrine Gland(s) | Thyroid | Pineal | Pituitary | Endocrine Pancreas | Adrenal Glands |
| Characteristic | Vigor; Physical Strength; Animation; Life | Mood; Soul; Spirit | Vitality; Mentality; Expression; Natural Abilities; Animal Spirit | Intent; Desire; Inclination; Thought; Idea | Drive; Will; Aspiration |
| Related Emotions | Grief & Worry | Anger | Joy | Pensiveness | Fear & Fright |
| Related Bowel | Large Intestine | Gallbladder | Small Intestine | Stomach | Bladder |

1. Indicates both blood vessels and nerves; 2. Nutrients (yíng 营); 3. Refined substances (jīng 精)

## Muscle System Organization

All the skeletal muscles and the diaphragm are described in the *LS 13: Longitudinal Muscles* (jīngjīn 经筋). [10,CH12] One of the most unique organizational features of the muscular system involves longitudinal association and grouping discovered by the Chinese. Here the musculoskeletal system is organized into 12 distinct longitudinal distributions related to the nerves and longitudinal blood vessels (jīngmài 经 脉) supplying the same regions, including related neurovascular nodes (acupoints). Each of these twelve muscle distributions is discussed in detail in Chapter 2 including illustrations and tabular information on: muscle name, function, origin, insertion, innervation, and nerve root. In addition, the kinesiology associated with each major joint (Chapter 6 through 17) is provided listing: each muscle, Chinese anatomical division, nerve root, and the prime mover (PM) or accessory or assistant mover (AM) function involved each joint articulation.

The Chinese noted that pain and pathology can reflect along the muscular distributions, including the spontaneous development of sensitive locations (ahshì xué 啊是穴). Correlation of this information at each joint provides a quick assessment of what longitudinal division may be involved in a patient's condition prior to performing any detailed assessment. Muscles were considered to represent the external body and have no special relationships with the internal organs. However, visceral referred pain first mentioned in the *Neijing* can reflect in the muscles of neck, shoulder, body trunk, and buttocks but not usually in those of the extremities.

Muscle and tendon distributions were thought of as a linked system passing over one particular joint and then continuing on to the next muscle and joint in the vertical pathway. Muscles in each distribution were determined by following the pathway of propagated sensation (PS) to needling experienced by a small percentage of the population. These phenomena are related to the axial organization of spinal cord including the spinal afferent processing system mediated by the propriospinal system.

Muscle action potentials can be measured at neurovascular nodes in response to PS along the muscle pathways.[25] The Chinese described all the muscles for each of the 12 longitudinal divisions starting with the hand or foot and moving up along the vertical pathways of the arm and legs. They were described mainly by noting the insertion and origin of each individual muscle or related group. This approach was used by the ancient Greeks as well. For some reason the ancient Chinese did provide actual names for three skeletal muscles including the gastrocnemius, quadriceps, and the sternocleidomastoid. The Chinese also described the diaphragm by name as well.

## Basic Comprehension of Nerves

The earliest first-hand Western account from Japanese and Chinese practitioners in Japan that Chinese theories involved continuous blood circulation, a branching network of arteries and veins, and nerves was provided by Willem ten Rhijne (1647-1700) in 1683.[26] The ancient Chinese used the character suǐ (髓) to denote nerves and the spinal cord and when used with the character jí (脊) for backbone, it refers to spinal nerves.[27;28] Later suǐ 髓 was considered to mean "marrow" consistent with the Western terminology of the time that referred to the spinal cord as "spinal marrow." The character suǐ 髓 consists of the two components of gǔ (骨) which means bone and suí (遀) which serves as the phonetic and means "to follow." So an obvious translation of suǐ 髓 would be: "something that follows the bones" and that is what nerves do even distributing through bone foramen as described in the *Neijing*.

The character gǔ (骨) also consist of two components, namely guǎ (冎) which means "skeleton or bones without flesh"[29] and ròu (肉) which means "flesh" referring to the muscles that attach to the bones. The character guǎ (冎) represents a bone which contains marrow as does the bone represented by the character gǔ (骨). So, it does not seem reasonable to use the character suǐ 髓 to mean "marrow" just because it contains gǔ (骨) as part of the character. One possible source in creating this confusion is from the *SW11* where the Yellow Emperor asks:

"I have heard from some physicians that perhaps the brain (nao 腦) and the nerves (sui 髓) are considered to be viscera ... Qi Bo directly replied: The brain, nerves, bones (gu 骨), blood vessels (mai 脉), gallbladder, and uterus are six organs generated by the earth's environment."

This seems to indicate that suǐ 髓 refers to nerves instead of marrow. Since suǐ 髓 immediately precedes gu 骨 in the later part of this discussion some have wrongly assumed that suǐ 髓 means bone marrow. However, the initial part of the conversation is about clarifying the classification of the brain and nerves. Furthermore all nerves were considered to be connected to the brain as noted in *SW 10*:

"All blood vessels relate to the eyes, all nerves (sui 髓) join the brain (nao 腦), the muscles and tendons belong to the joints, blood belongs to the heart, essential breath (qi 气) belongs to the lungs and these provide function to the four extremities and eight articulations from morning to night."

Additional indications that suǐ 髓 means nerves is provided by the Yellow Emperor in a discussion of embryonic and fetal development in response to being asked about blood vessel development in *LS10* as follow:

"Life for the human first starts when the reproductive essence combines (father's sperm unites with the mother's egg). As result of this conception the brain (nao 脑) and nerves (sui 髓) start to form and the bones (gu 骨) develop to provide a framework for the body. The vessels (mai 经) form to circulate nutrients (ying 营) and the muscles (jin 筋) develop to make the body strong. The flesh (rou 肉) develops to form the body trunk and the skin (pifu 皮肤) becomes firm and the hair (mao 毛) can grow long."

It is interesting to note that this quote is accurate in that the embryonic nerves develop first and blood vessels develop by following the nerves. In addition, the possible involvement of nerves in the function of neurovascular nodes (jié 节) (acupoints) is provided in *LS1*:

"That which we call nodes (jie 节) are the places that vitality signals (shenqi 神气) transmit inward and outward (efferent and afferent nerve signals), and is not just skin, flesh, muscles, and bones."

The character shén (神) can mean: vitality, mind, miraculous effect, or spirit. The term shénqì 神气 can be used to indicate nerve signals and modern names for nerves and the spinal cord are basically consistent with terminology of the *Neijing*, namely:

- Nerves: longitudinal nerves (shénjīng 神经)[28]
- Spinal cord: backbone nerves (jísuǐ 脊髓)[28]
- Spinal nerves: backbone longitudinal nerves (jísuǐ shénjīng 脊髓神经) or (jí shénjīng 脊神经)[28]

## Concepts of Pathology

Cause of human pathology was viewed by the ancient Chinese in terms of the total environment of daily and annual existence involving: atmospheric and seasonal conditions; physical wear and tear; emotions; stress of living in crowded cities; diet; lifestyles; condition of one's residence (including its location and the tranquility among the occupants); famine; epidemics; and pathogenic organisms. Collectively, the Chinese called the disease causing (pathogenic) factors "xiéqì (邪气)." This view of pathogeneses is still prevalent today with the addition of modern work loads, work place environments, computers, internet activities, television, cell phones, i-phones, and substance overuse. Disease was viewed as an ongoing contention between physiological function (zhèngqì 正气) and pathogenic factors (xiéqì 邪气). Normal health was considered to exist when physiological function was optimum and external factors were in normal range.[10, Fig 2.3]

The Chinese concept of physiological function was highly sophisticated for its time and involved the performance of all body systems. This idea embraces Cannon's[30;31] concept of feedback control of "homeostasis" as well as the unstable feed-forward aspects of hormone mediated vitalities and emotions (See Table 1.1) now called "allostatis."[10,CH13;32;33] A solid or substantial (shí 实) condition was considered to exist when physiological function/balance was optimum but external factors were abundant. A hollow (xū 虚) condition was considered to exist when external factors were in normal range but physiological function was below normal. There is a constant waxing and waning between external factors and internal function and normal health can be maintained as long as the body is resilient and capable of recovery. Chronic disease and pain, including chronic pain, can result when physiological balance does not fully recover.

Bodily function, including that contributed by the internal organs, relies on a continuous supply of oxygen ($O_2$) from inhaled air (qì 气), nutrients (yíng 营), and water. These are the potential energy sources that are converted by metabolic processes (zhēnqì 真气) to fuel cellular function, and hence physiological function. The Chinese placed emphasis on the idea that needling restored or stimulated metabolic processes; thereby strengthening physiological function to dissipate pathogenic conditions.

## Introduction of Needling Therapy

The small stone points (biānshí 砭石) were used several thousands years before the metal needle was adopted as first described in the *LS 1* (*Nine Needles and Twelve Sources*). The inherent advantage of needles was the fact they could be inserted and retained for shorter or longer periods of time depending on the desired therapeutic response. They could also be manipulated after insertion to enhance certain aspects of the physiological response to needling. Basically, the needles provide a better means of regulating and restoring bodily function to address disease and dysfunction. Needles also caused less damage to the skin and flesh as did the stone points. The Yellow Emperor explains why needling therapy was preferred, as follow:

"I support all my people though I receive a tax from them. I am saddened when they do not have adequate provisions or when their family members are sick. I wish they would not use poisonous or toxic medical remedies and not use the stone points (bianshi 砭石). Instead, I prefer to use fine metal needles to communicate with the longitudinal vessels to regulate blood and essential substance distribution in order to normalize the inverse (venous) and outward (arterial) flow of nutrients." (*LS 1*)

### Oldest Needles and Confirmed Practitioner

The earliest received evidence of metal needles recovered so far was found in the tomb belonging to Liu Sheng (154-113 BCE), King of Zhongshan.[3;11] This information would suggest that the unique Chinese treatment system involving the insertion of fine metal needles may have developed around 250-150 BCE. However, there are unsubstantiated reports of legendary practitioners dating back to the time of the Yellow Emperor (ca. 2674 BCE) but they were apparently still using the stone points.

The first mention of Chinese needling therapy related to a known physician is found in the *Historical Records of the Han Dynasty* (90 BCE), *Chapter 105* of Sima Qian (ca. 145-86 BCE). His name was Chunyu Yi (ca. 216-150 BCE)[3;14] who treated patients with herbs, moxibustion, and needling therapy. Chunyu Yi considered blood vessels to be the most important structures compared to other constituents of the body. He was brought before the Han court on a complaint by a well connected patient. Chunyu Yi provided information on his teachers and presented 25 patient case histories. Despite these efforts he was found guilty in 167 BCE of what could be called malpractice charges today. He was sentenced to mutilation punishment but his youngest of five daughters Tiying intervened on his behalf with the Emperor who commuted the sentence.

Given the sophisticated level of Chinese needling therapy at this point in time suggests that this practice may have developed much earlier. This is partly supported by Sima Qian's report on other notable practitioners whose existence has yet to be verified. The most famous of these is the legendary physician named Bian Que (ca.500 BCE) who lived during the later part of the Spring and Autumn period (770 BCE - 476 BCE). Bian Que used herbs, moxibustion, and needling therapy and is presently highly regarded as one of the most important early practitioners. We know from this report that Bian Que used metal needles suggesting they may have been used starting sometime before 500 BCE.

## Metal Needles Replace Stone Points

The first treatise of the *Lingshu* (*LS 1: Nine Needles and Twelve Sources*) provides a detailed description of nine different needles, including their shape, length and use. Additional information was also provided on the needles in *LS 78 (Treatise on Nine Needles)* indicating that each were used for specific conditions. Few details are provided on how the needles were clinically utilized except for the fine needle which was further described in *LS 3 (Explanation of the Fine Needle)*. It is clear from the descriptions of the needles that they were used for conditions that are still common today including pain and musculoskeletal problems.

Current practice of needling therapy concentrates almost exclusively on the modern equivalent of the ancient "fine" needle: "...used to treat cold and hot rheumatic pains situated in the collateral vessels. Because this needle is so fine, it can be retained for a long time to reduce pain, clear inflammation, and restore physiological balance (zhèngqì 正气). This is brought about by the influence on tissue metabolic processes (zhēnqì 真气) causing dissipation of the pathogenic conditions."*LS 78*

Some practitioners still perform limited bleeding using the modern three-cornered equivalent of the ancient "lance tip" needle: "...used to drain off heat and let blood to resolve chronic diseases including superficial ulcers, abscesses, carbuncles and heat conditions."

The ancient "sword-shaped" needle consisted of a blade device that could be used for lancing large abscesses and possibly for minor surgery. The modern equivalent of this needle is the ever present medical scalpel, which was: "...used to treat large abscesses, carbuncles and accumulated pus, as well as hot diseases caused by contention between hot and cold environmental conditions."

Two of the ancient needles were actually non evasive probes including the "round" needle which appears to be an instrument to possibly examine muscle and tendon strains and sprains or to massage areas between the muscles: "...used to treat conditions of the flesh and applied to the spaces between the muscles without injury to the muscles."

The other probe was called the "spoon" needle possibly to massage specific blood vessels: "...used to treat blood and vascular system diseases by pressing down on or massaging the vessels without causing their collapse. This stimulates metabolic processes (zhēnqì 真气) to dissipate pathogenic conditions."

## Early Western Exposure

Marco Polo was the first European to observe needling therapy being practiced in China during his long stay from 1275 to 1292 and may have brought the first reports to Europe. However, he did not mention anything about needling in the story of his *Travels*. Some two centuries later Jesuit missionaries visited China and were the first to introduce Chinese acupuncture to Europe. They made use of needling therapy and moxibustion, and taught it to others. Almost another century later the first European work on the subject was published by Girolamo Cardano (1508-1576), a physician and medical teacher in Milan.[34] Cardano's information was based on reports by travelers who had been treated with needling therapy and moxibustion in Asia. A Jesuit mission was already established in Japan by 1549 with missionaries being knowledgeable about needling therapy, moxibustion, and Chinese and Japanese terms of anatomy and physiology.[35] More information on needling therapy was obtained during the late sixteenth and seventeenth centuries. One mention was provided by Jakob de Bondt (1598-1631), the surgeon general to the Dutch East India Company, who observed acupuncture and moxibustion being used in Java.[36]

The earliest first-hand account on the anatomical and physiological basis of Chinese concepts was provided by the Western science trained physician Willem ten Rhijne (1647-1700) in 1683.[26] He joined the Dutch East India Company for an assignment in Java where he spent his first six months teaching anatomy to the surgeons of Djakarta. Ten Rhijne then sailed to the island of Dejima in Nagasaki Bay of Japan and stayed from October 1674 to October 1676. He sought to understand something about the medicine of Asia and had obtained four longitudinal-collateral vessel (jīngluò 经络) charts from local practitioners. These practitioners noted that Chinese concepts were based on the continuous circulation of inhaled air and nutrients by means of the blood vascular system. Furthermore, they explained that it involved the continued branching of out flowing arteries into smaller vessels and then the reverse process for return flowing veins essential to distribute blood throughout the body; they noted that nerves were involved as well. Ten Rhijne even observed a hydraulic device that demonstrated how blood continually circulates inhaled air and nutrients by means of the blood vascular system. He conducted his own dissection studies to confirm progressive branching of blood vessels suggesting that this was not understood by the West at the time. He described the branching blood vessels as being similar to the veins on a leaf. Ten Rhijne returned to Java where he worked for the remainder of his life.

Herman Buschof, a Dutch minister and friend of ten Rhijne wrote an account on moxibustion in the treatment of gout and arthritis in 1674. Andreas Cleyer, a German physician, who served with ten Rhijne in Java, wrote a book on acupuncture and the pulse in 1682. Englebert Kaempfer (1651-1716), a German physician who also worked at Dejima island wrote the most comprehensive Western account of moxibustion, with essays on acupuncture in 1712.[37;38]

By the start of the nineteenth century the practice of needling therapy in Europe was in a state of ridicule until Louis Berlioz (1776-1848) of France discovered ten

Rhijne's report on acupuncture. Berlioz used this information to start experimenting with needling in 1810 and was perhaps the first physician in France to actually practice the art.[39] He published an article in 1816 on the efficacy of acupuncture in treating digestive and nervous disorders.[39;40] Another important contributor was Sarlandiere le Chevalier of Paris who was the first to use an electrical device attached to inserted needles in 1825.[41] This was the first known application of electroneedling.

Numerous French articles appeared in medical journals shortly after the efforts of Berlioz in 1816, attesting to the utility of needling therapy. Its use continued in Italy along with the publication of articles and books on the subject.[34] Electroneedling was also reported by da Camino of Venice.[42;43] Interest in needling therapy was also stimulated in Germany and Sweden. A summary of acupuncture practice in Europe during this time is contained in the academic thesis of Gustaf Landgren (1805-1857) for his degree of Medicine Doctor at Uppsala University, May 16, 1829.[39] By the year 1900, analgesia by electroneedling promoted by Sarlandiere le Chevalier and da Camino was already in disrepute.[44] It is interesting the note that after Soulié de Morant created his energy-meridian concept he condemned all the above European work as being false acupuncture.[17]

Needling therapy was also imported to America where a few physicians tried their hand at needling therapy as early as 1822.[45] Ten Rhijne's report was first translated into English in 1826, and published in the *North American Medical and Surgical Journal* (1826; 1: 198–204).[46] One of the most notable practitioners was the Canadian physician, Sir William Osler (1848-1924). He practiced a variant form of acupuncture, and recommended its use for the treatment of lumbago and sciatica.[47] After Soulié de Morant's concept of energy flowing through meridians gained a foothold in Europe during the 1940s and 1950s, ten Rhijne's report on Chinese needling being based on vessels, nerves, and blood circulation was discredited as erroneous.

## Longitudinal Body Organization

The ancient Chinese were perhaps first to develop a standard system for anatomical reference to identify specific body locations. Instead of relative Western or even Chinese terms such as medial (nèi 内) and lateral (wài 外), or anterior and posterior the Chinese used the adjectives yáng (阳) for anything that is external and yīn (阴) for internal regions except in situations where the two terms can be used in opposition to each other such as comparing lateral to medial. The arms and legs were each divided into six easily identified longitudinal regions contrasted by yīn (阴) for the medial aspect and yáng (阳) for the lateral aspect. However, there is confusion as to where the medial (yīn 阴) regions transition onto the trunk proper since they are considered to traverse under the superficial lateral (yáng 阳) areas. The Chinese also used yīn and yáng terms to describe the relative location of the internal organs.

The earliest received evidence showing that ancient Chinese used standard anatomical nomenclature to describe the location of major blood vessels (mài 脉) running lengthwise in the body was found in the medical texts recovered from a tomb in 1973 at Mawangdui, China previously noted.[3;11] Three lateral (yáng 阳) blood vessels and three medial (yīn 阴) blood vessels were identified that traversed each leg along with three lateral (yáng 阳) and two medial (yīn 阴) vessels that traversed both arms. No blood vessel was identified for the hand transitional yin (juéyīn 厥 阴) region in these texts, but was included in the *Neijing* (*LS 10*) descriptions of vessels.

Collectively, the three yáng (阳) longitudinal vessels of the hand and feet where referred to as the lateral vessels of the hand and feet. Likewise, the three yīn (阴) longitudinal vessels of the hand and feet where referred to as the medial vessels of the hand and feet.[14,pp.60-61] Each of the lateral and medial aspects of the arms and legs were divided into three regions. For the lateral aspect of the hand and feet these consisted of the anterior lateral, lateral, and posterior lateral regions. The medial aspect of the hand and feet these were divided into the anterior medial, medial, and posterior medial regions. This resulted in 12 specific longitudinal regions on both sides of the body. These regions were named mostly by astronomical relationships to the sun, moon, stars, and planets as noted later (See Figure 1.2 and Table 1.2).

## Early Understanding of Longitudinal Relationships

The *Neijing* provides detailed information on the longitudinal organization of the body with bilateral symmetry with respect to the skeleton, brain, spinal cord and the distribution of major blood vessels, skeletal muscles, and peripheral nerves.[10] Most of this knowledge was considered to have been handed down from ancient times (*SW5*), perhaps from the Warring States Period (475 BCE to 221BCE) or even earlier. The ancient Chinese discovered the phenomena of propagated sensation (PS) provoked by needling that helped to identify which neurovascular nodes (acupoints) were related to each specific longitudinal body division (*LS26;LS75*).[10,pp.52-53] They also discovered organ referred pain reflected on various body regions (*LS74*)[10,p.49] some 2,000 years before William Head in 1893.[48] Postmortem autopsies allowed correlation of possible somatovisceral relationships between some neurovascular nodes along specific longitudinal vessel pathways and specific organs.

Other key discoveries included spinal segmental dominance and noting that certain nodes of the posterior lateral foot (PLF) body region (Table1.2), located on each side of the spine, had influence on specific internal organs. They also noted that distal nodes on the hand and feet evoked strong effects due to needling and other means of stimulation. Understanding of the spinal cord longitudinal organization along with segmental dominance and distal effects allowed the Chinese to develop the rational and effective treatment system of needling therapy. Modern science-based needling makes use of the longitudinal and segmental body organization.[10,CH14;49;50]

## Chinese Longitudinal View

The Chinese term jīng (经) is used to mean "longitude" or things that run lengthwise. This even applies to second character "jing" in the word *Neijing* generally translated as "classical texts" referring to characters written on vertical bamboo strips that are bound together in longitudinal scrolls. The term jīng can also apply to the warp of a fabric, main longitudinal arteries and veins of the body, and meridians.[29;51] In the *Neijing* it refers to longitudinal blood vessels, rivers, and muscle (jīn 筋) distributions as follow:

- *LS 10 Longitudinal Blood Vessels* (jīngmài 经 脉): provides an anatomically correct detailed description of the 12 main longitudinal blood vessels supplying the longitudinal body regions of each side consisting of out flowing arteries and return flowing veins [10,CH 9,10,&11]

- *LS 12 Longitudinal Waterways* (*Rivers*) (jīngshuǐ 经 水): describes the 12 main rivers of China that are considered to be similar to the 12 main longitudinal blood vessels on each side of the body
- *LS 13 Longitudinal Muscles* (jīngjīn 经 筋): provides an anatomically correct detailed description of the skeletal muscles that distribute longitudinally through the 12 main anatomical divisions on each side of the body[10,CH12] (See Chapter 2)

Much confusion about Chinese historic medical facts has resulted from inappropriate translation and use of the term "jīng (经)." This is used in both Chinese terms for meridian (jīngxiàn 经 线) and longitude (jīngdù 经 度). But, serious problems resulted by translating jingmai (longitudinal blood vessel) as "meridian."[17;19] English versions of acupuncture books from China often repeat these misconceptions while the Chinese versions of the same texts in Chinese are correct. The Chinese justify this practice by noting they are just using the accepted Western translation of Chinese concepts.

The term jīng (经) is also applied to the warp of a fabric causing some to think that the term longitudinal and collateral vessels (jīngluò 经 络) was referring to an invisible network.[52] Others have translated jīng (经) as "conduit" resulting in jīngmài being translated as "conduit vessel" and the longitudinal muscle (jīngjīn) distributions would presumably be called "conduit muscles" which does not seem to provide the clearest understanding.[3;14;53]

## Fundamental Body Plan

The ancient Chinese unknowingly discovered longitudinal body organization which is common to all other animals with some modifications. This feature first appeared in unsegmented flatworms around 600-570 million years ago. Flatworms are longitudinally organized with a head, body, and tail with bilateral symmetry. They are the simplest animals to have a bilateral nervous system involving longitudinal nerve cords which form transverse branches to supply sensory and motor nerve function at specific intervals along the body (segmental relationships).

Some 40-50 million years later the chordates appeared that had a notochord, which in vertebrates consists of an internal skeletal rod that is replaced with interlocking vertebrae during embryonic development. The earliest fossil chordate is the Yunanozoon Lividum from China and dates to the Early Cambrian Period some 525 Million years ago.[54] The central nervous system of chordates distributes on the dorsal aspect of the body opposite to the flatworms. Anton Dohrn proposed as early as 1875 that vertebrates inherited their central nervous system from an annelid (worm) ancestor and simply inverted their dorsoventral body axis during their evolution.[55] Recent molecular architectural studies of the annelid neurodevelopment confirm the important aspects of Dohrn's ideas showing the homology (similarity in structure and in origin) of the annelid and vertebrate trunk central nervous systems (CNS).[56] Flatworms evolved by crawling on the ground or the bottom of ponds. However, when they started swimming free they automatically inverted their bodies due to the properties of water reversing their control system effect.

The first fish then appeared during the Ordovian Period (510-439 million years ago).[57] Fishes quickly diversified and are the first known members of the Verbrata of the Chordate subgroup which gave rise to all subsequent vertebrates including amphibians, reptiles, birds, and mammals. The fundamental stages of longitudinal development and segmental dominance that is important to understanding Chinese needling therapy is clearly demonstrated by the careful study of either animal or human embryology.

## Chinese Body Orientation

Standard notation systems were devised over time to provide a means to reference certain features of the human body in order to relate information from one practitioner to another. The West eventually developed the idea of using imaginary orthogonal planes as a reference to describe body articulation (See Chapter 3). The ancient Chinese may have been the first to use a reference system by identifying twelve longitudinal regions on each side of the body. This scheme describes six yīn (阴) and yáng (阳) longitudinal anatomical divisions of the hands (shǒu 手) and feet (zú 足) on each side of the body as noted earlier. Their view on the order of blood circulation, somatovisceral relationships, and diurnal relationships or chronobiology and was included in their nomenclature as well (Table1.2, Cols.3, 4, & 5). This created a unique notation system that is not consistent with any known Western approach. Description for the twelve divisions in the West is usually only provided in Chinese pinyin pronunciation guide terms (Table1.2, Col.1). These are properly translated in Western terminology to provide a better understanding and application of these concepts (Table1.2, Col.2).

Table 1.2. Chinese and modern anatomical notation scheme for 12 longitudinal (jing) body regions, related vessels, and muscle distributions

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Chinese Anatomical Divisions (pīnyīn) | Longitudinal Region, Vessel, and Muscle Distributions | Vessel Type | Somatovisceral Relationship | Time Period |
| Shǒu Tàiyīn | Anterior Medial Hand (AMH) | Artery | Lungs | 3am-5am |
| Shǒu Yángmíng | Anterior Lateral Hand (ALH) | Vein | Large Intestine | 5am-7am |
| Zú Yángmíng | Anterior Lateral Foot (ALF) | Artery | Stomach | 7am-9am |
| Zú Tàiyīn | Anterior Medial Foot (AMF) | Vein | Pancreas | 9am-11am |
| Shǒu Shǎoyīn | Posterior Medial Hand (PMH) | Artery | Heart | 11am-1pm |
| Shǒu Tàiyáng | Posterior Lateral Hand (PLH) | Vein | Small Intestine | 1pm-3pm |
| Zú Tàiyáng | Posterior Lateral Foot (PLF) | Artery | Bladder | 3pm-5pm |
| Zú Shǎoyīn | Posterior Medial Foot (PMF) | Vein | Kidneys | 5pm-7pm |
| Shǒu Juéyīn | Medial Hand (MH) | Artery | Pericardium | 7pm-9pm |
| Shǒu Shǎoyáng | Lateral Hand (LH) | Vein | Internal Membranes[1] | 9pm-11pm |
| Zú Shǎoyáng | Lateral Foot (LF) | Artery | Gallbladder | 11pm-1am |
| Zú Juéyīn | Medial Foot (MF) | Vein | Liver | 1am-3am |

1. sānjiāo (三焦)

## Sky and Earth Orientation

The position of the sun with respect to the earth's daily rotation was used to divide the day into three yáng (阳) periods of 4 hours each based on the sun's position or incident angle with respect to a standing individual facing east with their hands to sides in the neutral position (See Figure 1.2). The three 4 hour periods between the yáng (阳) regions were assigned to yīn (阴) classification. All six of the 4 hour periods were divided to describe the vessel order of arteries first supplying the hands and then the feet. The Chinese understood that blood continually circulates in all the vessels at the same time by the heart. This could be verified by examining arterial pulses at nine different locations on the body.

The Chinese were first to introduce the idea of tracing blood distribution through the linear pathway of the longitudinal blood vessels on one side of the body and then the other side noted in *LS10*. The circulation order starts with an out flowing artery supplying the anterior medial aspect of the hand (AMH) which is drained by the veins associated with anterior lateral hand (ALH). A major branch of this vein also drains the anterior lateral head and face where it associates with the anterior lateral foot (ALF) artery which supplies the face, the body trunk, and the ALF region of the leg and foot. The ALF artery is drained by the anterior medial foot (AMF) veins directing venous blood back to the heart. This order of circulation between the hands and feet then continues to arteries and veins supplying and subsequently draining the posterior medial and lateral hand and foot and then the medial and lateral hand and foot (See Table1.2, Col.3).

## Circulation Order

The initial 4 hour yáng period of the hand and feet is from 5am to 9am and called the sunrise or bright yáng (阳 明) (See Figure 1.2). The second 4 hour yáng period from 1pm to 5pm is called the great yáng (太 阳) which is the name for the sun. The third 4 hour yáng period is from 9pm to 1am and called the lessor yáng (少 阳) which is the name for the stars visible at this time period. The yáng body areas occupy the anterior lateral, lateral, and posterior lateral aspect of the arms, legs, body, and head. Some neurovascular nodes along the six yáng vessel pathways have somatovisceral relationships and indications for the large intestine, stomach, small intestine, bladder, internal membrane systems (sānjiāo 三 焦), and the gallbladder.

The yīn body areas occupy the medial aspect of the arms and legs consisting of the great yīn (referring to the moon), the lessor yīn (referring to the planets), and the transitional or declining yīn (厥 阴) located between the greater and lessor yīn regions of the arm and legs. The yīn regions on the trunk are considered to traverse under the superficial yáng areas with neurovascular nodes on the anterior trunk which are considered yīn in comparison to the posterior body. Some neurovascular nodes along the six yīn vessel pathways have somatovisceral relationships and indications for the lungs, pancreas, spleen, heart, kidneys, pericardium, and the liver.

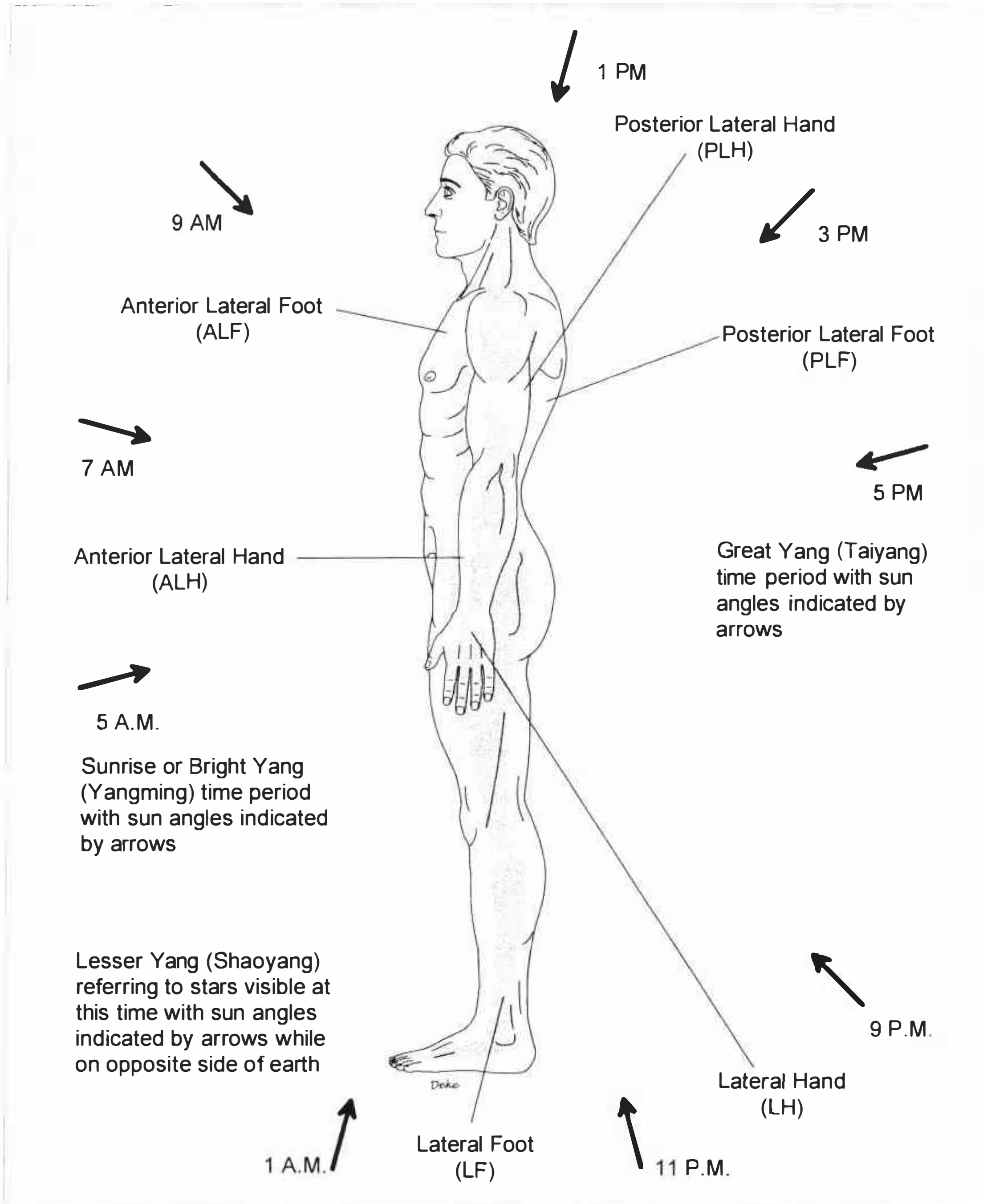


Figure 1.2. Standard Chinese anatomical orientation with respect to sun (yáng) position over 24 hour period showing longitudinal body regions for distribution of blood vessels, skeletal muscles, and neurovascular nodes (acupoints).

## First Concept of Chronobiology

Each longitudinal vessel giving rise to superficial neurovascular nodes was considered to have unique somatovisceral relationships involving blood vessels supplying each specific internal organ (See Table1.2, Col.4). Furthermore, a specific 2 hour time period was associated with each internal organ and vessel creating the original concept of chronobiology (See Table1.2, Cols 4 & 5). The Chinese attempted to show that organs had certain functions or situations during certain diurnal periods. This is mainly related to internal organ function but may also be associated with changes in blood flow needed to support eating and digestion of food, and other activities. It was known at this time that the liver and spleen stored blood during the night. The ancient Chinese also noted seasonal effects for specific internal organs that recovered during certain seasons or became worse in other seasons.

The blood circulation order starts with the lung vessels (3am-5am), since inhalation of air (qì 气) now know to contain oxygen ($O_2$), was understood to be most essential to sustain life. The AMH vessels consist of the radial arteries of each arm and the wrist pulse is considered related to lung function. It is know that certain conditions affect the lungs during in the early hours including decreased peak expiratory function (PEF). Next in order is the large intestine, related is the lung, which is usually active soon after awaking between 5am -7am (See Table1.2, Col.5). Individuals often consume their first meal which is broken down in the stomach (7am-9am). The stomach was considered responsible for nutrients (yíng 营) and the carotid pulse located on the ALF anatomical division. Partially digested food and water are passed on to the duodenum which triggers the pancreas (9am-11am) to neutralize stomach acid, provide digestive agents, and release insulin for cellular uptake of glucose. This is followed by the heart (11am-1pm) during its most active time of the diurnal cycle. The heart provides the greatest supply of resistance vessels to the small intestine (1pm-3pm) to support digestion which in turn delivers absorbed nutrients to the small intestine veins connected to the portal vein. The urinary bladder and kidneys are next in the order followed by pericardium and internal membrane system. Finally, the gallbladder collects and stores bile (11pm-1am) and the liver stores blood (1am-3pm).

## Neurovascular Node Designations and Use

From ancient times the Chinese have used their yīn (阴) -yáng (阳) longitudinal body divisions to name the major blood vessels, neurovascular node (acupoint) pathways, and the skeletal muscle distributions (Table1.2, Col.1). When Soulié de Morant translated the Chinese blood vessels as meridians in 1939 they were named by their anatomical regions in the yīn-yáng divisions. But, he thought that his meridians were also named for the internal organ for which the vessels have somatovisceral relationships.[17;58;59] He further complicated the problem by creating new nomenclature for the nodes by using the organ name or abbreviation as a prefix to an assigned sequential number as the accepted name for the specific nodes. Nodes along the ALF longitudinal division, for example, were named Stomach (ST) nodes 1 through 45. This nomenclature created a totally false impression that any neurovascular node along a given organ-named meridian was useful for treating conditions of that particular organ. Unfortunately, Western language acupuncture texts all follow this serious misdirection contributing to a further confusion that negatively reflects on the credibility of the Chinese.

### Location and Function of Neurovascular Nodes

Soulié de Morant's new nomenclature was contrary to the Chinese practice which give each node a specific Chinese name that indicates its possible location or function. The Chinese name for ST 1 is Chengqi (承泣) (Receive Tears) which is located directly below the pupil, between the eyeball and the lower infraorbital ridge.[61] This is obviously a place that receives tears and has indications for eye disorders. One famous node of the ALF anatomical region which is effective in resolving a wide range of gastrointestinal problems is ST 36 Zusanli (足 三 里) (Leg Three Miles). Its name indicates this node is located three Chinese inches (cun) below a reference point which happens to be the node Dubi (ST 35). Another example is DU 8 called Jīnsuō (筋 缩) (Contracted Muscles) located below the spinous process of the ninth thoracic vertebra. This is a special node that is effective in treating spasms in back muscles. There are many such examples.

Because of spinal segmental dominance, node location basically dictates its main clinical utility or function except for distal nodes. As example, all eight ALF nodes on the head (ST 1 to 8) only have indications for eye, teeth, face, jaw problems and headache with ST 40 to 45 having related distal effects for these conditions.[60] The ALF nodes ST 9 to 16 and 18 have indications for neck, upper chest, lungs, and breast disorders with ST 36 and ST 40 having related distal effects. Only the local and adjacent ALF nodes ST 19 to 25 overlying the stomach region are useful to address gastrointestinal problems, along with distal nodes ST 36, 37, and 44. The ALF nodes ST 26 to 30 on the lower abdomen have indication for urogenital, reproductive, lower abdominal problems, and hernia. In addition, all the ALF nodes on the leg (ST31 to 45) also have musculoskeletal indications.

One of the first step in trying to restore the original Chinese concepts and reduce confusion is to replace the organ names or initials by the Chinese anatomical division names and initials such as ALF 1 for ST 1, AMH 1 for LU 1 and so on (See Table 1.3). All neurovascular nodes referenced in this text, including those in treatment protocol tables, are identified by a prefix representing an abbreviation for one of the hand or foot longitudinal body regions as noted in Table 1.2, Col.2 and Table 1.3. The order for some of the terminal nodes in the posterior medial foot (PMF) region has been changed to correct another problem. However, these nodal names and their locations are unchanged. This involves changing the order of: KD 3 Taixi to PMF 6 Taixi; KD 4 Dazhong to PMF 5 Dazhong; KD 5 Shuiquan to PMF 4 Shuiquan; and KD 6 Zhaohai to PMF 3 Zhaohai.

Table 1.3. Chinese anatomical division nomenclature for neurovascular nodes (acupoints) versus (Vs) the usage introduced by Soulié de Morant.

| Chinese arteries | | French meridians | Chinese veins | | French meridians |
|---|---|---|---|---|---|
| AMH 1 to 11 | Vs | LU 1 to 11 | ALH 1 to 20 | Vs | LI 1 to 20 |
| ALF 1 to 45 | Vs | ST 1 to 45 | AMF 1 to 21 | Vs | SP 1 to 21 |
| PMH 1 to 9 | Vs | HT 1 to 9 | PLH 1 to 19 | Vs | SI 1 to 19 |
| PLF 1 to 67 | Vs | BL 1 to 67 | PMF 1 to 27 | Vs | KD 1 to 27 |
| MH 1 to 9 | Vs | PC 1 to 9 | LH 1 to 23 | Vs | IM[1] 1 to 23 |
| LF 1 to 44 | Vs | GB 1 to 44 | MF 1 to 14 | Vs | LV 1 to 14 |

1. Internal Membrane System (sānjiāo 三 焦)

## Impact of Confusing Nomenclature

Naming all the nodes (acupoints) along a longitudinal division by a specific internal organ has created unnecessary confusion. As result, node selection for some practitioners may be a somewhat random process. This is especially troubling given the fact that only the local and adjacent and appropriate distal nodes for any anatomical division have consistent clinical utility. This is true whether it is for treating an internal organ or musculoskeletal problem. Basically, local and adjacent nodes take advantage of spinal segmental (or cranial nerve) dominance with distal nodes selected also within the same spinal level. Understanding these fundamental relationships provides a rational basis for selecting nodes consistent with achieving repeatable results.[10;49;50] The problem is further complicated by practitioners adhering to the concept of non-existent meridians which supposedly do not involve nerves. Lack of interest in understanding the known mechanisms of needling is a major limiting factor as well.[10,CH14;61;62] The net effect of these problems has been poor results in acupuncture research studies over the years and finding that sham acupoints are often as good as well known nodes.[63]

Numerous articles on acupuncture have been listed in the Medline since the 1970's but few involved clinical studies, and even fewer yet involved placebo-controlled randomized clinical trials (RCT). There is an essential need for clinical evidence of acupuncture if needling therapy is to be accepted by mainstream medicine. Lack of rigor in the present literature database provides insignificant support to achieve this goal.[64] Database searches may produce a large number of acupuncture references with titles that are not fully consistent with the content. As it is with other clinical study reports the abstracts of acupuncture reports may be drawing conclusions not supported by the presented weak data. Some studies are presented in such a way that it is difficult to duplicate the original data.

Additional problems involve a wide variety of concepts and techniques used by different practitioners. This is especially true for those involving what is known in the United States and Europe as Traditional Chinese Medicine (TCM) that rely on a metaphysical understanding of acupuncture.[65;66] They argue that TCM is so different from Western medicine that they cannot be held to using RCTs in clinical trials.

## Correcting the Energy-Meridian View

It is interesting to note that changing from the metaphysical application of Chinese needling therapy to that of the real world only involves a shift in one's mind set. All licensed or certified acupuncturists have invested considerable time and effort to learn the location and indications for most of their meridian needling sites (acupoints). Many have even sought to understand the dermatome or spinal cord segment that serves each of these locations. Some must have realized that the pathways of acupoints (neurovascular nodes) run longitudinally up and down the arms, legs, and body. They have also learned that: "the muscle regions and cutaneous regions are the sites where the qì (气 inhaled breath and yíng 营 nutrients), and blood (xuè 血) of the meridians nourish the muscles, tendons and skin"[58] without realizing these are longitudinal distributions of actual skeletal muscles (See Chapter 2). Changing to real world anatomy only requires the elimination of the false terms "meridians or channels" and replacing them with the original Chinese longitudinal body notation to name the vessels, acupoints, acupoint pathways, and skeletal muscle distributions (See Tables 1.2 and 1.3). Everything else they have learned that is useful for treatment approaches is still applicable.

## Developing Consistent Treatment Protocols

The Chinese longitudinal muscle distributions provide a means of developing rational, effective, and consistent needling therapy treatment approaches. These are derived from clinical experience and a science-based understanding of Chinese medical concepts, the musculoskeletal system, physiological mechanisms of needling, and neurophysiology. They provide a rational approach to obtain consistent results for clinical trials to verify possible utility for needling therapy. This is essential since little valid research based evidence has yet to be provided given the confusion and mystery associated with acupuncture as previously noted.

Each joint of the arms and legs, including the shoulders and hips, are served by 6 muscle distributions. Pain and pathology of a given joint area typically reflects in one or two muscle distributions, although more can also be involved. Treatment consists of selecting possible Local and Adjacent, Proximal, and Distal (LAPD) nodes for any given problem affecting specific longitudinal muscular distribution (See Figure 1.3). Candidate treatment protocols for pain and musculoskeletal problems are presented in Chapters 6 through 17 for all the main articulations of the body. They are presented in tabular form and take advantage of spinal segmental dominance, proximal effects, and distal effect provoked by the afferent nerve processing system. Suggested application of electroneedling (EN) is also included.

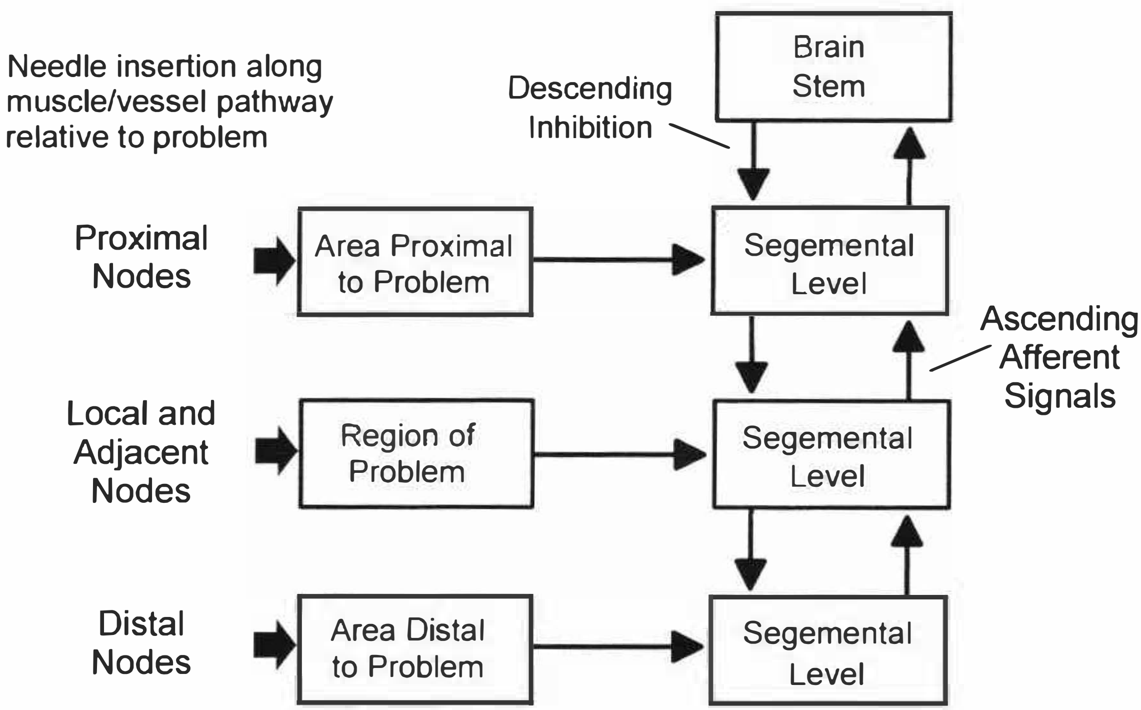


Figure 1.3. Schematic of neurovascular node selection that are local and adjacent (LA) to the problem area that integrate at same spinal nerve level, along with proximal (P) nodes that integrate at the same or higher segmental region, and the distal (D) nodes on the extremity associated with the affected muscle distribution, to direct descending restorative processes.

One interesting approach by the Chinese was to only use neurovascular nodes (acupoints) of the lateral hand and foot distributions in treatment of muscular problems. Part of the reason for this is the fact that the lateral distributions have better distal nodes and also have more tonic type muscles. Another reason for this is that medial and lateral regions of the hand and feet are related in terms of out flowing arteries and return flowing veins and related nerves. The treatment protocols presented in tabular form in Chapters 6 through 17 generally follow this strategy. Early clinical studies indicated that the use of only local and adjacent nodes did not resolve the problem. Adding distal nodes improved clinical results. Maximum clinical effectiveness was only achieved by using local and adjacent, proximal, and distal nodes together (See example of LAPD protocols in Table 1.4).

### *Local and Adjacent Nodes*

Selecting nodes associated with the affected joint simply involve considering those located in or near the region of the problem. These represent the local and adjacent area of the problem that take advantage of the segmental dominance features of the afferent processing system. Basically, afferent nerve signals stimulated by needling the local and adjacent area of the problem distribute to the same spinal region as the pain signals emanating from the local and adjacent area of the presenting problem. This assures that descending control and pain inhibition signals will be directed down to the same area as the presenting problem (See Figure 1.3).[10,CH15;50;51] The restorative effects involve inhibition of pain, reducing inflammation, restoring blood flow the area, normalizing homeostasis, and possibly restoring muscular function. An example for possible candidate local and adjacent neurovascular nodes for a problem affecting the shoulder is provided in Table 1.4. Suggested candidate nodes are based on the actual muscles or the affected joint. The actual nodes selected depend on the specific location of the problem. Four candidate nodes are listed in this example for problems in the anterior lateral aspect of the shoulder involving the anterior medial hand and anterior lateral hand (AMH & ALH) muscle distributions. Four other candidate nodes are listed for problems in the anterior lateral aspect of the shoulder involving the anterior, medial, and posterior lateral hand (ALH, LH & PLH) muscle distributions.

Table 1.4. Candidate regional, proximal and distal nodes for pain and disorders of the shoulder (See Chapter 9 Table 9.4).

| Pain or Disorder of the Shoulder | Candidate Local & Adjacent Nodes | MD* | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Anterior Lateral | Yunmen (AMH 2)<br>Jugu (ALH 16)<br>Jianyu (ALH 15)<br>Jianliao (LH 14) | AMH<br>ALH | Fengchi (LF 20)<br><br>Dazhu (PLF 11)**<br>Feishu (PLF 13) | Hegu (ALH 4) |
| Lateral Posterior | Jugu (ALH 16)<br>Jianliao (LH 14) | ALH | Dazhu (PLF 11)<br>Feishu (PLF 13) | Hegu (ALH 4) |
| | Jianzhen (PLH 9) | LH | Fengchi (LF 20) | Zhongzhu (LH 3) |
| | Naoshu (PLH 10) | PLH | Tianzhu (PLF 10)<br>Jianzhongshu (PLH 15) | Houxi (PLH 3) |

* Muscular distribution
** Add if signs of subscapularis tendonitis or pain

### *Proximal Nodes*

These nodes are selected that are usually at a higher spinal integration site than the local and adjacent nodes selected to address the presenting problem. Proximal nodes are often located on the posterior regions of the lumbar, thoracic, or upper neck depending on the prime location of the problem. These nodes enhance the therapeutic effect of the local and adjacent node or spread the restorative effects to a slightly higher level along the spinal cord. In the case of sacral, lumbar, or thoracic problems, the proximal nodes are represented by the local and adjacent nodes on the back. One possible proximal neurovascular node is listed in Table 1.4 for anterior lateral shoulder problems is Fengchi (LF 20). The subscapularis muscle belongs to the anterior lateral hand (ALH) muscle distribution. Any signs of subscapularis tendonitis or pain can be addressed by adding the nodes Dazhu (PLF 11) and Feishu (PLF 13) even though these nodes are assigned to the posterior lateral foot (PLF) vessel. The anterior lateral hand (ALH) muscle distribution ties into the spine with the rhomboid muscles which include the nodes Dazhu (PLF 11) and Feishu (PLF 13). Needling these two nodes along with other more distal ALF nodes, including either Jianyu (ALH 15) or Jugu (ALH 15), and especially Hegu (ALF 4), will address problem with the subscapularis muscle. Both nodes Dazhu (PLF 11) and Feishu (PLF 13) are appropriate proximal nodes to address problems in the lateral posterior shoulder involving the ALH muscle distribution; the proximal node Fengchi (LF 20) is appropriate for lateral hand (LH) muscle distribution involvement; and both Tianzhu (PLF 10) and Jianzhongshu (PLH 15) are appropriate proximal nodes for the posterior lateral hand (PLH) muscle distribution.

### *Distal Nodes*

These nodes are unique in that they are typically located on the hands or feet which have a high density of afferent sensory nerve fibers. As a consequence, distal nodes provoke strong responses. Distal nodes are selected on the affected extremity associated with the prime longitudinal muscle distribution involved in the presenting problem. Distal nodes may also be selected on adjacent muscle distributions. Some have characterized these nodes as being a window into the entire associated muscular distribution and therefore are essential in treatment approaches. Selection of distal nodes in Table 1.4 for problems affecting the anterior lateral shoulder only involve the anterior lateral hand (ALH) node Hegu (ALH 4) even though the problem may also involve muscles in the anterior medial hand (AMH) muscle distribution. Distal nodes for problems of the lateral posterior shoulder involve: Hegu (ALH 4) for the anterior lateral hand (ALH) muscle distribution; Zhongzhu (LH 3) for the lateral hand (LH) muscle distribution; and Houxi (PLH 3) for the posterior lateral hand (PLH) muscle distribution.

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# 2

# Chinese Muscular Distributions

The most important and unique aspects of Chinese orthopedics involves a systematic approach to treating musculoskeletal problems, once a proper assessment has been completed. This relies on a physiological understanding of the principles of needling therapy including spinal segmental dominance of neurovascular node (acupoint) indications and spinal axial organization. The other aspect of assessment and treatment concerns application of the Chinese longitudinal muscular distributions[a] that are consistent with the neurovascular nodal (acupoint) pathways along the body. Six specific muscle distributions are involved in the articulation of each joint in the extremities. All twelve of the Chinese longitudinal muscle distributions are presented herein including the muscle name, function, origin, insertion, and innervation including appropriate nerve roots. In addition, Chapters 7 through 17 lists all muscles involved in the articulation of each particular joint providing their name, longitudinal muscle distribution identifier, and nerve root. The kinesiology of the muscles is also provided in terms of muscle functions in being prime movers (PM) or associate/assistant/ movers (AM) for each direction of joint movement.

Rational treatment protocols involve selecting candidate nodes related to specific muscle distributions that are: 1) local and adjacent (LA) to the problem that consider spinal segmental dominance; 2) those that are proximal (P) to the problem that take advantage of spinal axial relationships; and 3) distal (D) nodes that may be related to either or both spinal segmental or axial relationships. This treatment approach provides a rational strategy that is based on how the body and spinal afferent processing system is organized. This approach also allows development of rational treatment protocols for needling therapy research. Candidate needling therapy treatment protocols provided in Chapters 6 through 17 is based on LAPD approach.

## View of Pathology

Western orthopedic disease terminology is exclusively applied in Chapters 3 through 17 since this is the world standard used by all other medical practitioners. Furthermore, it is difficult to accurately correlate ancient Chinese descriptions of orthopedic conditions with present day problems. However, it is important to examine some of the Chinese ideas of physiological function or balance which do have a high degree of correspondence with present day understanding. Cause of disease was viewed by the ancient Chinese as a contention between normal physiological function and external factors including atmospheric and climatic conditions, and possible infective agents. Bodily physiological function also includes its normal resistance and recovering capacity. Consequently, the body can tolerate a certain level in the variation of external factors without becoming ill. However, when external factors are excessive, either by magnitude

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[a] Description of the twelve muscular distributions provided in this chapter are derived from the author's original translation of *Treatise 13*: *Longitudinal Muscles* from the *Huangdi Neijing*, *Lingshu* volume.

or duration, the body will mount a strong defensive response. The Chinese considered this to be an external cause disease termed as solid or substantial condition. When physiological function is strong the affected individual should normally recover. If bodily function eventually weakens due to the external assault, the disease may become more serious, and could potentially become fatal.

The Chinese also considered an opposite cause of disease which occurs when external factors are in a normal non-pathogenic level but some aspect of bodily or physiological function may be insufficient. This situation leads to an internal disease condition termed a hollow or empty disorder. Internal insufficiencies could be result of internal organ problems, vascular disease, emotional strain, disturbed vitalities mediated by the endocrine glands, immune and defensive system problems, nutrition, lifestyle, and other conditions. The Chinese considered emotions and vitalities to be an important source of internal disorders.

There is a constant waxing and waning between external factors and internal function, including emotional strain. If this situation persists eventually impairing the body's normal resistance and recovering capacity, it can lead to chronic illness. This is typically noted in orthopedic conditions of chronic pain, arthritis, rheumatism, and other conditions. All humans (and animals) have a sophisticated endogenous control system which provokes the sensation of pain when the skin, tissue, or bones are injured. The pain normally subsides as the injuries heal. However, many people also develop pain and dysfunction without any obvious history of significant injury, overstrain, or trauma. This would indicate possible derangement of some aspect of physiological function. Many orthopedic conditions are also the result of trauma and wear and tear. Properly directed needling therapy is effective in addressing both categories of problems because it facilitates tissue healing, mediates pain relief, restores local blood flow, and restores sympathetic and parasympathetic balance, and hence homeostasis.

## Orthopedic Conditions in the *Neijing*

Some twenty-one treatises of the *Neijing Lingshu* (*LS*) and *Suwen* (*SW*) cover needling therapy and the treatment of orthopedic conditions. The principal cause of pain and other problems for the Chinese mainly related to enviornmental conditions, emotional strain, diet, physical stress, wear and tear, and injury, much as it is in present times. The cause of internal organ and external body pain is described in the *SW 39 Pathogenesis of Pain* including how pain in one region or organ affects another part of the body. A specific discussion on the cause of pain in the muscular system is noted as follows:

"When environmental cold remains in the external region of the vessels (and related nerves and muscles) causing the vessels to be cold, it results in contractions and inability to extend the legs, contractions and inability to extend the legs then causes an acute insufficiency of the vessels. This acute insufficiency results in stretching the small collateral vessels of the muscles resulting sudden pain. This pain can be relieved by slight warming of the area; however, if the cold attacks again the pain can persist for an extended period." (*SW 39*)

From this viewpoint most musculoskeletal problems are considered to be due to environmental and other influences on the superficial and deep vessels, since these structures supply all the oxygen from inhaled air and nutrients to the muscles and joints.

The *Suwen* described additional orthopedic conditions including treatises: *SW 41 Needling for Low Back Pain*; *SW 43 Rheumatism*; and *SW 44 Flaccidity of the Four Limbs*. The *Lingshu* described other conditions including: *LS 27 Circular Rheumatic Pain* (possibly referring to rheumatic fever) and *LS 53 Individual Pain Tolerance*. Cerebral vascular accident (CVA) or stroke was described separately and noted to be the result of major blockage of vessels in the brain.

## Physiological Function

The first Western research into possible internal body balance was provided by the renowned experimental medical researcher Claude Bernard (1813-1878). During post mortem examination he discovered that the internal body conditions appeared normal and showing no signs of disease. He referred to it as the balance of the *milieu interieur* and considered this constancy of the internal environment to be responsible for a free and independent life (Bernard, 1865). The American physiologist Walter B. Cannon (1871-1945) extended Bernard's ideas by introducing the term "homeostasis" to indicate that bodily systems actually have stable feedback control capability to maintain certain functions or parametes at constant values (Cannon, 1914). Homeostasis basically means to control something at the same (homeo) set point (stasis). Control of normal bodily temperature at 98.6° Farenheight is one important example. However, there are some serious conditions in which body temperature exceeds this level; such as in case of illiness or hyperthermia or lower temperature due to hypothermia.

## Homeostasis and Allostasis

Cannon explored the limits of homeostasis in animal research that led him discover that sympathetic splanchnic nerve stimulation of the adrenal medulla released important catecholamine hormones into the blood stream including epinephrine and norepinephrine. Epinephrine increases heart and breathing rate, dilates the bronchi to increase air intake capacity, increases blood flow to the legs, while restricting blood flow to the arms. Cannon described this as the fight-or-flight emergency or defense reaction to allow an animal or human to either escape danger or prepare the body for a life threatening battle. Hans Selye (1936; 1950) coined the term "stress response" to explain the wear and tear strain that causes pain and pathology for humans and animals alike.

Other endocrine glands come into play during this emergency reaction including the pituitary, thyroid, parathyroid, and the endocrine pancreas. Inappropriate activity of the pineal gland also leads to conditions that influence the body's control of pain. The concept of homeostasis denotes stable, but essential, feedback control mechanisms whereas the fight or flight response is a feed-forward unstable response. The feed-forward response is designed to mediate a short duration emergency response, after which the individual can relax and fully recover. However, the structure of so-called civilized societies provides long duration stressful exposures that lead to many problems, especially those that affect the musculoskeletal system resulting in pain and orthopedic conditions.

Concepts of physiological function and regulation considers these feed-forward aspects now referred to as allostasis, meaning *stability through change* first proposed by Sterling and Eyer (1988). The idea of allostasis provides a broader insight into understanding physiology and pathophysiology and the impact on health (Schulkin, 2003; 2004). As it turns out the ancient Chinese already touched on this problem and developed the idea that each main viscera mediated one specific attribute of human vitality (See Table 1.1). Vitalities mediate emotions and are clearly identifiable with the present understanding of the endocrine glands (Kendall, 2002).

## Chinese View of Physiological Function

The ancient Chinese had a clear understanding that some essential component in inhaled air was circulated in the blood vascular system that was critical to sustain life. This has long been verified to be oxygen. They also understood that certain refined substances were circulated in the blood stream. This included nutrients absorbed by the small intestine veins, defensive or immune substances, and substance of vitality that mediate emotions now called hormones (See Figure 2.1). The Chinese were first to note that defensive substances could leave arterial blood circulation to mount a defensive reaction and then be drained back to the subclavian veins by the lymphatic vessels.

The Chinese also described several unique functional aspects including: nerve signals; a concept referred to as ancestral function that included the combined function of the heart and lungs; internal organ function; and first description of true function or energy production which occurs within cellular mitochondria to fuel bodily function, now referred to as cellular metabolism. The anatomical and physiological components of physiological balance are clearly consistent with modern understanding including the ideas of homeostasis and allostasis (See Figure 2.1).

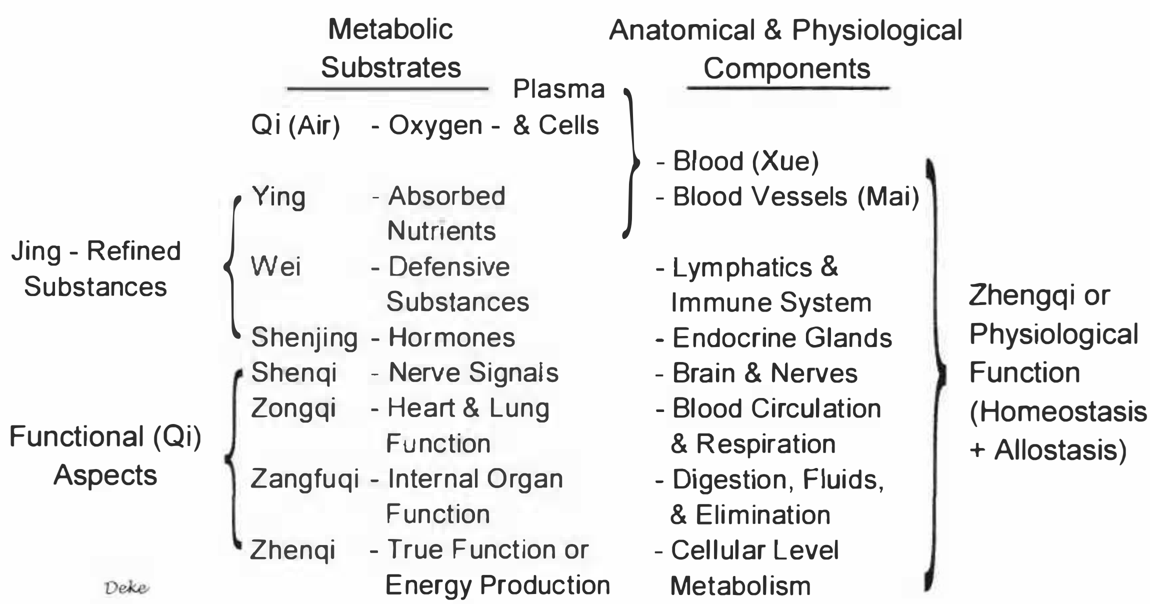



Figure 2.1. Modern view of metabolic, functional, anatomical, and physiological aspects of Chinese concept of physiological function regulated by homeostatic and allostatic means

### Relationships of Organs, Endocrines, and Vitalities

The ancient Chinese were the first to systematically relate the impact of emotions on the internal organ vitalities that lead to certain pathological manifestations (*LS 8*: *Root of Vitality*). The vitalities assigned to each of the five viscera correlate well with the function of the endocrine glands which have a corresponding influence on emotions (See Table 1.1). However, emotions themselves also have an impact on the endocrine glands that lead to many problems. The *LS 8* notes that unresolved fear and dread can result in aching bones, flaccid paralysis, and cold limbs. Fear and dread also impairs functional activity that if not resolved could become fatal. Emotions that impact vitalities were noted to cause damage to prominent muscles and wasting of muscle tissue. If this condition persisted it could put the person at risk of dying early, usually before the age of thirty. The Chinese were also the first to recognize the influence of daily, monthly, and annual time periods on the function of the internal organs and on health that is now referred to as chronobiology. Consistency in daily awake and sleep periods was noted to be essential in maintaining health.

### Impact of Diet on Musculoskeletal System

Since food intake is necessary for growth, development, and to sustain the body, it is obvious that improper intake of certain foods would have an impact on health. The Chinese categorized foods into five flavor or taste groups related to each viscus and thought to dynamically interrelate in terms of the five earth phase relationships (See Table 2.1). Evidence of these relationships has yet to be established. The sour flavor is related to the liver, bitter to the heart, sweet to the pancreas (formerly thought to be the spleen, See Chapter 1), pungent to the lungs, and salty to the kidneys. A neutral flavor is also recognized. Some flavors were avoided in diseases of the muscles, tendons, flesh, and bones. Excess consumption of specific flavors of food and herbs were considered to harm the functional activity of related viscera; causing injury to muscles and tendons resulting in flaccidity, bone related fatigue, and shortening of muscles. Excess consumption of some flavors was considered to have a direct impact on bone pain and musculoskeletal problems. In addition, certain flavors were used to counteract excess consumption of other flavors.

## Longitudinal Muscular Organization

The ancient Chinese carefully identified all the muscles of the human body, correctly noting their origins and insertions. They further noted that muscles are longitudinally organized in a manner similar to the longitudinal vessels that supply the muscles, and related neurovascular nodal (acupoints) pathways. Muscle and tendon distributions are viewed as a linked system starting at the extremities and passing over one particular joint and then continuing up longitudinally to the next muscle and joint in line. Sensitive site locations, propagated sensation pathways, and musculoskeletal pain and dysfunction patterns, are consistent with these distributions. These relationships are mediated by the propriospinal system, and somatovisceral and somatosomatic mechanisms and reflect the organization of the spinal afferent processing system of the body.

Table 2.1. Ancient Chinese view of harm to body by excess consumption of specific flavors viewed in terms of the ancient Chinese 5 phase relationships.

| | Sour | Bitter | Sweet | Pungent | Salty |
|---|---|---|---|---|---|
| 1. Condition that flavor is avoided | Disease of muscles and tendons | Blood disease | Diseases of flesh | Disorders of essential breath | Disease of bones |
| 2. Harm of excess consumption on functional activity | Accumulation of liver fluids and exhaustion of pancreas functional activity | Failure of pancreas to moisten, impairing stomach function, causing it to thicken | Shortness of breath, heart fullness with dark complexion, and imbalance of kidney functional activity | Injures muscles and tendons causing flaccidity, and depletion of endocrine gland hormones | Bone related fatigue and shortening of the muscles, restraining of heart function |
| 3. Effect of excess consumption | Thickening of flesh and protrusion of lips | Withering of skin and body hair to fall out | Pain in bones and falling out of hair on head | Cramps in tendons and muscles and withering of finger and toe nails | Stiffening of blood vessels and change in their color |
| 4. Flavors used to counteract excess consumption | Pungent, except when liver disease present | Salty, except when heart disease present | Sour, except when pancreas disease present | Bitter, except when lung disease present | Sweet, except when kidney disease present |

In the Chinese anatomical and physiological view, muscles are organized in longitudinal distributions patterns in the same twelve anatomical body regions as their related distribution vessels (See Table 1.2 and Figure 1.2). Unlike the vessels, muscles do not make physical connections with the internal organs, with the possible exception of the diaphragm. Muscles can however, develop spasm, cramps, and pain as result organ problems. The Chinese considered muscles to represent the external body. Most musculoskeletal problems are usually external disorders, unless an internal organ is the primary source of the problem, or if diet and emotions are the main cause of the problem. Description of the twelve muscular distributions demonstrates a sophisticated understanding of the muscular system. Muscles are supplied by specific longitudinal distribution vessels and nerves associated with each longitudinal regions of the body. Propagated sensation stimulated by needling travels along the superficial muscular and vessel pathways.

Furthermore, development of sensitive locations due to musculoskeletal pathology, usually distribute along these same muscular pathways. Sensitive sites can reflect organ pathology as well. Palpation of sensitive sites is normally a part of the examination process. This routine is repeated each time the patient returns for further treatment, and disappearance of sensitive locations, indicate how well the treatment is proceeding. Sensitive sites (ahshi nodes) were first investigated in the West by the Huneke brothers in 1928 where they developed a technique of injecting these areas with local anesthetics. They called this practice “neural therapy” and a variation of the technique is referred to as “trigger point” therapy (Huneke; Travell; Baldry; Dosch).

## Aspects of Muscular Control

Voluntary control of the striated skeletal muscles is mainly accomplished by signals originating in the motor cortex of the brain mediated by upper motor neurons that distribute to various segmental levels on the opposite side of the spinal cord. Here they synapse on lower motor neurons. The basal ganglia and cerebellum have important roles related to providing signals to make the control of muscles and coordination a smooth process. Problems in the basal ganglia system include Parkinson's disease and other movement anomalies. The basal ganglia are influenced by and participate in responses to needling therapy. Motor control relies on afferent feedback signals from the periphery associated with the lower motor neurons that provide information on load, position and acceleration, which are operative at the spinal segmental and brain levels.

## Proprioceptive Involvement

Lower motor neurons require a feedback servo signal from the muscle tissue involving afferent muscle spindles signals and efferent input via the gamma motor nerve control loop. Voluntary signals from upper motor neurons have no effect in contracting the target peripheral muscle unless there is a corresponding proprioceptive input from the target muscle. This system provides a feedback control system to assure smooth, precise, controlled, and safe contraction of the skeletal muscles. This system normally prevents individuals from picking up excess loads or trying to put force on a structure when the angular conditions at the particular joint are not proper.

Perhaps the most important aspect of the proprioceptive system is the mediation of spinal reflexes that affect the target muscle at its specific spinal segmental level. However, the afferent proprioceptive signals provide input to the propriospinal system involving long and short neural loops in the spinal cord. These nerve fibers send proprioceptive information to various muscles throughout the entire body, including to the opposite side, in order to respond to ongoing conditions of normal and emergency responses. Typical responses produce ipsilateral flexion of one limb and contralateral extension of the limb on the opposite side of the body. Some propriospinal reflexes affect the ipsilateral leg and the contralateral arm, and vise versa. Proprioceptive responses can also provoke autonomic reflexes as well.

## Propriospinal Communication

Most essential to Chinese treatment modalities, especially needling therapy is that the propriospinal system provides the primary neural communication pathway to send spinal cord dorsal root reflexes (DRR) to various parts of the body that participate in mediating autonomic and somatic homeostasis. The net effect of this is to restore blood flow, reduce muscle spasms, normalize visceral function, and reduce pain. If threshold conditions are proper a propagated sensation (PS) can be experienced in some individuals that travels along the vessel nodal path and muscular distribution. Group II static load muscle spindle fibers are the responsible for mediating this phenomena. The group II muscle spindles are affected by local pressure and temperature and hence environmental conditions have a direct impact on orthopedic conditions. Both lower temperatures and mechanical pressure can inhibit the group II fibers while the opposite conditions of lower atmospheric pressure and higher ambient temperatures can enhance their participation. Surgical procedures and injuries that produce scars across nodal pathways and muscular distributions can potentially impair the normal communication of the proprioceptive system that leads weakness, muscular dysfunction, and pain.

The organization of the spinal afferent processing system, including the propriospinal system, also provides the mechanisms to mediate important reflex phenomena. Some of these reflexes are mediated at or near the same segmental level that contains the structures involved. This is much the case for deep tendon reflexes. Other reflexes involve the participation of higher levels of the CNS and therefore can be used in conjunction with the tendon reflexes to help isolate a problem, such as determining if an upper or lower motor neuron was involved in the problem.

Several well known and applied deep tendon reflexes have been in use for some time, even including by the ancient Chinese. One involving the mandible is used to determine proper supply to the temporalis muscle by the 5th cranial nerve motor fibers. Other deep tendon reflexes involve both the brachial plexus (See Table 3.7) and the plexuses of the low back (See Table 3.8). Deep tendon muscle reflexes that are below normal indicate possible problems affecting lower motor neurons. Hyperactive deep tendon reflexes indicate possible involvement of upper motor neurons.

## Needling Mechanisms

Present research into the role of the spinal afferent processing and propriospinal neural systems in needling stimulated reactions and viscerosomatic relationships are now beginning to provide a clear understanding of the physiological means to explain how needling the superficial body brings about beneficial and restorative processes (Kendall 2002, CH 14). Initiating and sustaining these reactions require participation of both vascular and neural components at the site of needle insertion. Furthermore, many indications for nodal sites display somatotopically organized somatovisceral relationships. Basically, indications for nodal sites are mostly related to the spinal level where their local afferent fibers distribute and integrate with visceral afferents at the same spinal cord segment.

### Initial Response to Needling

The critical feature of neurovascular nodes is the synergistic way the vascular and neural components interact. Needle insertion causes production of bradykinin via blood coagulation tissue reactions which stimulates the substance P containing afferent Aδ nociceptive fibers that activate local, spinal and brainstem restorative processes. The initial needling response is sustained by an axon reflex of the Aδ fibers by releasing substance P directly on the capillary bed associated with the tissue that is damaged by the inserted needle. The tissue reaction also produces immune complement C3 which activates the immune complement system alternative pathway, which in turn causes degranulation of mass cells in the local tissue and their plasma counterpart, the basophils, attracted to the site affected by the needle micro trauma.

Kinin protease produced in these reactions serves to stimulate the tissue response to preferentially produce more bradykinin which then further sustains the initial activation of the Aδ fibers. The local vascular structures also participate in the needling reaction processes to enhance outflow of immune cells that participate in the initial reaction as well as in the restorative processes. If the Aδ nociceptive fibers are inhibited, the needling reaction cannot be sustained. The somatic Aδ afferent fibers converge with visceral afferents in the spinal dorsal horn to form somatovisceral connections, and also stimulate the spinal afferent processing system which ultimately results in descending control signals from the brainstem back to the same spinal cord level that provided the afferent signals.

Needling also activates the proprioceptive group II static load muscle spindle fibers that bring the propriospinal system into play. When threshold conditions permit the patient may feel a propagation sensation (PS) of an electrical type nature along the nodal pathway represented by an organ-related distribution vessel. This PS travels from node to node and seems to follow along the line that results from connecting the nodal location for any one distribution vessel. Most individuals can feel the PS over one or two nodes, while the rare sensitive responders can feel the signal traverse along the entire nodal pathway and many collateral branches. The propriospinal system is activated by needling even though the subject does not consciously feel the PS.

## Directing Descending Control

Purpose of the PS signal is to activate many reflex responses, which can be remote to the needling site, mainly involving the muscular system. The other role of PS is to direct the descending control signals, from the brainstem via the dorsolateral funiculus of the cord. to the correct spinal segmental levels to provide restorative effect. Descending control signals to the spinal cord results in: inhibition of nociceptive fibers (pain signals); restoration of blood flow and vascular tone in the periphery and in the viscera; relaxation of residual muscular tension (antispasmodic feature); restoration of visceral homeostasis; and control features of tissues responses to needling that enhances immune responses and promotes tissue healing.

## Somatotopic Indications

The indications and use of nodal sites are related to their local area of influence on the body as well as relationships to muscle and vessel distributions and the internal organs. Nodes also have influence on the underlying related vessels in the peripheral regions of the arms and legs as well as other regions of the face, hands, feet and the auricle. Thus many nodes in these areas have unique capabilities and some located below the elbows or knees are considered to be special communication nodes. The historic indications for nodes are based on their characteristics and location and are grouped as follows:

1. Indications involving vascular, circulatory, musculoskeletal, pain disorders, skin, tissue or sensory organ problems, related to the node's physical location in relation to regional anatomic features and the particular distribution vessel that supplies the region.
2. Conditions involving pain and dysfunction in some portion of the muscular distribution pathway to which the node and vessel belong, even though the problem is remote (either distal or proximal) to the selected node.
3. Physiological effects, including the influence of vessel relationships, on one or more organ systems due to the node's relation to specific spinal segmental levels (or brain stem) that converge with corresponding afferent signals from the related viscera.

4. Special known effects for certain nodes or conditions treated due to unique communication pathways or relationships to the specific node.

Since muscular and visceral problems can often be viewed as a general category, it is helpful to consider these indications separately from each other. This makes the task of understanding the use of neurovascular nodes easier. Nodes of each distribution vessel can be viewed separately with respect to their internal and musculoskeletal indications. Visceral related indication show a good correspondence with the node location and its potential influence on autonomic systems related to or mediating at the same spinal cord segmental level or brainstem area. Musculoskeletal indications show a clear relationship between the node and the underlying muscles and structure. These somatovisceral and somatosomatic relationships hold true for all regions of the body including the face, trunk, upper extremities, and lower extremities. Indications for some nodes show distal effect that corresponds to an area of the body that is remote to the node in question. This indicates the involvement of neural communication that is mediated by the spinal afferent processing system, perhaps involving the propriospinal system.

## Longitudinal Distribution of Muscles

Each specific longitudinal muscular distribution is served, both in terms of blood circulation and neural innervation, by one of the twelve longitudinal distribution vessels. The muscular pathways described in the *LS 13* represent a clear depiction of all of the skeletal muscles in the body. Some of these are identified by specific Chinese names for the gastrocnemius, quadriceps, and sternocleidomastoid muscles, and the diaphragm. Other muscles are accurately described throughout the body including the temporalis, occipitalis, frontalis, pectoralis, deltoids, and trapezius. Location of particular muscles and their area of insertion and origin are anatomically correct.

However, many of the muscles are only mentioned by their travel routes, insertion site, and their origins. The ancients did not make the subtle distinction between the insertion and origin related to place of attachment and area of action. They simply called all the major sites of tendon and muscular attachment as either insertion, knotting, or tying locations. This method of describing muscles is not unusual since the practice of naming each specific muscle in the body did not come into use until the 19th century. The presently understood Western name of each muscle is provided in the following paragraphs for each of the twelve longitudinal body regions (See Figure 1.2) of the upper and lower extremities.

The muscular system, comprised mostly of muscle tissue, has several unique features aside from the function of moving the body. First, many muscles have different capabilities to perform their specific function, related to the speed of the muscle and its inherent strength. It is now known that muscles are composed of different types of tissue fibers to mediate their respective functions (Table 3.3). The ancient Chinese may have appreciated the subtle differences between the muscles, borne out by the fact that nodal sites in muscles are usually found in the slower muscles, and are not found in fast muscles.

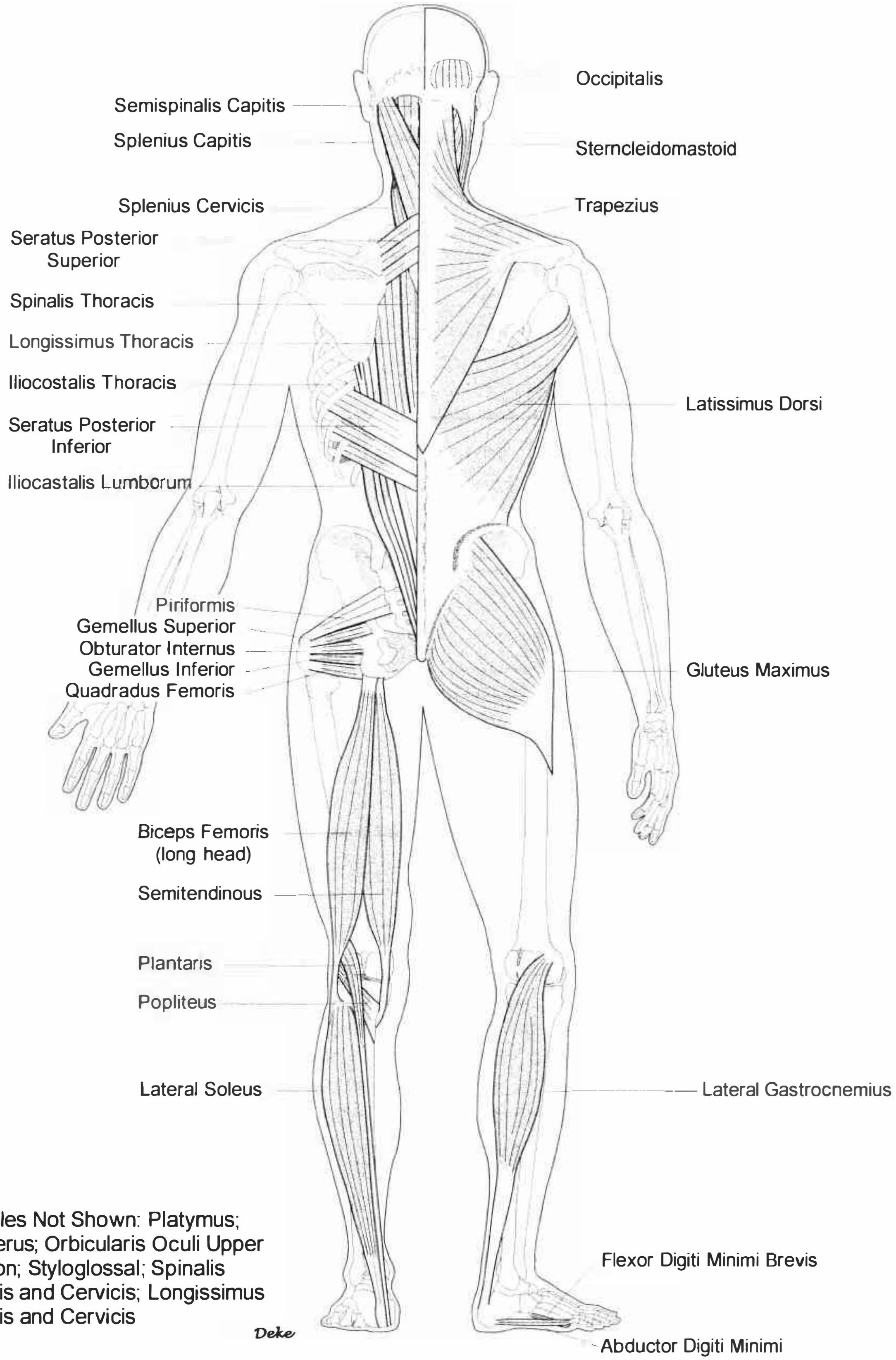
Muscles are arranged in longitudinal pathways, and sensitive sites within these routes are useful for diagnosis and assessment of treatment. Temperature and color variations in the cutaneous regions that overlie the muscle and vessel distribution pathways are also useful for diagnosis. The related pathology reflected along each distribution is provided along with the description of the muscular distributions. Treatment strategies were also provided for each longitudinal muscle distribution that indicated the use of a preheated needle. It is known that needles were sharpened and heated prior to treatment. It is not understood if the heating was a prophylactic process or not, but the needles had to be cooled before insertion into patients.

## Posterior Lateral Foot (PLF) Muscles

Muscles and related tendons belonging to the posterior lateral lower extremity generally follow along the course of the distribution vessel neurovascular nodes pathways assigned to the Chinese PLF anatomical division of the body (See Figure 2.2 and Table 2.2a and 2.2b) as follow: The PLF muscular distribution starts at the small toe including the flexor digiti minimi brevis ($5^{th}$ toe) and abductor minimi digiti and ties into the ankle (calcaneus bone). From here the pathway deflects upward with the lateral soleus tying into the posterior aspect of the knee (upper shaft of fibula). Another muscular pathway distributed from the heel ties into the calcaneus and travels upward accompanying the former muscle (lateral soleus) as the plantaris to tie into the back of the knee (lateral condyle of femur). The plantaris overlies the popliteus muscle which is not mentioned. (*LS 13*)

Another branch from the lateral aspect of the heel forms the specifically named lateral gastrocnemius muscle traveling above to the popliteal fossa (lateral condyle of femur). From above the medial aspect of the popliteal fossa and former pathway on the lateral popliteal fossa, the (PLF) muscular pathway distributes upward as the biceps femoris long head and semitendinosus muscles tying into the buttocks (ischial tuberosity). Starting from the ischial tuberosity this distribution includes the lateral hip rotators to include the gemellus inferior, gemellus superior, quadratus femoris, obturator internus, and piriformis and muscles. The buttocks include the gluteus maximus muscles that overlie the lateral hip rotators. (*LS 13*)

The PLF muscle distribution continues from the gluteus maximus to travel up each side of the spine with the erector spinae muscles including: iliocostalis lumborum, thoracis and cervicis; longissimus thoracis, cervicis and capitis; and spinalis thoracis, cervicis and capitis to the nape of the neck. Here a branch enters into the root of the tongue to include the styloglossal muscle. Also included are the serratus posterior superior and inferior muscles. The distribution continues up the neck with the semispinalis capitis, splenius capitis, splenius cervicis, longissimus capitis, and trapezius, to insert into the occipital bone. As the distribution continues over the head in includes the occipitalis and galea aponeurotica, and then descends to the nose with the procerus muscle. Another branch enters below the axilla with the latissimus dorsi and then from the supraclavicular fossa the distribution travels above to tie into the mastoid process with the sternocleidomastoid. Another branch travels out from the supraclavicular fossa slantingly upward toward the lower border of the zygoma with the platysma. (*LS 13*)




Muscles Not Shown: Platymus; Procerus; Orbicularis Oculi Upper Portion; Styloglossal; Spinalis Capitis and Cervicis; Longissimus Capitis and Cervicis

Figure 2.2. Muscles of the posterior lateral foot (PLF) longitudinal body region

Table 2.2a. Muscles of the posterior lateral foot (PLF) longitudinal distribution

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Procerus | Draws skin of forehead down | Bridge of nose | Skin over root of nose | Facial CN VII |
| Orbicularis oculi, upper orbital and palpebral part | Closes eyelid | Medial aspect of maxillary and frontal bones and medial palpebral ligament | Encircles upper orbit and pass across eyelid to form lateral palpebral raphe | Facial CN VII |
| Platysma | Depresses jaw and lower lip; wrinkles skin of neck and chest | Acromion, clavicle and fascia over deltoid and pectoralis major | Lower border of mandible, risorius and opposite platysma | Facial, cervical branch CN VII |
| Occipitalis | Draws scalp back | Occipital bone and mastoid part of temporal bone | Galea aponeurotica | Facial CN VII |
| Sternocleido-mastoid | One side rotates head to opposite side; both sides depresses head | Consist of two heads, one from sternum and other from clavicle | Mastoid process and lateral part of superior curved line of occipital bone | Spinal accessory CN XI; C1, 2, 3 |
| Trapezius | Raises and pulls Shoulder back; rotates scapula; extends or draws head to one side | Occipital bone; nuchal ligament; spinous processes of 7th cervical to 12th thoracic vertebrae | Acromion, scapular spine and lateral third of clavicle | Spinal accessory CN XI; C2, 3, 4 (upper, middle, & lower fibers) |
| Styloglossal | Pulls tongue backward and upward | Styloid process of temporal bone | Sides of tongue | Hypoglossal CN XII |
| Splenius capitis | One side turns head to same side; both sides extend head | Lower half of nuchal ligament; 7th cervical and first three thoracic vertebrae | Occipital bone; mastoid process of temporal bone | Branches of dorsal rami of middle cervical spinal nerves C4, 5, 6 |
| Splenius cervicis | Rotates and extends head and neck | Spines of 3rd to 6th thoracic vertebrae | Transverse process of 1st and 2nd cervical vertebrae | Branches of dorsal rami of cervical C6, 7, 8 |
| Semispinalis capitis | Rotates and draws head backwards | Transverse processes of lower four cervical and upper six thoracic vertebrae | Occipital bone, between the inferior and superior curved line | Branches of dorsal rami of cervical spinal nerves C1 - 5 |
| Latissimus dorsi | Adducts, extends, rotates arm medially; raises trunk and pelvis | Posterior crest of ilium, spinous processes of lower 6 thoracic and lumbar vertebrae, and outer part of last 4 ribs | Bicipital groove of the humerus | Thoracodorsal C6, 7, 8 |
| Serratus posterior superior | Elevates the ribs | Spines of 7th cervical and 2 upper thoracic vertebrae | Angles of 2nd to 5th ribs | Branches of ventral rami of thoracic T1 - 4 |
| Serratus posterior inferior | Draws ribs back and down | Spines of lower 2 thoracic and 2 upper lumbar vertebra | Lower 4 ribs | Branches of ventral rami of thoracic T9 - 12 |
| Spinalis capitis | Extends head, or turns head slightly to one side | Spinous processes of 7th cervical and upper thoracic vertebrae | Occipital bone | Dorsal rami of cervical and thoracic spinal C6, 7, 8 |
| Spinalis cervicis | Extends cervical spine | Spinous processes of 7th cervical and upper 2 thoracic vertebrae | Spinous process of axis | Dorsal rami of cervical and thoracic spinal C6, 7, 8 |
| Spinalis thoracis | Unilateral flexion of spine; bilateral extension and hyperextension of vertebral column | Spinous processes of thoracic vertebrae T10, 11, 12 and lumbar vertebrae L1, 2 | Spines of thoracic vertebrae T3 to 8, (9) | Posterior rami of thoracic nerves T4 - 12 |
| Longissimus capitis | Keeps head erect, extends head, or draws back to same side | Transverse processes of lower cervical and upper 4 or 5 thoracic vertebrae | Mastoid process of temporal bone | Dorsal rami of lower cervical spinal C6, 7, 8 |

Table 2.2b. Muscles of the posterior lateral foot (PLF) longitudinal body region (continued).

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Semispinalis cervicis | Bilateral extension and hyperextension of cervical spine; unilateral flexion of the neck and head | Transverse processes of 1st to 6th, articular processes of 4th to 7th cervical vertebrae | spinous processes of 2nd to 5th cervical vertebrae | Posterior rami of cervical nerves C3, 4, 5, 6 |
| Semispinalis thoracis | Extends spine and rotates it toward opposite side | Transverse process of 6th to 10th thoracic vertebrae | Spinous process of 1st to 4th thoracic and 6th-7th cervical vertebrae | Posterior rami of thoracic nerves T1 to 6 |
| Longissimus cervicis | Unilateral flexion of neck; bilateral extension and hypertension of neck | Transverse processes of 1st to 4th, & sometimes 5th thoracic vertebrae | Transverse processes of 2nd to 6th cervical vertebrae and thoracic | Dorsal rami of lower cervical C6, 7, 8 |
| Longissimus thoracis | Extends spinal column | Transverse processes of lumbar vertebrae and Thoracolumbar fascia | Transverse processes of thoracic vertebrae and lower 9 to 10 ribs | Dorsal rami of thoracic and lumbar spinal T4 to L3 |
| Iliocostalis cervicis | Extends cervical spine | Angles of 3rd to 6th ribs | Transverse processes of 4th to 6th cervical vertebrae | Dorsal rami of cervical spinal C6, 7, 8 |
| Iliocostalis thoracis | Keeps dorsal spine erect | Angles of 7th to 12th ribs | 1st to 6th ribs and 7th cervical vertebra | Dorsal rami of thoracic spinal T1 to 6 |
| Iliocostalis lumborum | Bilateral extension and hyperextension of spine; unilateral flexion of spine | Broad tendon from sacrum, lumbar vertebrae spinous processes, and inner lip of iliac crest | Angles of 6th to 12th ribs | Branches of thoracic and lumbar spinal T5 to L3 |
| Gluteus max. Upper fibers Lower fibers | Extends and rotates thigh | Superior curved iliac line and crest, sacrum and coccyx | Iliotibial tract and femur below the greater trochanter | Inferior gluteal L5, S1, 2 |
| Piriformis | Abducts and rotates thigh outward | Great sacrosciatic notch of ilium and margins of anterior sacral foramina | Upper margin of greater trochanter | Branch of sacral L(5), S1, S2 |
| Obturator internus | Rotates thigh outward | Pubis, ischium, obturator foramen | Inner surface of greater trochanter | Sacral plexus L5, S1, 2 |
| Quadratus femoris | Rotates thigh outward | Ischial tuberosity | Intertrochanteric ridge | Sciatic L4, 5, S1 |
| Gemellus superior | Rotates thigh outward | Ischial spine | Greater trochanter | Sacral plexus L5, S1, 2 |
| Gemellus inferior | Rotates thigh outward | Ischial tuberosity | Greater trochanter | Sacral L4, 5, S1 |
| Biceps femoris (Long head) | Flexes knee and rotates knee outward | Ischial tuberosity | Lateral condyle of tibia and head of fibula | Tibial portion of sciatic L5, S1, 2 |
| Semitendinosus | Extends thigh; flexes and rotates leg | Ischial tuberosity | On shaft of tibia below internal tuberosity | Tibial portion of sciatic L5, S1, 2 |
| Popliteus | Rotates tibia medially or femur laterally | Lateral condyle of femur | Posterior surface of tibial shaft | Tibial L4, 5, S1 |
| Gastrocnemius (Lateral head) | Plantar flexes foot and flexes leg | Lateral condyle of femur | Tendo calcaneus | Tibial S1, 2 |
| Plantaris | Plantar flexes foot | Lateral condyle of femur | Calcaneus | Tibial L4, 5; S1 |
| Lateral Soleus | Plantar flexes and rotates foot | Upper shaft of fibula | Tendo calcaneus | Tibial L5, S1, 2 |
| Abductor digiti minimi | Abducts little toe | Lateral tuberosity of calcaneus; plantar fascia | Lateral side of 1st phalange of little toe | Lateral plantar S1, 2 |
| Flexor digiti minimi brevis | Flexes little toe | Base of 5th metatarsal and sheath of peroneus longus | Lateral side of 1st phalange of little toe | External plantar S1, 2 |

### PLF Muscle Pathology

When the posterior lateral foot (PLF) longitudinal muscular distribution pathway is disordered it will result in pain and swelling in the small toe and the region of the heel, contractions in the back of the knee, abnormal curvature in the back, muscular spasms in the nape of the neck, inability to raise the shoulders due to pain, cramp like pain in the axilla extending to the supraclavicular fossa, and inability to turn the upper body to the left or to the right. (*LS 13*)

### PLF Treatment Strategies

To treat the above disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes and locations along the PLF muscular pathways. Symptoms associated with this muscular distribution are called "midspring" rheumatism. (*LS 13*)

## Posterior Medial Foot (PMF) Muscles

Muscles and related tendons belonging to the posterior medial lower extremity generally follow along the course of the distribution vessel neurovascular node pathway assigned to the PMF longitudinal body region. The longitudinal distribution of the muscles and related tendons belonging to the posterior medial lower extremity starts below the small toe with the flexor digitorum brevis, plantar interosseous, and lumbricals (See Figure 2.3 and Table 2.3a and 2.3b). It then includes the quadratus plantae, adductor hallucis, flexor hallucis brevis, and abductor digiti minimi muscles. From the calcaneous, this distribution continues up the medial leg with the medial soleus and medial gastrocnemius, to insert above at the medial aspect of the fibula. It then follows up along the thigh with the semimembranosus, adductor magnus, adductor longus and adductor brevis muscles. (*LS 13*)

From here it travels to region of the sexual organ to include the deep transverse perineal and iliococcygeus muscles, and then follows along the inner aspect of the spine with the coccygeus and quadratus lumborum muscles. Continuing up each side of the back bone this distribution includes the transversospinal group of muscles including the semispinalis cervicis and thoracis; rotatores thoracis; levatores costarum brevis and longi; intertransversarii; and multifidi muscles. It then travels up to the nape of the neck with the obliquus capitis inferior, obliquus capitis superior; rectus capitis posterior major and minor; longus colli, longus capitis; and rectus capitis anterior and rectus capitis lateralis muscles. (*LS 13*)

### PMF Muscle Pathology

Disease manifestations of the PMF longitudinal muscular pathways include acute cramps in the bottom of the feet as well as pain and cramps at the major insertion sites for these muscles (ankle, heel, knee, pubic region, back and nape of neck). Diseases specifically associated with this muscular distribution include epilepsy, alternating contraction and relaxation of the limbs leading to tetanus or convulsions. (*LS 13*)

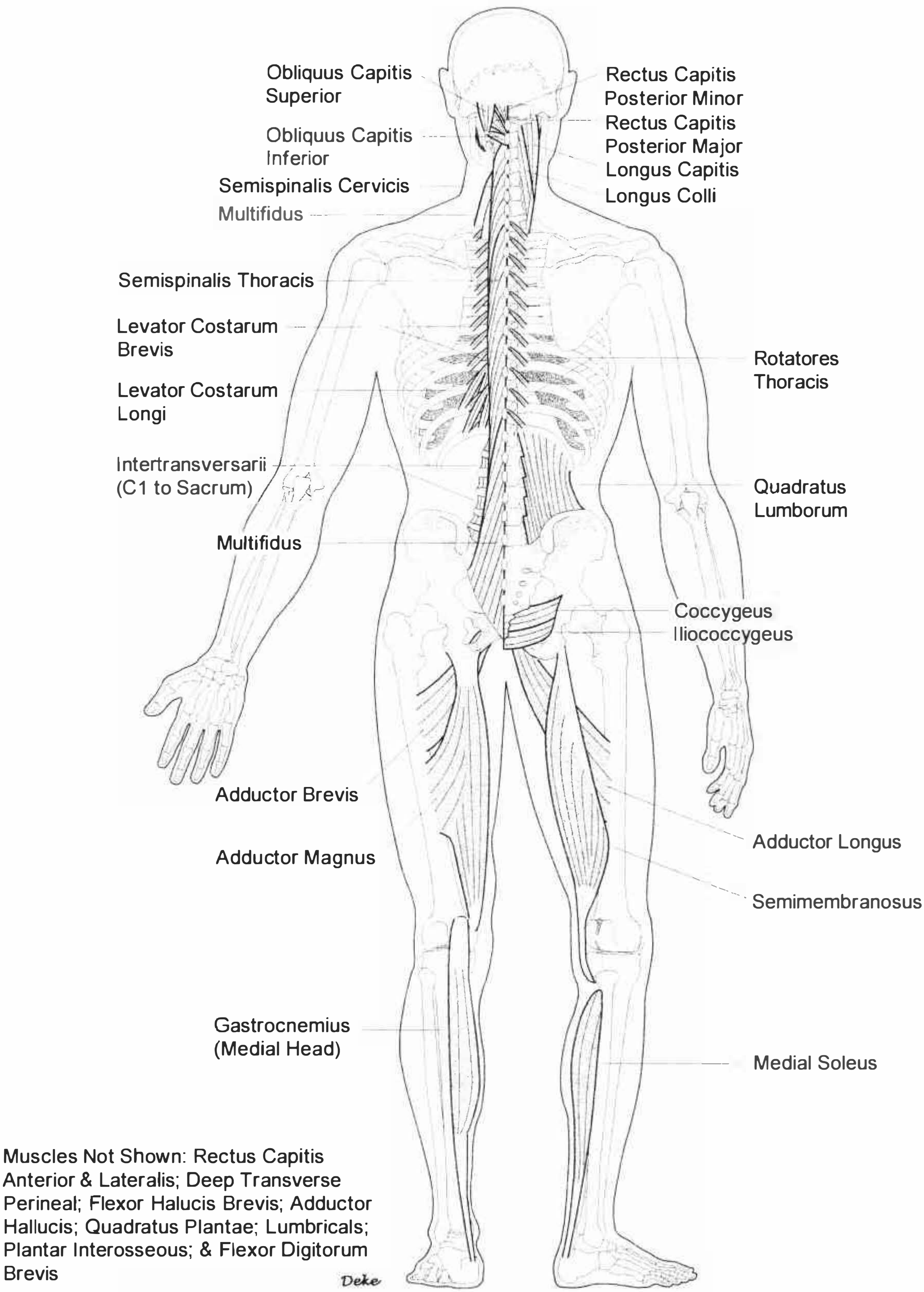



Figure 2.3. Muscles of the posterior medial foot (PMF) longitudinal body region

Table 2.3a. Muscles of the posterior medial foot (PMF) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Longus colli cervicis | Rotates and bends neck forward | Transverse processes of 3rd to 5th cervical vertebrae | Anterior atlas; body of 2nd to 4th and transverse processes of 5th & 6th cervical vertebrae | Branches of 2nd to 7th cervical nerves C2 - 7 |
| Longus capitis | Flexes head | Transverse processes of 3rd to 6th cervical vertebrae | Occipital bone; basilar process | Branches of 1st to 3rd cervical nerves C1, 2, 3 |
| Rectus capitis anterior | Rotates and inclines head | Base of atlas | Occipital bone; basilar process | Between 1st and 2nd cervical nerves C1, 2 |
| Rectus capitis lateralis | Supports head; inclines head laterally | Transverse processes of atlas | Occipital bone jugular process | Between 1st and 2nd cervical nerves C1, 2 |
| Rectus capitis posterior minor | Extends head | Posterior tubercle of atlas | Occipital bone | Suboccipital nerve, dorsal rami of C1; C1, 2 |
| Rectus capitis posterior major | Extends head, rotates to same side | Spinous process of axis | Occipital bone | Suboccipital nerve, dorsal rami of C1; C1, 2 |
| Obliquus capitis superior | Extends head, flexes toward same side | Transverse processes of atlas | Occipital bone | Suboccipital nerve, dorsal rami of C1; C1, 2 |
| Obliquus capitis inferior | Turns face toward same side | Spinous process of axis | Transverse processes of atlas | Suboccipital nerve, dorsal rami of C1; C1, 2 |
| Interspinales: cervical, thoracic, & lumbar | Extend neck and trunk | Upper border of spinous process (C3 to scarum) | Lower border of spinous process above (C2 to L5) | Dorsal primary rami of spinal nerves C2 – 8; T1 – 12; L1 - 5 |
| Rotatores: cervical, thoracic, & lumbar | Rotates & extends vertebral column to opposite side | Transverse processes of 3rd cervical to sacrum | Lamina of next vertebrae above | Dorsal rami of spinal C2 – 8; T1 – 12; L1 - 5 |
| Levatores costarum brevis | Raises ribs and flexes vertebral column | Transverse processes of 7th cervical to 11th thoracic vertebrae | Rib next below | Ventral and dorsal rami of spinal T1 - 6 |
| Levatores costarum longi | Raises lower ribs and flexes vertebral column | Transverse processes of 9th and 10th thoracic vertebrae | Second rib next below | Ventral and dorsal rami of spinal T6 - 10 |
| Intertransversarii: cervical, thoracic, & lumbar | Laterally bends neck and trunk | Transverse processes of vertebral column | To next transverse process below, from C1 to sacrum | Ventral and dorsal rami of spinal C2 – 8; T1 – 12; L1 - 5 |
| Multifidus: cervical, thoracic, & lumbar | Rotates spinal column | Iliac spine; sacrum; thoracic and cervical vertebrae | Laminae and spinous process of next 4 vertebrae above | Dorsal rami of spinal C2 - 8; T1 - 12; L1 - 5 |
| Quadratus lumborum | Flexes trunk laterally and forward | Iliac crest, iliolumbar ligament, lower lumbar vertebrae | Upper lumbar vertebrae and 12th rib | Branches of 12th thoracic and 1st lumbar T12 - L3 |
| Coccygeus | Supports coccyx, closes pelvic outlet | Sacrospinous ligament and ischial spine | Lower part of sacrum and coccyx | 3rd and 4th sacral S3, 4 |
| Iliococcygeus | Supports pelvic floor | Pelvic fascia, ischial spine | Rectum, coccyx and fibrous raphe of perineum | Sacral and perineal S3, 4 |
| Deep transverse perineal | Helps expel urine in females and urine and semen in males | Ischial rami | Central tendon of perineum | Perineal branch of pudendal |
| Adductor brevis | Adducts and flexes thigh | Inferior ramis of pubis | Upper part of linea aspera of femur | Branch of obturator L2, 3, 4 |
| Adductor longus | Adducts and flexes thigh | Pubic crest | Middle of linea aspera of femur | Branch of obturator L2, 3, 4 |
| Adductor magnus upper & lower | Adducts thigh and rotates it outward | Ischiopubic ramus; ischial tuberosity | Medial condyle and linea aspera of femu | Branch of obturator and sciatic L2 - 5, S1 |

Table 2.3b. Muscles of the posterior medial foot (PMF) longitudinal distribution (continued)

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Semimembranosus | Extends thigh or trunk; flexes leg | Ischial tuberosity | Medial condyle of femur | Tibial L5, S1, 2 |
| Soleus (medial portion) | Plantar flexes and rotates foot | Oblique line of tibia and upper fibula | Tendo calcaneus | Tibial L5, S1, 2 |
| Gastrocnemius (Medial head) | Plantar flexes foot and flexes leg | Medial condyle of femur | Tendo calcaneus | Tibial S1, 2 |
| Flexor hallucis brevis | Flexes big toe | Cuboid; 3rd cuneiform | Base of big toe proximal phalanx | Medial plantar L4, 5, S1 |
| Adductor hallucis | Adducts big toe | Tarsal terminations of middle metatarsal bones | Base of big toe 1st phalanx | Lateral plantar S1, 2 |
| Quadratus plantae | Assists in flexing toes | Inferior os calsis by 2 heads at inner and outer borders | Tendons of flexor digitorum longus | Lateral plantar S1, 2 |
| Lumbricals | Flex 1st and extend 2nd and 3rd phalanges | Tendons of flexor digitorum longus | First phalanx of extensor tendon | External and internal plantar L4, 5 (1st) S1, S2 (2nd-4th) |
| Plantar interossei | Adduct 3 outer toes | 3rd, 4th and 5th metatarsal bones | First phalanx of corresponding toe | External plantar S1, 2 |
| Flexor digitorum brevis | Flexes toes at proximal interphalangeal joint | Medial tuberosity of calcaneus; plantar fascia | Middle phalange of 4 lateral toes | Medial plantar L4. 5, S1 |

If the (PMF) disorders involve the more superficial muscles in the back, the patient will be unable to bend forward. If it involves the deeper muscles in the back, the patient will be unable to bend their heads backwards. Hence, a more superficial PLF type disorder will cause abnormal curvature in the lumbar region due to contraction of superficial muscles, resulting in inability to bend forward. If it is a deeper PMF type disorder, it will result in the inability to bend backwards due to contraction of the deeper muscles. Symptoms associated with this muscular distribution are called "midautumn" rheumatism. (*LS 13*)

### *PMF Treatment Strategies*

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes along these muscular pathways. If disorders of the PMF muscular distribution occur internally (deeper muscles of the back), they can be relieved by stretching exercises and consuming herbal remedies. However, if the present muscles are in contraction and seized, and the seized component is a very dominant feature (such as with tetanus) the disease is considered incurable. (*LS 13*)

## Anterior Lateral Foot (ALF) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the anterior lateral lower extremity (ALF) starts in the region surrounding the third toe to include the 2nd and 3rd dorsal interosseous muscles (Figures 2.4 and 2.5, and Table 2.4a and b ). It then inserts into the dorsum of the foot with the extensor hallucis brevis muscles continuing up leg with the extensor digitorum longus, peroneus tertius, and tibialis anterior muscles. Above the knee this distribution continues with the vastus intermedius and rectus femoris muscles. From the femur it sends a branch to join the backbone with the psoas major and minor, and iliacus muscles. Another branch consisting of the obturator externus distributes to gather around the sexual organs. This distribution then travels above along the abdomen as the rectus abdominis muscles, and continuing above the supraclavicular fossa to include the sternohyoid, sternothyroid and thyrohyoid muscles and then the mylohyoid muscle. The anterior lateral foot (ALF) longitudinal muscular distribution includes several important facial muscles including the mentalis, depressor labii inferior, orbicularis oris, zygomaticus major, zygomaticus minor, levator labii superioris alaeque nasi, lower orbicularis oculi (palpebral and orbital parts), and the masseter (See Figure 2.5). (*LS 13*)

### *ALF Muscle Pathology*

When the ALF muscular distribution is disordered it will result in acute cramps in the middle toe and along the tibia, foot tremors, acute cramps in the rectus femoris muscle, swelling and edema in the anterior aspect of the thigh, incarcerated hernia, contractions of the abdomen (spasms), stretching sensation from the supraclavicular fossa reaching the jaw (cheek), unexpected or sudden deviation of the mouth, with acute condition that the eye cannot close (Bell's palsy). If the condition is caused by heat, the muscles will be relaxed and the eye will not be able to open (ptosis of the eyelid). If the muscles of the cheek have a cold sensation, it will cause acute drawing of the cheeks and alterations or movements in the mouth. If heat conditions are present it will result in relaxation and release of the muscles, with inability to contract and consequently will cause deviation of the mouth. (*LS 13*)

### *ALF Treatment Strategies*

To treat these conditions an ointment made from horse fats can be applied in case of contractions (spasms and cramps), while white wine mixed with cinnamon can be used to apply to the areas in the case where the muscles are relaxed. A hook made of mulberry wood can be used to support the angle of the mouth. Mulberry wood coals can be placed in a pit, whose depth and size is dictated by how long it takes to warm (radiant heat application) the patient when they are seated. Apply the ointment like ironing the spastic muscles of the cheeks, and the patient, just for the time being, can drink good wine and eat roasted meat. Even if they do not normally drink, they can make an individual effort to do so and thereby enhance the effect of massage that is applied to bring about a cure. (*LS 13*)

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes along the ALF muscular pathways. Symptoms associated with the ALF longitudinal muscle distribution are called "late spring" rheumatism. (*LS 13*)

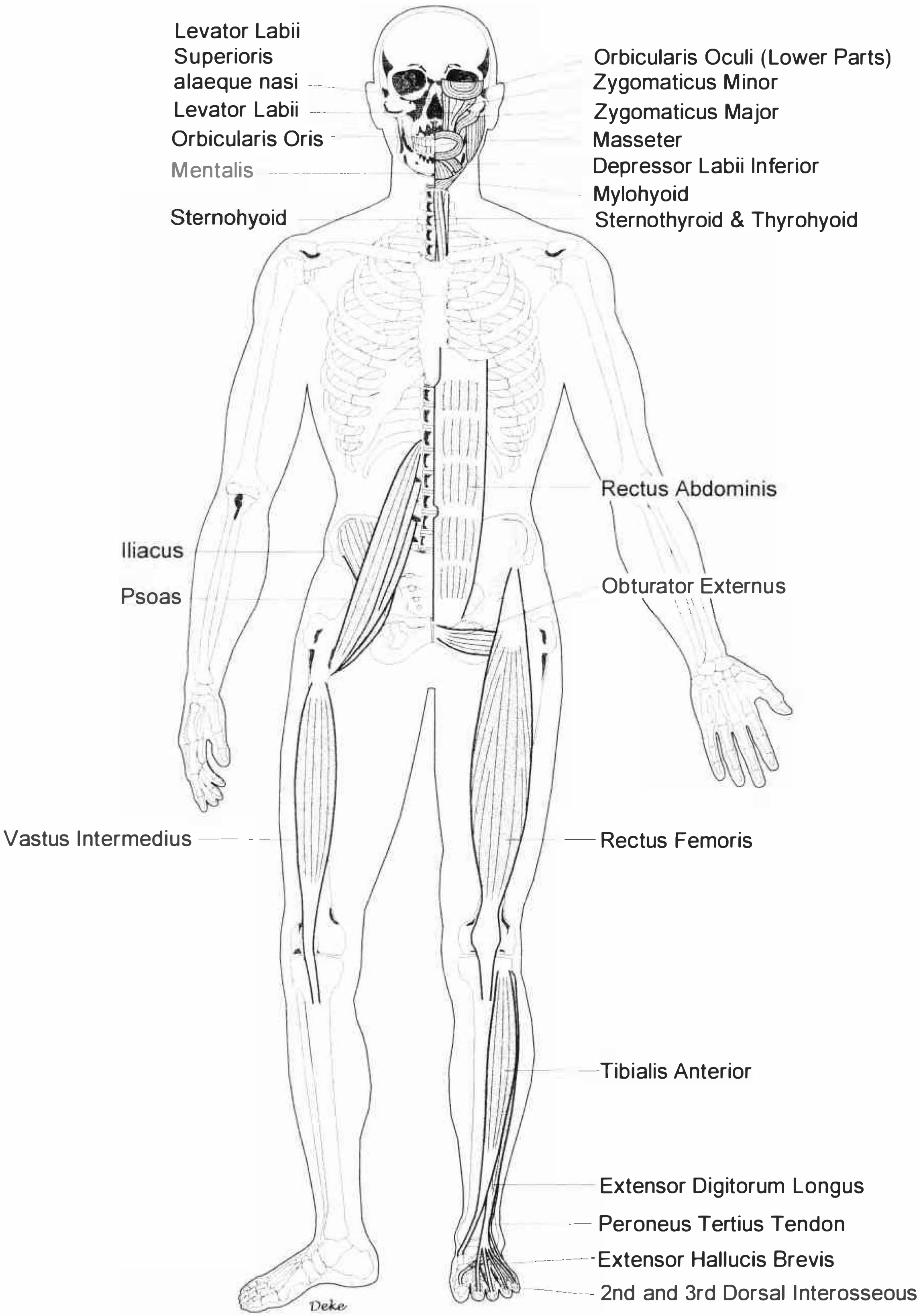



Figure 2.4. Muscles of the anterior lateral foot (ALF) longitudinal body region

Table 2.4a. Muscles of the anterior lateral foot (ALF) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Orbicularis oculi, lower palpebral and orbital parts | Close eyelid | Medial aspect of maxillary and frontal bones and medial palpebral ligament | Encircles lower orbit and pass across eyelid to form lateral palpebral raphe | Facial CN VII |
| Levator labii superioris alaeque nasi | Elevates upper lip, dilates nostrils | Maxillary nasal process | Nasal ala cartilage and upper lip | Facial CN VII, infraorbital branch |
| Zygomaticus minor | Draws upper lip up and out | Zygomatic bone | Angle of mouth, orbicularis oris | Facial CN VII |
| Zygomaticus major | Draws upper lip upward, backward and outward | Zygomatic bone | Angle of mouth | Facial CN VII |
| Orbicularis oris | Closes and puckers lips | Nasal septum and canine fossa of mandible | Buccinator and skin at angle of mouth | Facial CN VII |
| Mentalis | Raises and protrudes lower lip | Incisive fossa of mandible | Skin of chin | Facial CN VII |
| Depressor labii inferior | Depresses lower lip | External oblique line of mandible | Lower lip and orbicularis oris | Facial CN VII |
| Masseter | Mastication | Zygomatic arch and malar process of superior maxilla | Angle and lateral surface of ramus mandible | Trigeminal CN V, mandibular division |
| Mylohyoid | Depresses jaw, elevates floor of mouth and hyoid | Mandible | Body of hyoid | Trigeminal CN V |
| Sternohyoid | Depresses hyoid | Manubrium | Body of hyoid | Upper cervical through ansa hypoglossi |
| Sternothyroid | Depresses larynx | Manubrium | Thyroid cartilage | Upper cervical through ansa hypoglossi |
| Thyrohyoid | Depresses hyoid or raises larynx | Thyroid cartilage | Hyoid | First cervical through hypoglossal |
| Rectus abdominis | Flexes or bends vertebral column to one side; compresses abdominal contents | Crest of pubis and ligaments of pubic symphysis | Cartilages of 5th, 6th and 7th ribs | Branches of intercostal T7-T12 |
| Obturator externus | Rotates thigh outward (laterally) | Pubis, ischium, superficial surface of obturator membrane | Trochaneric fossa of femur | Obturator L3, 4 |
| Psoas major | Flexes thigh or trunk, adducts and rotates it medially | Transverse processes of last thoracic and all lumbar vertebrae | Lessor trochanter of femur | Lumbar plexus L1, 2, 3, (4) |
| Psoas minor | Tenses iliac fascia | Twelfth thoracic and 1st lumbar vertebrae | Iliac fascia and iliopectineal tuberosity | Branch of lumbar L1 |
| Iliacus | Flexes and rotates thigh | Margin of iliac fossa; sacrum | Fibers converge into lateral side of psoas major tendon | Branches of femoral L(1), 2, 3, 4 |
| Rectus femoris | Extends leg, assists in flexing hip joint | Anterior inferior iliac spine | Base of patella, tuberosity and condyles of tibia | Femoral L2, 3, 4 |
| Vastus intermedius | Extends leg | Ventral surface of femur | Base of patella, tuberosity and condyles of tibia | Femoral L2, 3, 4 |

Table 2.4b. Muscles of the anterior lateral foot (ALF) longitudinal body region (continued).

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Tibialis anterior | Dorsiflex and invert foot | Lateral condyle and upper lateral portion of tibia | Internal cuneiform and base of 1st metatarsal | Deep peroneal L4, 5, S1 |
| Peroneus tertius | Dorifiexes foot | Lower third of fibula, medial surface | Base of 5th metatarsal | Deep peroneal L4, 5, S1 |
| Extensor digitorum longus | Extends metatarsophalangeal joints and assists in extending interphalangeal joints of 2nd - 5th digits | Lateral condyle of tibia, proximal three fourths od anterior fibula. | By tendons to the 2nd - 5th digits | Peroneal L4, 5, S1 |
| Extensor hallucis brevis | Extends big toe | Anterolateral upper surface of calcaneus | Proximal phalange of big toe | Deep peroneal L4, 5, S1 |
| 2nd and 3rd Dorsal Interosseous | Adducts 2nd, 3rd and 4th toes | Shaft of 2nd, 3rd and 4th metatarsals | First phalanges of the toes | Lateral plantar S1, 2 |

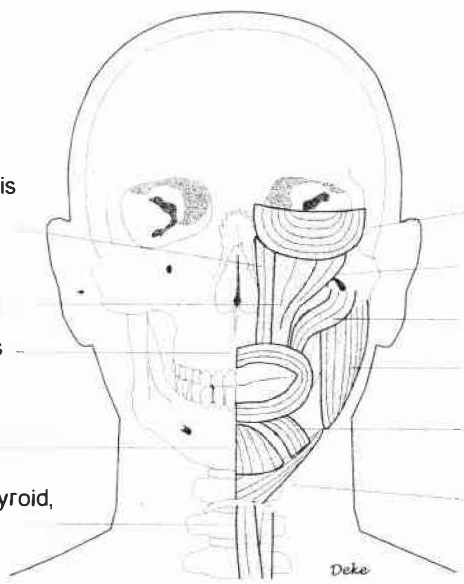



Figure 2.5. Muscles of the anterior lateral foot (ALF) on the face and upper neck.

## Anterior Medial Foot (AMF) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the anterior medial lower extremity start at the medial aspect of the big toe with the abductor hallucis (See Figure 2.6 and Table 2.5). Above this it continues to the knee with the tibialis posterior and flexor digitorum longus, and to the medial aspect of the fibula with the flexor hallucis longus muscle. This distribution travels above following along the inner aspect of the thigh to include the vastus medialis and sartorius muscles, and then distributes to the sexual organs to include the pectineus muscle. Above this it ties into the umbilicus (linea alba) following interiorly along the abdomen to tie into the lower ribs (hypochondrium). Here it spreads out into the chest with the internal intercostals muscles and internally these travels around to connect to the spine with the external intercostals muscles. (*LS 13*)

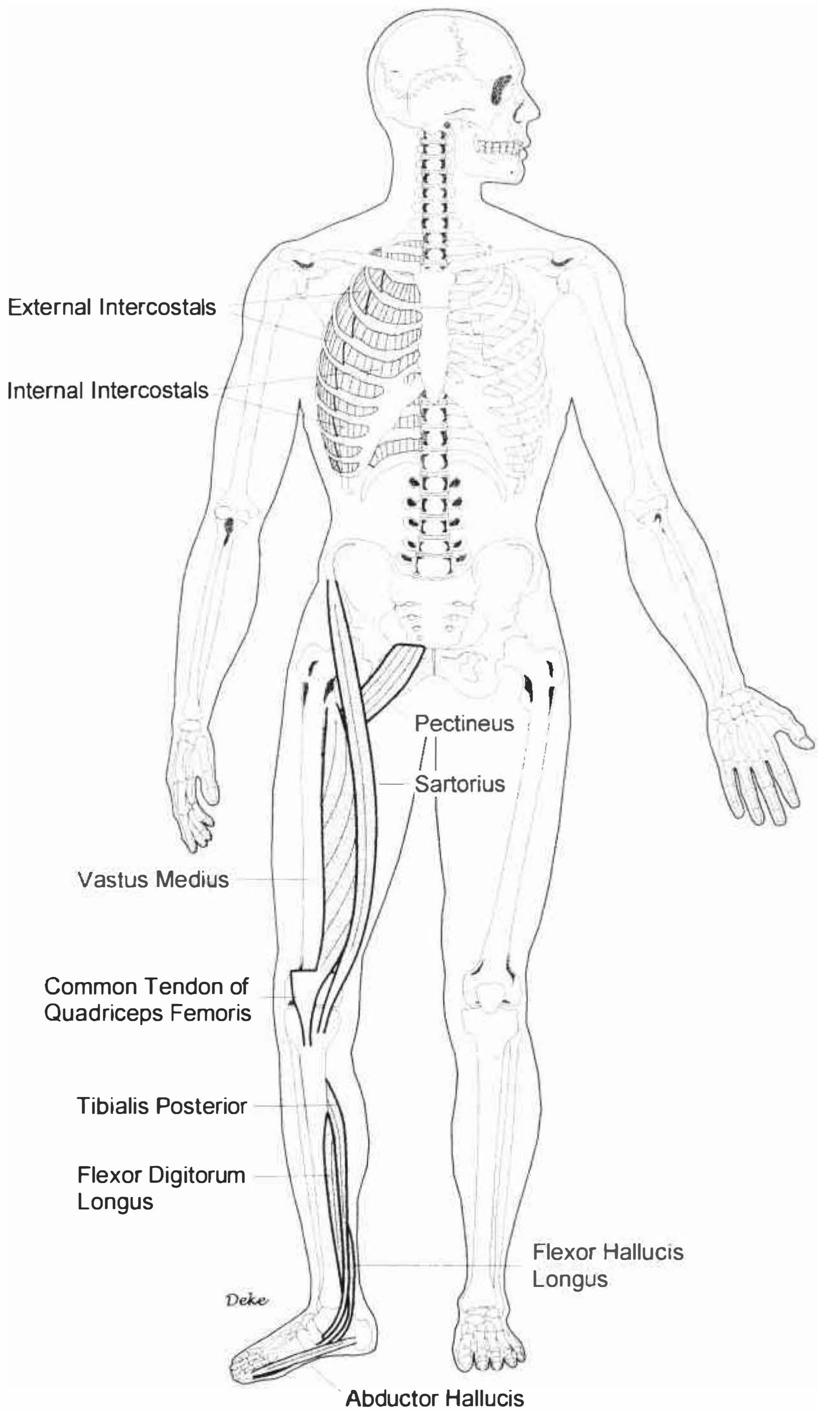



Figure 2.6. Muscles of the anterior medial foot (AMF) longitudinal body region

### *AMF Muscle Pathology*

Disease manifestations of the anterior medial foot (AMF) muscular distribution includes pain in the big toe and medial ankle, acute cramps and pain in the medial knee and pain in the upper medial fibula, a stretching pain sensation along the inner thigh, a cramping pain around the genitalia, a stretching pain from below the umbilicus extending up through the ribs on each side (internal intercostals muscles), and a stretching pain extending from the breast around to the spine (external intercostals muscles). Symptoms associated with this muscular distribution are called "early autumn" rheumatism. (*LS 13*)

### *AMF Treatment Strategies*

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes and other areas along the anterior medial foot (AMF) longitudinal muscular pathway. Symptoms associated with this muscular distribution are called "early autumn" rheumatism which corresponds to the month of August. (*LS 13*)

Table 2.5. Muscles of the anterior medial foot (AMF) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| External intercostals | Raises ribs during inspiration | Lower border of a rib | Upper border of a rib below the origin | Intercostal T1-T11 |
| Internal intercostals | Depresses ribs during forced expiration | Ridge on inner surface of a rib | Upper border of a rib below the origin | Intercostal T1-T11 |
| Pectineus | Flexes, adducts thigh | Pubic spine | Femur distal to lessor trochanter | Branch of obturator & femoral L2, 3, 4 |
| Sartorius | Flexes and laterally rotates thigh | Anterior superior iliac spine | Medial surface of upper tibia | Femoral L2, 3, (4) |
| Vastus medius | Extends leg, draws patella in | Intertrochanteric line; medial lip of linea aspera of femur | Common tendon of quadriceps femoris | Branches of femoral L2, 3, 4 |
| Tibialis posterior | Inverts foot; assists in plantar flexion | Shaft of tibia and fibula and interosseous membrane | Internal cunieform, cuboid, navicular and 2nd-4th metatarsal | Tibial L5, S1 |
| Flexor digitorum longus | Plantar flexes foot, flexes toes | Posterior surface of tibial shaft | Distal phalanges of 2nd-5th toe | Tibial L4, 5, S1 |
| Flexor hallucis longus | Plantar flexes foot, flexes big toe | Posterior surface of fibula | Base of big toe distal phalanx | Tibial L5, S1, 2 |
| Abductor hallucis | Abducts and flexes big toe | Plantar fascia; medial tuberosity of calcaneus | Base of big toe distal phalanx, medial surface | Medial plantar L5, S1, 2 |

## Lateral Foot (LF) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the lateral lower extremity starts at the small and forth toe with the 4th dorsal interosseous muscle (See Figure 2.7 and Table 2.6). It continues to the lateral malleolus with the extensor digitorum brevis muscle and follows up along the tibia with the peroneus brevis and peroneus longus muscles. Above the knee it continues with the biceps femoris (short head) and vastus lateralis traveling above the thigh including the iliotibial tract, tensor fascia latae, and the gluteus medius and gluteus minimus. It continues above between the iliac crest and hypochondrium to include the external oblique, internal oblique and transverse abdominis muscles. This muscular pathway continues up to insert into the supraclavicular fossa with the superior serratus anterior and subclavius muscles. Above this the LF muscular distribution continues up to the neck with the scalenus anterior muscle ending on the head to include the temporalis and frontalis muscles. (*LS 13*)

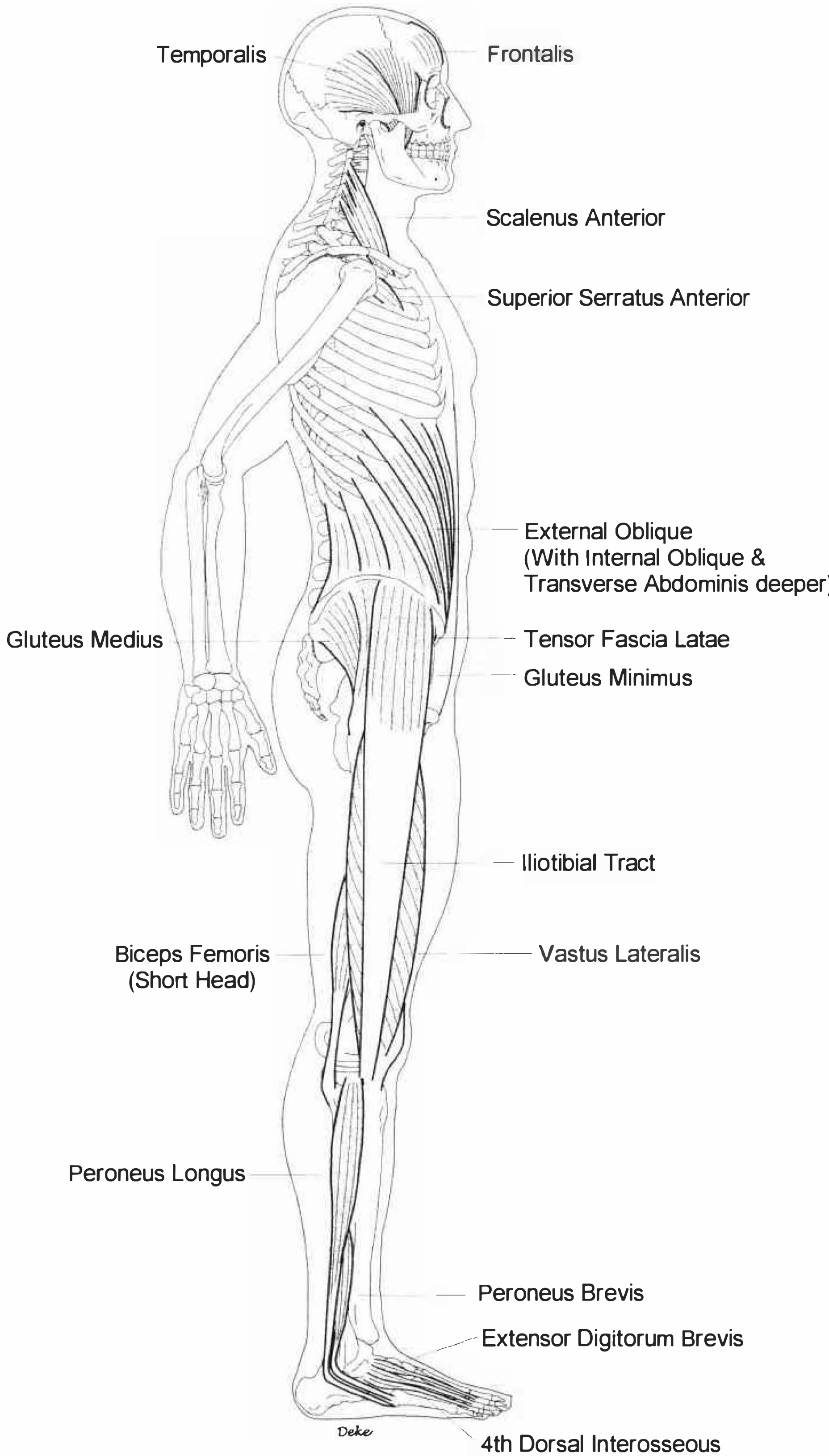



Figure 2.7. Muscles of the lateral foot (LF) longitudinal body region

Table 2.6. Muscles of the lateral foot (LF) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Frontalis | Raises eyebrows, pulls scalp forward | Procerus, corrugator and orbicularis oculi | Galea aponeurotica | Facial |
| Temporalis | Raises mandible, closing jaw | Temporal fossa of skull and deep surface of temporal fascia | Coronoid process of mandible | Trigeminal |
| Scalenus anterior | Flexes neck and elevates 1st rib | Transverse processes of 3rd to 6th cervical vertebrae | Tubercle of 1st rib | Cervical plexus C3 - 8 |
| Subclavius | Elevates 1st rib or draws clavicle forward and downward | First rib and its cartilage | Undersurface of calicle | Nerve fibers from 5th and 6th cervical C5 - 6 |
| Superior serratus anterior | Pulls scapula anteriorly and upward | Outer surface of upper ribs | Medial border of scapula | Long thoracic C5 - 6 |
| External oblique | Contracts abdomen and viscera | Lower 8 ribs | Anterior half of Iliac crest, linea alba and pubic crest | Branches of intercostal and ilioinguinal and iliohypogastric T7-12 |
| Internal oblique | Compresses viscera, flexes thorax forward | Iliac crest, inguinal ligament, lumbar fascia | Costal cartilages of lower 3 or 4 ribs, linea alba, pubic crest | Branches of intercostal and ilioinguinal and iliohypogastric T7-L1 |
| Transverse abdominis | Compresses abdomen, flexes thorax | Iliac crest, inguinal ligament, lumbar fascia, 7th to 12th costal cartilages | Pubic crest, iliopectineal line, linea alba and xiphoid cartilage | Branches of intercostal and ilioinguinal and iliohypogastric T8-12 |
| Gluteus medius | Abducts thigh and medially rotates thigh | Lateral surface of ilium | Lateral surface of greater trochanter | Superior gluteal L4, 5, S1, S2 |
| Gluteus minimus | Abducts thigh and medially rotates thigh | Lateral surface of ilium | Anterior surface of greater trochanter | Superior gluteal L4, 5, S1, S2 |
| Tensor fasciae latae | Steadies femur on tibia and pelvis on femur | Anterior iliac crest; lateral surface of anterior superior iliac spine | Iliotibial tract | Superior gluteal L4, 5, S1 |
| Iliotibial tract (tendon) | Provides deep fascia of thigh to connect tensor fasciae latae to knee | Iliac crest and tensor fasciae latae | Lateral condyle of tibia | |
| Vastus lateralis | Extends leg | Greater trochanter and linea aspera of femur | Base of patella, tuberosity and condyles of tibia | Femoral L2, 3, 4 |
| Biceps femoris (short head) | Flexes and rotates knee outward | From linea aspera of femur | Lateral condyle of tibia and head of fibula | Peroneal L5, S1, 2 |
| Peroneus longus | Extends, abducts and everts foot | External condyle of tibia and upper fibula | Tendon to internal cuneifonn and 1st metatarsal | Branch of peroneal L4, 5, S1 |
| Peroneus brevis | Extends and abducts foot | Middle portion of fibula | Base of 5th metatarsal | Branch of peroneal L4, 5, S1 |
| Extensor digitorum brevis | Extends toes | Dorsal surface of os calcis | Tendons of extensor digitorum longus and 1st phalanx of big toe | Branch of peroneal L4, 5, S1 |
| 4th Dorsal interosseous | Adducts toes | Shaft of 4th and 5th metatarsals | First phalanges of 4th and 5th toe | External plantar S1, 2 |

## *LF Muscle Pathology*

When the LF longitudinal muscular pathway is disordered it can result in acute cramps in the fourth and fifth toes, stretched muscles and acute cramps in the lateral aspect of the knee. The knee is unable to bend or extend, along with contractions in the back of the knee. Conditions can include tight and stretched muscles in the anterior aspect of the thigh and posteriorly in the sacral region. Extending above there can be pain in the lateral abdomen and hypochondrium. Extending further upward there can be spasms in the supraclavicular region, the breast, and in the neck muscles and tendons. If the spasms extend from left to right, the right eye will not be able to open, because the (right side) of this muscular pathway extends up along the right side of the forehead where it combines with one of the singular vessel. Since the muscle and tendons on the left side connect with those on the right (frontalis muscle), when the left aspect of the head is injured it can result in paralysis of the right foot. This is called the "mutual relationship of the muscle connections" (referring to possible brain injury affecting the motor cortex. (*LS 13*)

### *LF Treatment Strategies*

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes along these muscular pathways. Symptoms associated with this muscular distribution are called "early spring" rheumatism. (*LS 13*)

## Medial Foot (MF) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the medial lower extremity starts on the upper region of the big toe with the tendon of extensor hallucis longus, and then includes the 1st dorsal interosseous muscle (See Figure 2.8 and Table 2.7). Above this it follows along the tibia with the extensor hallucis longus muscle, continuing along the inner thigh with the gracilis muscle to tie into the region of the sex organs with the pubococcygeus. Here the MF longitudinal muscular distribution makes connections with all the other muscles in this local region. (*LS 13*)

### *MF Muscle Pathology*

When the MF muscular pathway is disordered it can cause pain in the big toe and the anterior region of the medial malleolus, pain in the medial aspect of the fibula, and pain and acute cramps of the inner thigh. Also, the sexual organs will be dysfunctional, including impotence in the case of internal injury. If the injury is due to cold, there will be contraction and shrinkage of the sex organs. In case of injury due to heat, there may be abnormal erection (priapism) that can not be put away. (*LS 13*)

### *MF Treatment Strategies*

The preceding disorders are treated by promoting the circulation of water and clearing the sexual organ vital substance. If these disorders involve pain and acute cramps they should be treated by quick insertion with a (previously) heated needle of indefinite duration. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes along this muscular pathway. Symptoms associated with the MF muscular distribution are called “late-autumn” rheumatism. (*LS 13*)

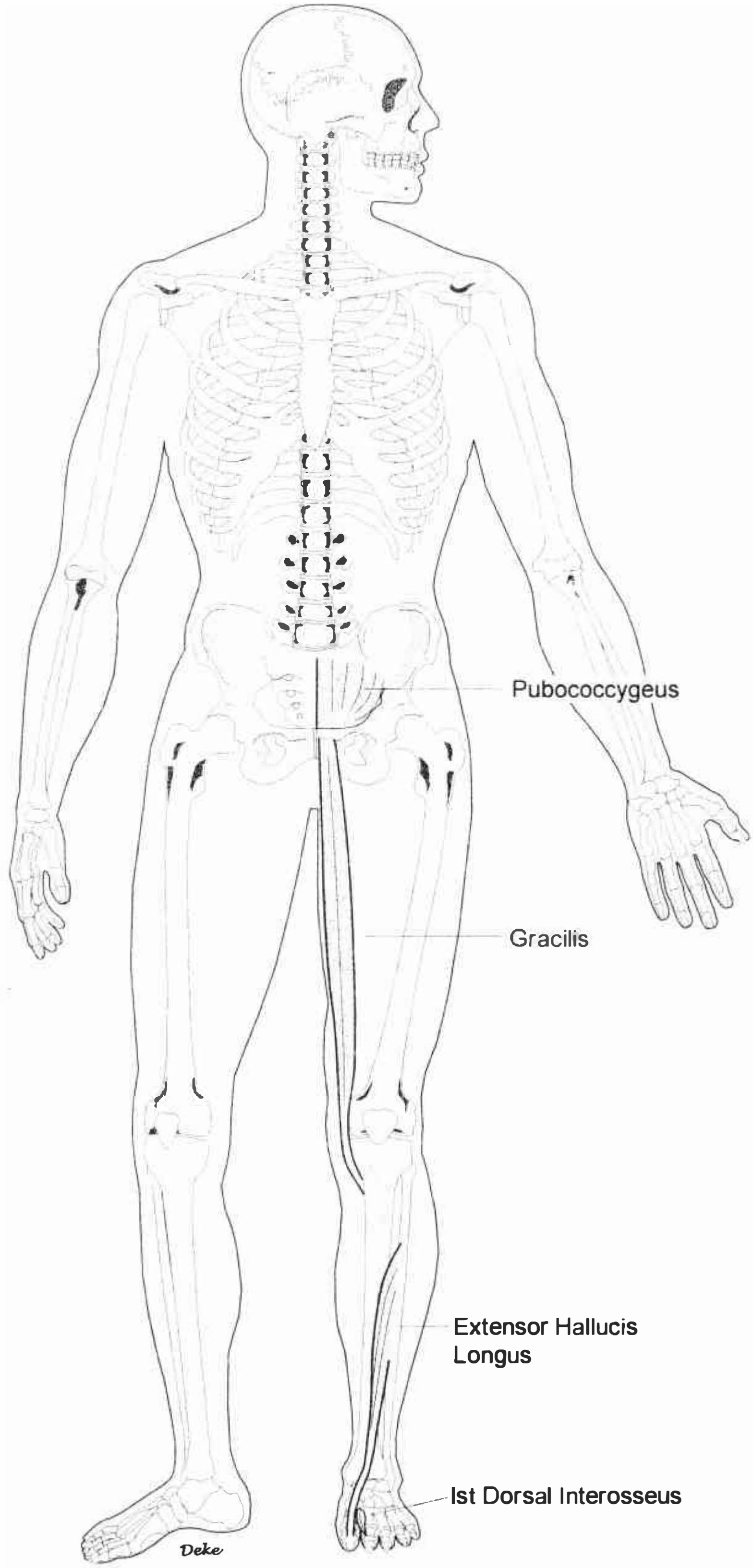



Figure 2.8. Muscles of the medial foot (MF) longitudinal body region

Table 2.7. Muscles of the medial foot (MF) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Pubococcygeus | Supports rectum and pelvic floor, aids in defecation | Pubis, pelvic fascia, ischial spine | Rectum, coccyx and fibrous raphe of perineum | Sacral and perineal S3, 4 |
| Gracilis | Medially rotates and flexes leg | Pubic arch and body of pubis | Medial surface of shaft of tibia | Branch of obturator L2, 3, (4) |
| Extensor hallucis longus | Extends big toe; dorsiflexes foot | Fibula and interosseous membrane | Dorsal surface base of distal phalanx of big toe | Deep peroneal L4, 5, S1 |
| 1st dorsal interosseus | Adducts 2nd toe | Shaft of second metatarsal | First phalange of 2nd toe | External plantar S1, 2 |

## Anterior Lateral Hand (ALH) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the anterior lateral upper extremity starts at the thumb and forefinger and ties into the wrist to include the 1st dorsal interosseous, adductor pollicis and extensor pollicis brevis muscles (See Figure 2.9 and Table 2.8). Above it follows the forearm to include the extensor digitorum communis, extensor carpi radialis longus, extensor carpi radialis brevis and the supinator. Continuing along the upper arm it includes the biceps brachii, long head, and the middle deltoid. A branch distributes to the scapula with the subscapularis, and then on to spine with the rhomboid major and minor muscles. A branch from the scapula travels up to the neck with the omohyoid, and branch continues up with the digastric, anterior belly to the face to include the depressor anguli oris, risorius, and buccinator. Another upward branch in the neck includes the scalenus medius muscle, and continuing upward to the protuberance to the left (sphenoid bone), attaches with the head by the lateral pterygoid, and down to the right to the chin with the medial pterygoid muscle. (*LS 13*)

### *ALH Muscle Pathology*

When the ALH longitudinal muscular distribution is disordered, it will result in pain and acute cramps along its traveling route (this includes problems affecting the fingers, hand, wrist, arm, elbow, shoulder, upper back, neck, and face). There will be an inability to raise the shoulders and also the inability to turn the neck left or right to look either direction. (*LS 13*)

### *ALH Treatment Strategies*

To treat the above described disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes along the ALH longitudinal muscular pathways. Symptoms associated with the ALH muscular distribution are called "early-summer" rheumatism. (*LS 13*)

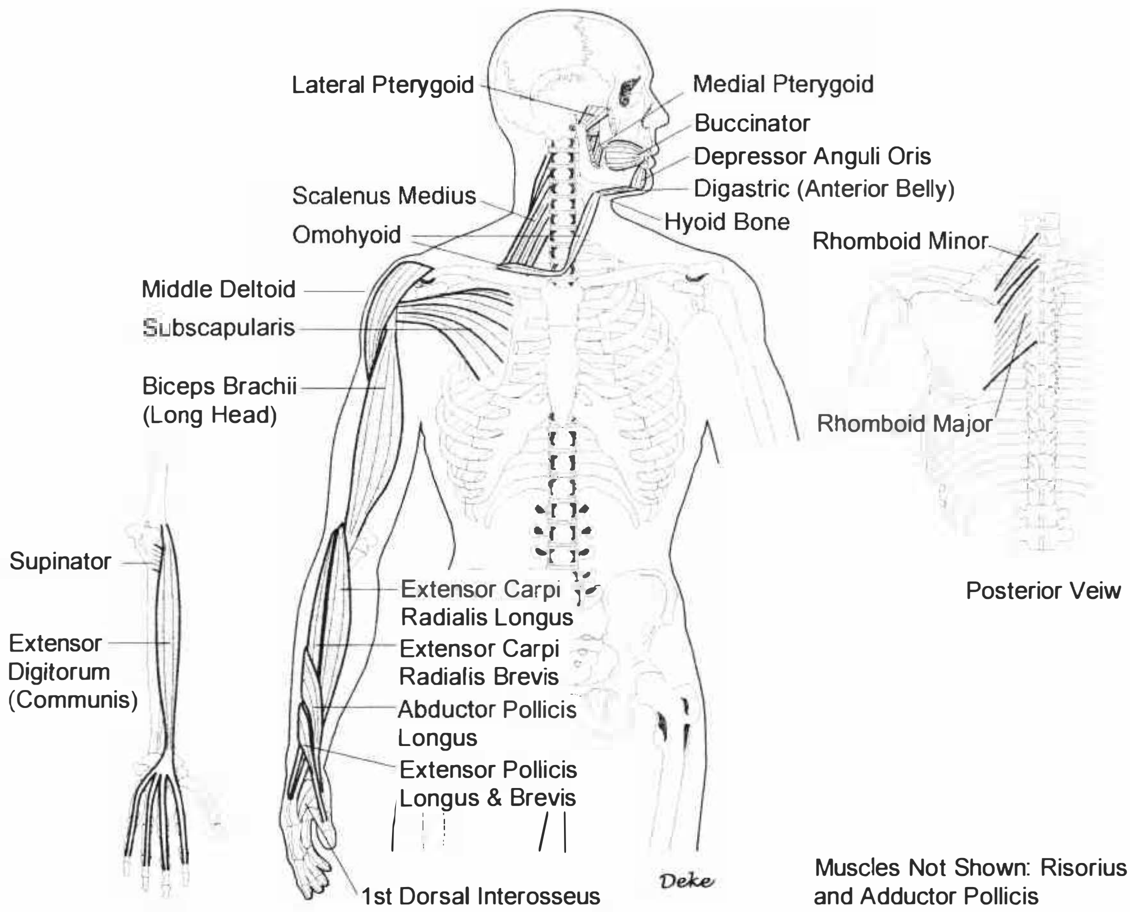



Figure 2.9. Muscles of the anterior lateral hand (ALH) longitudinal body region

## Anterior Medial Hand (AMH) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the anterior medial upper extremity (AMH), arise at the superior aspect of the thumb with the tendon of extensor pollicis brevis (See Figure 2.10 and Table 2.9). From here it distributes above and ties in behind the thenar region with the opponens pollicis; abductor pollicis brevis; and flexor pollicis brevis, superficial and deep head, and distributes to the lateral side of where the radial pulse is detected. It then follows up along the forearm to tie into the center region of the elbow with the flexor pollicis longus and brachioradialis. It continues up the medial aspect of the upper arm with the biceps brachii, short head to enter the region below the axilla and moves out to the supraclavicular fossa and ties into the shoulder anterior to the acromion extremity with the anterior deltoid. Above it ties into supraclavicular fossa (coracoid process of scapula). Below, it ties into the interior region of the chest with the pectoralis minor, where it spreads below with the transversus thoracis to pass through the cardia to include the diaphragm, joining the cardia below (crura of diaphragm) and then supporting the hypochondrium. (*LS 13*)

Table 2.8. Muscles of the anterior lateral hand (ALH) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Medial pterygoid | Raises mandible closing jaw | Pterygoid fossa of sphenoid; palatine bone; tuberosity of maxilla | Inner surface of angle of mandible | Trigeminal CN 5 |
| Lateral pterygoid | Opens jaw, brings jaw forward, moves jaw from side to side | Great wing of sphenoid and infratemporal ridge; outer plate of sphenoid process | Neck of condyle of mandible | Trigeminal CN 5 |
| Buccinator | Compresses cheek and draws back angle of mouth | Posterior alveolar processes of maxilla and mandible | Orbicularis oris at angle of mouth | Facial CN 7 |
| Risorius | Compresses cheek and draws angle of mouth outward | Fascia over masseter muscle | Angle of mouth | Facial CN 7 |
| Depressor anguli oris | Depresses angle of mouth | Lateral oblique line of mandible | Angle of mouth | Facial CN 7 |
| Digastric, anterior belly | Raises hyoid or depresses mandible, opening mouth | Mandible | Hyoid | Trigeminal CN 5 |
| Scalenus Medius | Flexes neck and elevates 1st rib | Transverse processes of 2nd to 7th cervical vertebrae | Cranial surface of 1st rib between tubercle and subclavian groove | Cervical and brachial plexus C3 - 8 |
| Omohyoid | Depresses hyoid | Superior border of scapula | Lateral border of hyoid | Branches from ansa cervicalis |
| Rhomboid minor | Moves scapula backward | Spinous process of 7th cervical and 1st thoracic vertebrae | Scapular vertebral border at root of spine | Dorsal scapular C4, 5 |
| Rhomboid major | Moves scapula backward | Spines of 2nd to 5th thoracic vertebrae | Scapular vertebral border | Dorsal scapular C4, 5 |
| Subscapularis | Medially rotates arm | Subscapular fossa | Lessor tubercle of humerus | Subscapular C5, 6, 7 |
| Middle deltoid | Abducts arm | Acromion | Deltoid tuberosity on shaft of humerus | Axillary C5, 6 |
| Biceps brachii, long head | Flexes forearm; supinates forearm and hand | Upper margin of glenoid cavity of scapula | Tuberosity of radius; deep fascia of medial forearm | Musculocutaneous C5, 6 |
| Supinator | Supinates forearm and hand | Lateral epicondyle of humerus; shaft of ulna | Lateral and anterior surfaces of shaft of radius | Posterior interosseous C5, 6, (7) |
| Extensor carpi radialis longus | Extends, abducts wrist | Lower third of lateral supracondylar ridge of humerus | Base of 2nd metacarpal bone | Radial C6, 7, 8 |
| Extensor carpi radialis brevis | Extends, abducts wrist | Lateral epicondyle of humerus | Base of 3rd metacarpal bone | Radial C6, 7, 8 |
| Extensor digitorum communis | Extends wrist and fingers | Lateral epicondyle of humerus | Extensor tendon to each finger, from common extensor tendon | Posterior interosseous C6, 7, 8 |
| Extensor pollicis longus | Extends phalanges of thumb | Lateral side of dorsal surface of ulna | Base of 2nd phalanx of thumb | Radial C6, 7, 8 |
| Extensor pollicis brevis | Extends proximal phalanx of thumb | Dorsal surface of radius; interosseous membrane | Dorsal surface of proximal phalanx of thumb | Posterior interosseous C6, 7, 8 |
| Abductor pollicis longus | Abducts, extends thumb | Posterior surface of radius and ulna | Radial side of base of 1st metacarpal | Posterior interosseous C6, 7, 8 |
| Adductor pollicis | Adducts thumb | Capitate; trapezoid; 2nd and 3rd metacarpals | Ulnar side of base of 1st phalanx of thumb | Ulnar C8, T1 |
| 1st dorsal interosseus, lateral and medial heads | Abducts index finger | Sides of 1st and 2nd metacarpals | Proximal phalanx and dorsal digital expansion of 2nd finger | Ulnar C8, T1 |

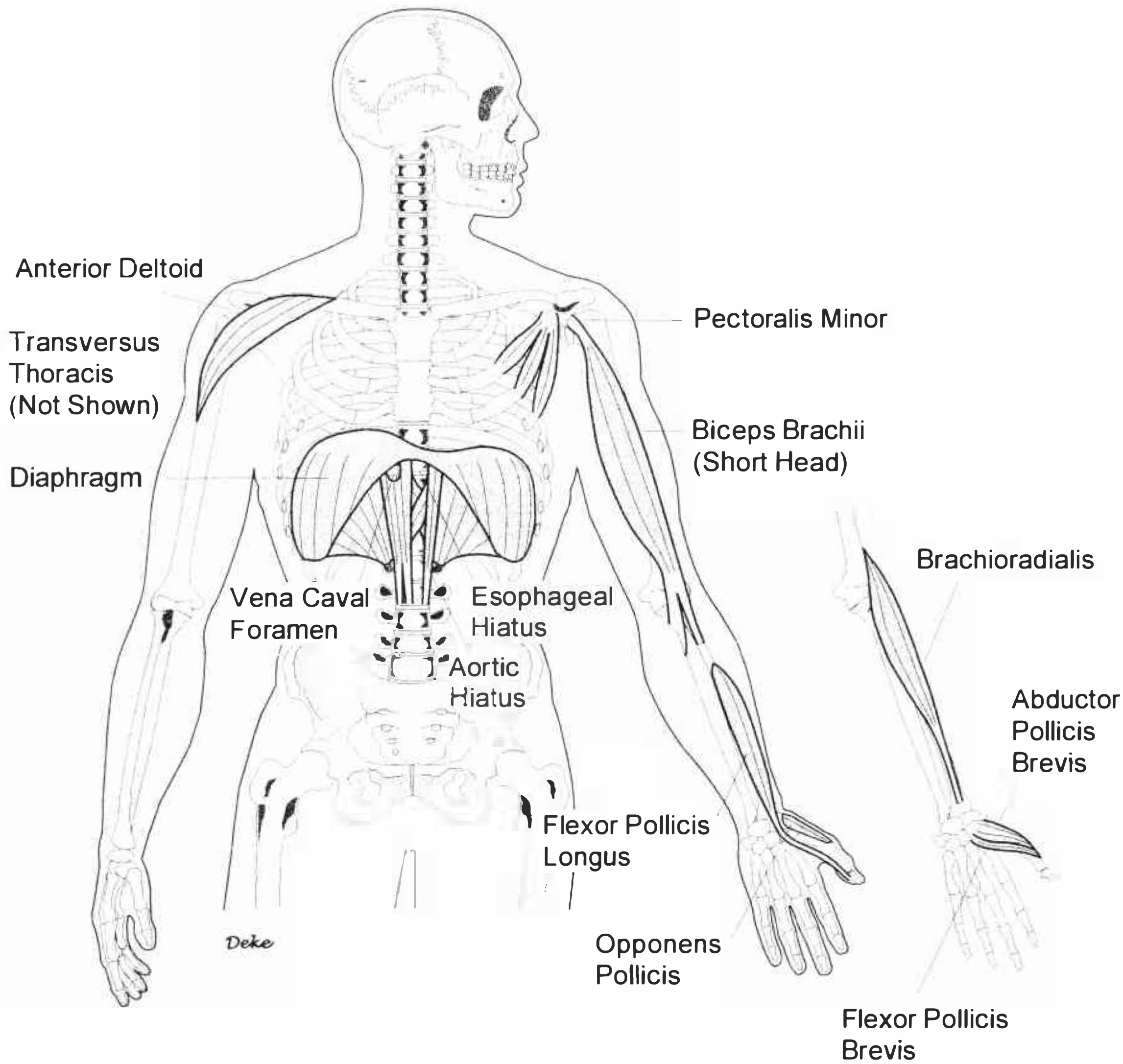



Figure 2.10. Muscles of the anterior medial hand (AMH) longitudinal body region

### *AMH Muscle Pathology*

When the AMH muscle distribution pathway is disordered it will result in acute cramps along its longitudinal traveling route, and severe pain that result in dyspnea affecting the region of the cardia, spasms in the sides of the ribs and spitting or vomiting blood. (*LS 13*)

### *AMH Treatment Strategies*

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive areas and neurovascular nodes along the anterior medial hand (AMH) muscular pathways. Symptoms associated with this muscular distribution are called "midwinter" rheumatism. (*LS 13*)

Table 2.9. Muscles of the anterior medial hand (AMH) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Diaphragm | Increases vertical diameter of thorax by pulling central tendon downward during inspiration | Xiphoid process; costal cartilages of lower 6 ribs; lumbar vertebrae | Central tendon | Phrenic C3, 4, 5 |
| Transversus thoracis | Narrows the chest | Sternum and xiphoid cartilage | Costal cartilages of 2nd to 6th ribs | Branches of intercostal T3, 4, 5, 6 |
| Pectoralis minor | Depresses shoulder and rotates scapula downward | Upper margins and outer surfaces of 3rd to 5th ribs; fasciae covering intercostals | Medial border of coracoid process of scapula | Anterior thoracic C7, 8, T1 |
| Anterior deltoid | Abducts arm; flexes and medially rotates arm | Lateral third of clavicle | Deltoid tuberosity on shaft of humerus | Axillary C5, 6 |
| Biceps brachii, short head | Flexes forearm; supinates forearm and hand | Coracoid process of scapula | Tuberosity of radius; deep fascia of medial forearm | Musculocutaneous C5, 6 |
| Brachioradialis | Flexes forearm | Lateral supracondyloid ridge of humerus | Lower end of radius | Radial C5, 6 |
| Flexor pollicis longus | Flexes phalanges of thumb | Body of radius, anterior surface | Base of distal phalanx of thumb | Anterior interosseous C7, 8, T1 |
| Flexor pollicis brevis, sup. and deep heads | Flexes proximal phalanx of thumb | Flexor retinaculum; tubercle of trapezium | Base of proximal phalanx of thumb | Median and ulnar C6, 7, 8, T1 (sup head) C8, T1 (deep head) |
| Abductor pollicis brevis | Abducts thumb | Flexor retinaculum; scaphoid; trapezium | Lateral surface of base of proximal phalanx of thumb | Median C7, 8, T1 |
| Opponens pollicis | Opposes thumb, medially rotates and flexes 1st metacarpal | Tubercle of trapezium; flexor retinaculum | Radial side of 1st metacarpal | Median C6, 7, 8, T1 |

## Lateral Hand (LH) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the lateral upper extremity starts at the little finger and the fourth finger with the 4th interosseous muscle (Figure 2.11 and Table 2.10). It follows along the center of the forearm to include the extensor indicis and extensor pollicis longus, as well as the extensor digiti minimi and extensor carpi ulnaris that tie into the elbow, and then includes the anconeus muscle. Above it wraps around the lateral aspect of the upper arm with the lateral head of the triceps brachii, then up to the shoulder with the posterior deltoid, and then the supraspinatus, as well as traveling to the neck with the scalenus posterior muscle. A branch of this distribution includes the stylohyoid muscle where a branch fastens to the root of the tongue with the hyoglossus and genioglossus muscles. Another branch includes the temporoparietalis muscle. (*LS 13*)

### *LH Muscle Pathology*

When this muscular distribution is disordered it will result in acute cramps along its traveling route and also will cause the tongue to curl up. Symptoms associated with this distribution are called “late-summer” rheumatism. (*LS 13*)

### *LH Treatment Strategies*

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive areas and neurovascular nodes along the lateral hand (LH) muscular pathways. (*LS 13*)

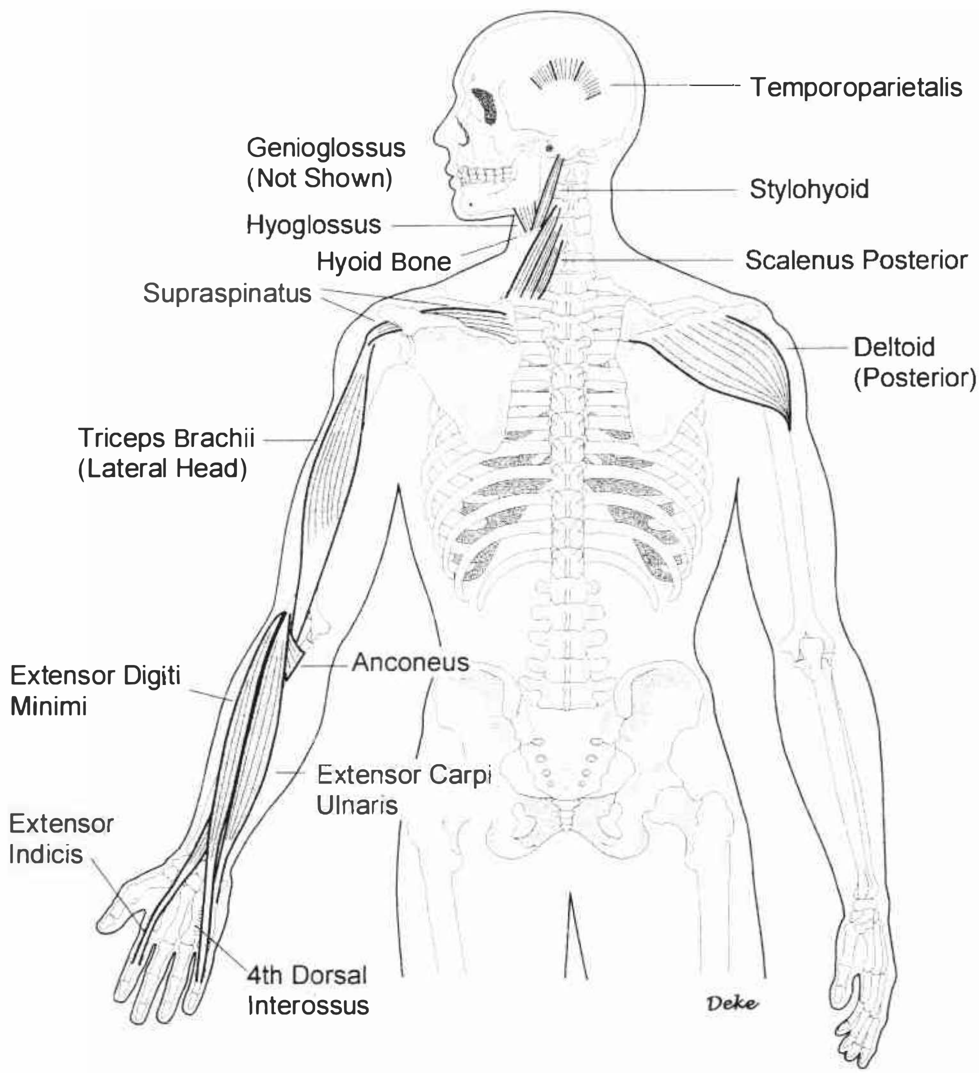



Figure 2.11. Muscles of the lateral hand (LH) longitudinal body region

## Medial Hand (MH) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the medial upper extremity starts with the 1st and 2nd palmar interosseous and associated lumbrical muscles (Figure 2.12 and Table 2.11). From here the distribution travels up to the medial aspect of the elbow with the flexor carpi radialis and flexor digitorum profundus, and includes the pronator quadratus lower on the forearm. Above the elbow, it follows the inner aspect of the upper arm with the coracobrachialis muscle. From here it spreads anteriorly and posteriorly to clasp to the upper ribs on the sides with the serratus anterior muscles. Another branch spreads to the center of the chest with the pectoralis major, clavicular and upper sternal portions, and inserts into the humerus. (*LS 13*)

Table 2.10. Muscles of the lateral hand (LH) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Temporoparietalis | | Galea aponeurotica | | Facial CN 7 |
| Genioglossus | Depresses tongue and thrusts it forward | Internal surface of mandible, near the symphysis | Inferior surface of tongue; hyoid bone | Hypoglossal CN 12 |
| Hypoglossus | Depresses tongue | Body of hyoid | Side of tongue | Hypoglossal CN 12 |
| Stylohyoid | Draws hyoid up and to the back | Styloid process | Body of hyoid | Facial CN 7 |
| Posterior scalenus | Flexes neck, elevates 2nd rib | Transverse processes of 4th to 6th cervical vertebrae | Second rib | Cervical and brachial plexus C3 - 8 |
| Supraspinatus | Abducts arm | Fossa superior to scapular spine | Greater tuberosity of humerus | Subscapular C4, 5, 6 |
| Posterior deltoid | Abducts, extends and laterally rotates arm | Spine of scapula | Shaft of humerus | Axillary C5, 6 |
| Triceps brachii, lateral head | Extends forearm | Lateral and posterior surfaces of shaft of humerus | Olecranon of ulna | Radial C6, 7, 8 |
| Anconeus | Extends forearm | Posterior surface of lateral epicondyle of humerus | Olecranon and dorsal surface of ulna | Radial C7, 8, T1 |
| Extensor digiti minimi | Extends little finger | Lateral epicondyle of humerus | Dorsum of phalanx of little finger | Radial C6, 7, 8 |
| Extensor carpi ulnaris | Extends, adducts wrist | Lateral epicondyle of humerus | Base of 5th metacarpal | Radial C6, 7, 8 |
| Extensor indicis | Extends index finger | Dorsal surface and interosseous membrane of ulna | Phalanges of index finger | Posterior interosseous C6, 7, 8 |
| 4th dorsal interosseus | Abducts 4th finger | Sides of 4th and 5th metacarpal | Proximal phalange of 4th finger | Ulnar C8, T1 |

### *MH Muscle Pathology*

Disorders of the medial hand (MH) longitudinal muscular distribution pathway include acute cramps along its traveling route, and pain in the anterior region of the chest (sternum) with dyspnea related to the region of the cardia. (*LS 13*)

### *MH Treatment Strategies*

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive areas and neurovascular nodes along the MH muscular pathways. Symptoms associated with the MH muscle distribution are called "early-winter" rheumatism. (*LS 13*)

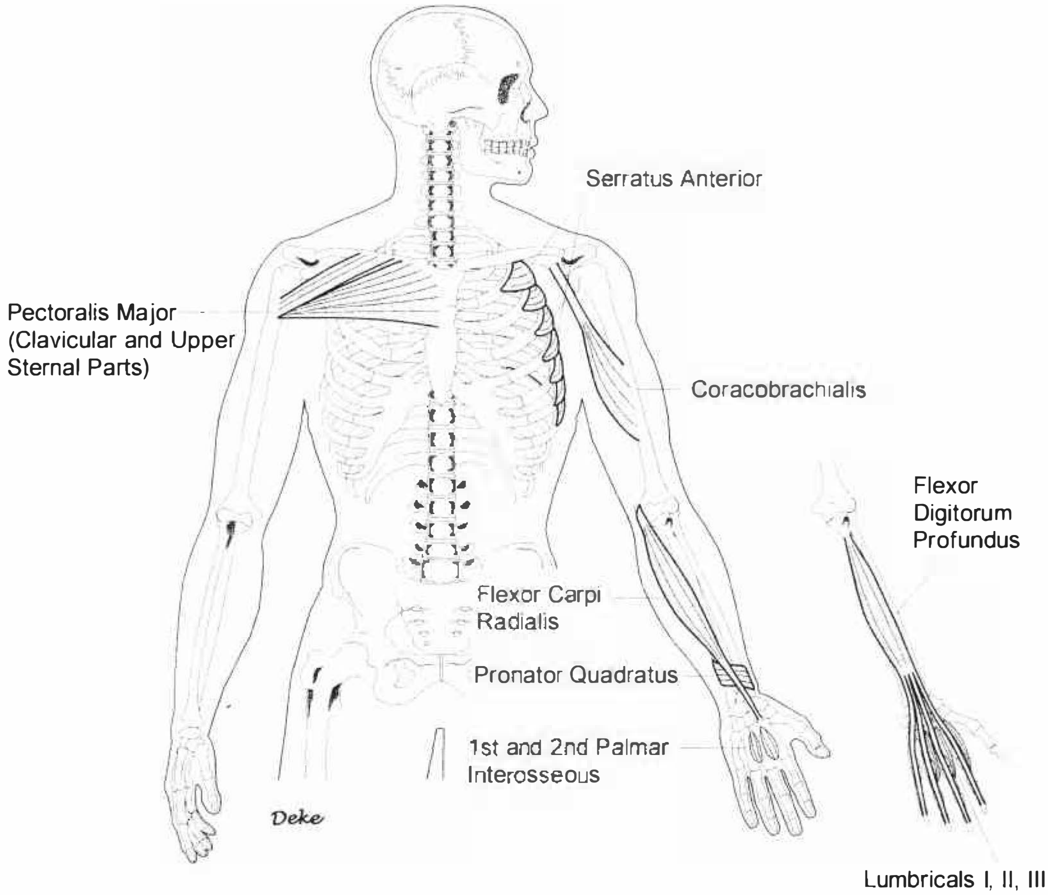



Figure 2.12. Muscles of the medial hand (MH) longitudinal body region

Table 2.11. Muscles of the medial hand (MH) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Serratus anterior | Moves scapula forward and away from spine | Outer surfaces and superior borders of upper 8 or 9 ribs; fasciae covering intercostals | Ventral surface of scapular vertebral border | Long thoracic C5, 6, 7, 8 |
| Pectoralis major, clavicular and upper sternal portions | Adducts, flexes and rotates arm medially | Anterior surface of sternal half of clavicle; upper half of sternum; aponeurosis of external oblique; costal cartilages of upper ribs | Lateral border of bicepital groove of humerus | Anterior thoracic C5, 6, 7 |
| Coracobrachialis | Adducts and flexes arm | Coracoid process of scapula | Medial and middle surface of humerus | Musculocutaneous C5, 6, 7 |
| Flexor carpi radialis | Flexes and abducts wrist | Medial epicondyle of humerus | Base of 2nd and 3rd metacarpals | Median C7, 8 |
| Flexor digitorum profundus | Flexes distal phalanx of each finger | Medial and anterior surface of shaft off ulna | Bases of distal phalanges of fingers | Ulnar and median C8, T1 |
| Pronator quadratus | Pronates forearm and hand | Lower part of anterior surface of ulna | Lower part of anterior surface of radius | Anterior interosseous C8, T1 |
| Lumbricals I, II and III | Flexes 1st and extends 2nd and 3rd phalanges | Tendon of flexor digitorum profundus muscle | First phalanx and extensor tendon of 2nd, 3rd & 4th finger | Median and ulnar C(6), 7, 8, T1 |
| 1st and 2nd palmar interosseous | Adducts 2nd and 4th fingers | Second and 4th metacarpal bones | Dorsal digital expansions of index and ring fingers | Ulnar C8, T1 |

## Posterior Lateral Hand (PLH) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the posterior lateral upper extremity starts at the superior border of the small finger with the tendon of the extensor digiti minimi and ties into the wrist with the abductor digiti minimi (Figure 2.13 and Table 2.12). It follows up the posterior lateral aspect of the forearm with the flexor carpi ulnaris. Snapping the tendon at this point will cause a response to radiate down to the little finger. From here the distribution continues upward with the long head of the triceps brachii muscle. Posteriorly it winds around the scapula to include the teres major, teres minor, and infraspinatus muscles and then follows along the neck with the levator scapulae muscle. Another branch ties into the ear with the auricularis posterior, anterior, and superior muscles. Below this it ties into the chin with the posterior belly of the digastric muscle. (*LS 13*)

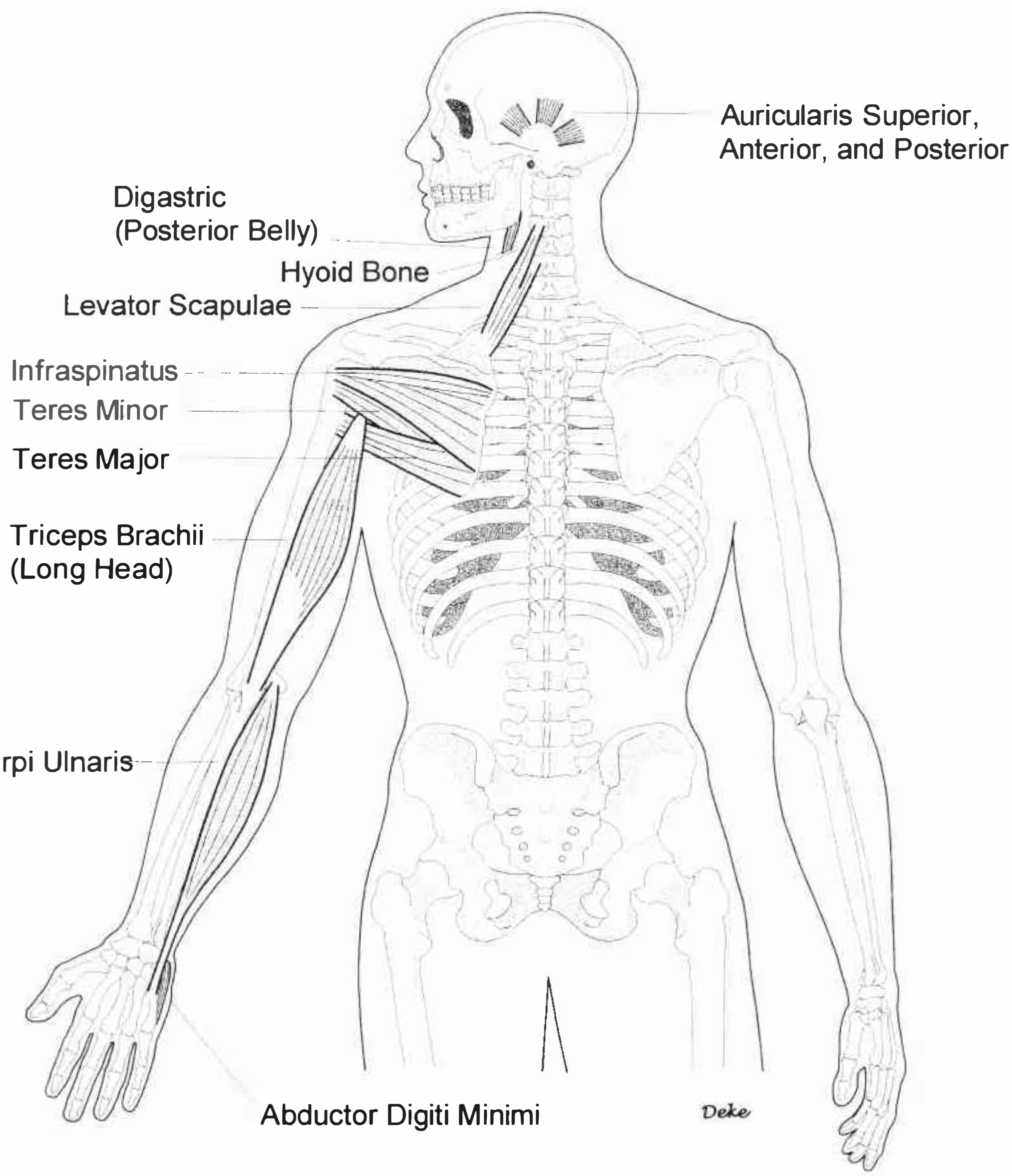



Figure 2.13. Muscles of the posterior lateral hand (PLH) longitudinal body region

Table 2.12. Muscles of the posterior lateral hand (PLH) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Digastric, post. belly | Raises hyoid or depresses mandible to open mouth | Mandible | Hyoid | Trigeminal and facial CN V, CN VII |
| Auricularis superior | Elevates pinna of ear | Galea aponeurotica | Upper portion of pinna of ear | Facial CN VII |
| Auricularis anterior | Draws pinna of ear forward | Superficial temporal fascia | Helix of ear anteriorly | Facial CN VII |
| Auricularis posterior | Draws pinna of ear backward | Mastoid process | Root of auricle | Facial CN VII |
| Levator scapulae | Elevates scapula | Upper 4 or 5 cervical vertebrae | Vertebral border of scapula | Dorsal scapular C3, 4, 5 |
| Infraspinatus | Rotates arm backward and outward | Infraspinous fossa of scapula | Greater tubercle of humerus | Subscapular from brachial plexus C5, 6 |
| Teres minor | Rotates arm outward | Dorsal surface of axillary border of scapula | Greater tubercle of humerus | Branch of axillary C5, 6 |
| Teres major | Adducts, extends and rotates arm medially | Posterior axillary border of scapula | Medial border of bicepital groove of humerus | Branch of lower subscapular C5, 6, 7 |
| Triceps brachii, long head | Extends forearm | Axillary border of scapula below glenoid cavity | Olecranon of ulna | Radial C6, 7, 8, T1 |
| Flexor carpi ulnaris | Flexes and abducts wrist | Medial epicondyle of humerus; upper two thirds of ulnar dorsal border | Pisiform, hamate, and 5th metacarpals | Ulnar C8, T1 |
| Abductor digiti minimi | Abducts little finger | Pisiform bone: tendon of flexor carpi ulnaris | Medial base surface of little finger proximal phalanx | Ulnar C8, T1 |

### *PLH Muscle Pathology*

When this muscular distribution pathway is disordered it will result in pain in the little finger as well as in the posterior aspect of the medial epicondyle of the elbow which follows along the inner aspect of the arm to enter below the axilla causing pain below the axilla, pain in the posterior aspect of the axilla, pain wrapping around the scapula and leading to the neck, pain and ringing in the ears leading to the chin. There can also be a heavy sensation in the eye after having been closed for some time, and spasms in neck muscles which can result in fistula of these muscles and swelling in the neck. (*LS 13*)

### *PLH Treatment Strategies*

When there are cold or hot sensations in the neck, they should be treated by quick insertion with a (previously) heated needle of indefinite duration. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes. If there is swelling, this should be treated by use of very sharp needles. In addition, since this muscular pathway passes through the angle of the jaw, follows anterior to the ear, connects with the outer canthus of the eye and upper jaw, and ties into the temporal region, there can be pain along these traveling areas as well as acute cramps. (*LS 13*)

To treat the above mentioned disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive neurovascular nodes along these muscular pathways. Symptoms associated with this muscular distribution are called "midsummer" rheumatism. (*LS 13*)

## Posterior Medial Hand (PMH) Muscles

The longitudinal distribution of the muscles and related tendons belonging to the posterior medial upper extremity starts with the 3rd palmar interosseous and associated lumbrical muscles (See Figure 2.14 and Table 2.13). From here it continues as the flexor digiti minimi, opponens digiti minimi, and palmaris brevis muscles. Above this it ties into the medial aspect of the elbow with the flexor digitorum superficialis, palmaris longus, and pronator teres muscles. From here it extends on the upper arm with the brachialis and the triceps brachii, medial head. It travels across the bosom to ties into the center of the chest with the pectoralis major, lower sternal, costal and abdominal portions, and has its insertion in the upper arm. From here it is fastened to the ligaments that descend to the umbilicus including the costoxiphoid and linea Alba ligaments. (*LS 13*)

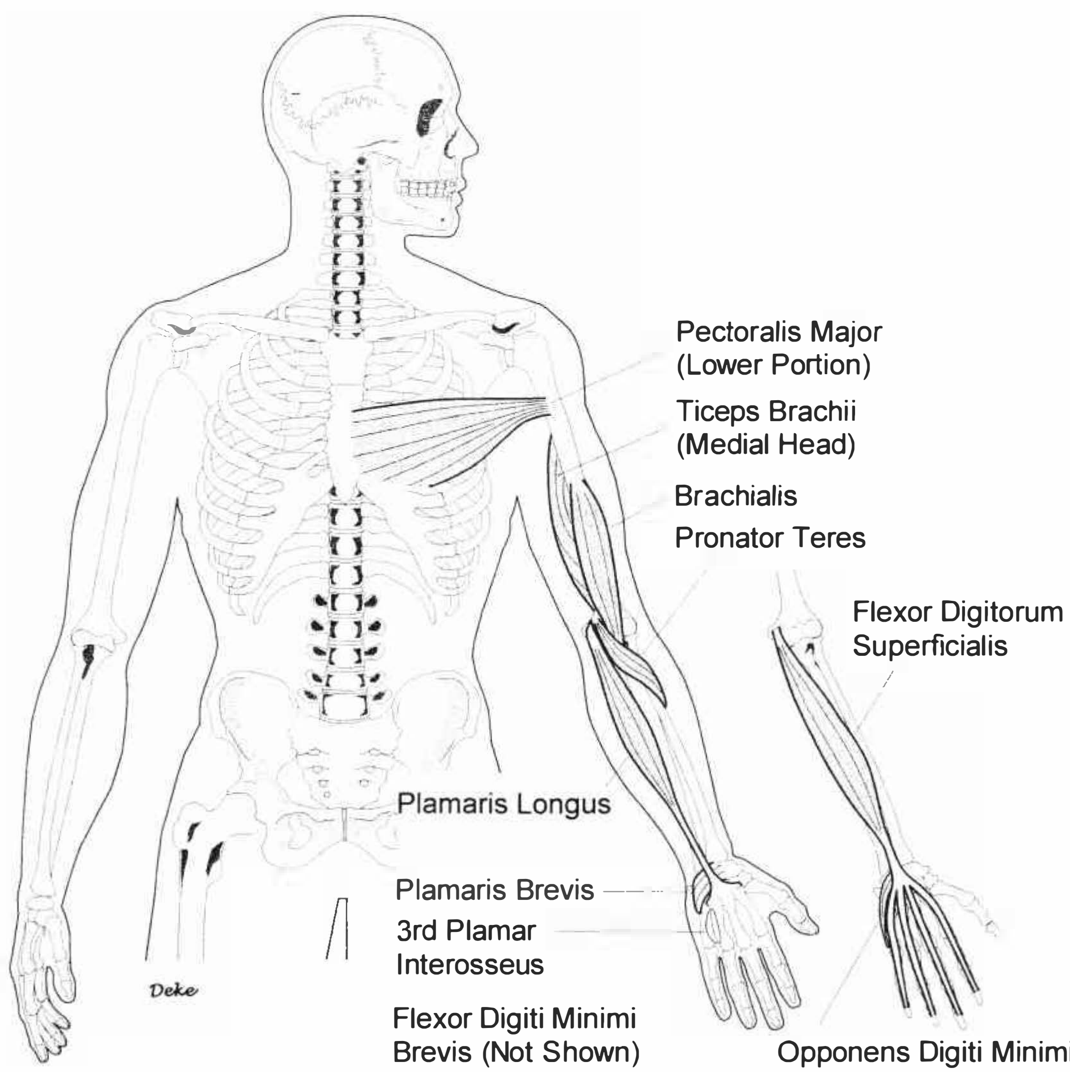



Figure 2.14. Muscles of the posterior medial hand (PMH) longitudinal body region

Table 2.13. Muscles of the posterior medial hand (PMH) longitudinal body region

| Muscle | Function | Origin | Insertion | Innervation & Root |
|---|---|---|---|---|
| Pectoralis major, lower sternal, costal and abdominal portions | Adducts, flexes and rotates arm medially | Lower half of sternum; aponeurosis of external oblique; costal cartilages of middle and lower ribs | Lateral border of bicipital groove of humerus | Anterior thoracic C7, 8, T1 |
| Triceps brachii, medial head | Extends forearm | Posterior surface of shaft of humerus below lateral head | Olecranon of the ulna | Radial C6, 7, 8, T1 |
| Brachialis | Flexes forearm | Lower half of anterior surface of humerus | Coronoid process and tuberosity of the ulna | Musculocutaneous and radial C5, 6 |
| Pronator teres | Pronates forearm and hand | Coronoid process of ulna and medial epicondyle of humerus | Middle lateral surface of shaft of radius | Median C6, 7 |
| Flexor digitorum superficialis | Flexes middle and then proximal phalanges | Coronoid process of ulna and medial epicondyle of humerus, humeroulnar head; radial head; anterior border of radius | Middle phalanges of fingers | Median C7, 8, T1 |
| Palmaris longus | Flexes wrist | Medial epicondyle of humerus | Palmar aponeurosis | Median C7, 8, T1 |
| Palmaris brevis | Wrinkles skin on side of hand | Central part of palmar aponeurosis and transverse carpal ligament | Skin of ulnar side of hand | Ulnar C8, T1 |
| Flexor digiti minimi brevis | Flexes little finger | Hamate; flexor retinaculum | Ulnar side of base of proximal phalanx of little finger | Ulnar C8, T1 |
| Opponens digiti minimi | Flexes and laterally rotates little finger | Hamate; flexor retinaculum | Ulnar side of 5th metacarpal | Ulnar C8, T1 |
| Lumbrical III & IV | Flexes 1st and extends 2nd and 3rd phalanges | Tendon of flexor digitorum profundus muscle | First phalanx and extensor tendon of 5th finger | Median and ulnar C8, T1 |
| 3rd palmar interosseus | Adducts little finger | Fifth metacarpal bone | Dorsal digital expansions of little finger | Ulnar C8, T1 |

### *PMH Muscle Pathology*

Serious disorders of this muscular longitudinal pathway include a condition called "fu liang", which means bent over like a bridge. This disorder causes pressure on the heart and a sensation in the arms like a net wrapped around the elbow. Ordinary disorders of this muscular distribution include acute cramps and muscular pain in the muscles along its traveling route (this includes conditions affecting the fingers, hands, wrist, arm, elbow, shoulder, and chest). (*LS 13*)

### *PMH Treatment Strategies*

To treat these disorders, quick insertion with a (previously) heated needle of indefinite duration, should be employed. To understand the duration and frequency of treatment involves assessing the effectiveness by palpation of painful and sensitive locations and neurovascular nodes along these muscular pathways. If the condition of "fu liang" worsens to include the spitting of blood and pus, there is no cure and death will follow. Symptoms associated with this distribution are called “late-winter” rheumatism. (*LS 13*)

# 3

# Basis of Chinese Orthopedics

The Chinese approach to orthopedics is based on a solid foundation of historically-based information as understood by present day views of anatomy and physiology involving the cardiovascular, musculoskeletal, and nervous systems. Critical to this is the sophisticated Chinese understanding of the vascular system, including identification of critical neurovascular nodes (acupoints) and their pathways supplied by superficial vessels, and the elucidation on the longitudinal organization of the muscular system (See Chapter 2). Key to the Chinese efforts was the fact that longitudinal organization of the bodily systems is dominated by spinal segmental related events that give rise to somatovisceral and somatosomatic relationships and directing needling-induced restorative actions. It is now understood that these features are mediated by axial (longitudinal) relationships of the spinal cord that communicate with peripheral nerves at specific spinal segmental levels.

Chinese orthopedics relies on a physiological understanding of the mechanisms induced by needling (acupuncture) (Chapter 2). Knowledge of these mechanisms in conjunction with the longitudinal muscular distributions provides a rational approach to develop effective Chinese treatment protocols for orthopedic conditions. The Chinese have a long history in treating orthopedic conditions including trauma and war wounds. They also resolved dislocated joints, treated fractures, and performed surgical procedures related to orthopedics. In addition, the Chinese conducted orthopedic examinations based on observation, examination, and movement of body limbs and joints, and also conducted reflex testing. They also developed a wide range of active care modalities involving flexibility, movement, rehabilitation, and strengthening exercises.

## Logical Process of Assessment and Diagnosis

Orthopedic examination, assessment, and diagnosis rely on a solid understanding of functional anatomy including the essential importance of the nervous system. Focus is on those aspects of anatomy and physiology related to orthopedic function and dysfunction. Disability or pain involving the musculoskeletal system manifests mainly in the muscles and joints of the body. Problems are usually reflected in the articulation of specific body regions or limbs and may be isolated to a particular longitudinal muscular distribution. By careful clinical examination of the articular system it is possible to isolate the most likely muscles, tendons or joints involved in a particular problem.

All movable joints have corresponding tendons, muscles, ligaments, and synovial capsules. These unique anatomical characteristics provide a basis for specific tests and reflexes yield objective information by which to make a diagnosis. Two of the most important tests involve range of motion (ROM) and muscle strength testing. Characteristics of the joint performance through the range of motion including the feel at the end of joint movement can be assessed as well as possible problems affecting the joint capsule. Key reflexes and sensibility testing along with the information derived on key muscles, permits a neurological evaluation of the presenting problem.

Collection of valid information pertaining to the problem can follow a somewhat logical process that starts with a complete patient history. Initial observations can provide a gross understanding of the limitations imposed by the problem. More specific active movements on part of the patient then provide specific indications. Special orthopedic tests may be considered to develop a better understanding of the problem. Neurological assessment in terms of reflexes and cutaneous distributions provide additional information to further assess the presenting problem. Joint behavior is then assessed by practitioner controlled passive (on part of patient) movements. Affected areas of the body and palpated and specific diagnostic imaging studies may be considered. The orthopedic assessment is preceded by review of the regional anatomy, physiology, and pathology. Finally a treatment plan is devised to address likely problems of the particular body region. This musculoskeletal assessment sequence and treatment is repeated in Chapters 6 through 17 that address all major areas of the body that include:

- Regional anatomy
    - Osteology and arthrology
    - Muscles, nerves, and vessels
    - Surface anatomy
- Normal physiology
    - Muscular distributions
    - Kinesiology
- Typical conditions affecting area
- Musculoskeletal Assessment
    - Patient history (Subjective)
    - Observation (Objective)
    - Examination of movement (Assessment)
        - Active
        - Passive
        - Resistive
    - Special tests
    - Reflexes and cutaneous distribution
    - Joint play movement
    - Palpation of affected area(s)
    - Diagnostic imaging
- Treatment planning and protocols (Plan)
    - Massage, mobilization, and manipulation
    - Needling therapy including possible electroneedling (EN)

- Movement and rehabilitation exercise
- Herbal remedies (herbal remedies are not recommend in this text)

## Rational Basis of Chinese Therapeutics

Chinese therapeutics strategies where derived in China and used to address orthopedic conditions. These approaches have been in use since ancient times and has survived today with little change. The main principle of application relies on the anatomical organization and physiological relationships of the body, including longitudinal (axial) and segmental relationships of the spinal cord. Most important of these is utilizing the twelve longitudinal muscular distributions and related neurovascular node pathways in a systematic approach to bring about restorative responses (See Chapter 2).

### *Treatment Strategy*

Inserting a needle anywhere in the human body will bring about complex defensive reactions that are mediated by tissue damage responses, immune complement system activation, differential neurogenic local blood vessel control, nociceptive and proprioceptive responses, and sustaining the response through neurogenic mechanisms. The overall effect is to activate central nervous system (CNS) mediated descending control to specific spinal segmental levels in order to reduce pain, reduce muscle spasms, restore blood flow, and restore autonomic balance and homeostasis (See Chapter 2).

Restorative descending control is provided to the area of the body which originated the needling responses. Recognition of this fact allows the practitioner to apply a rational scheme to direct restorative descending control responses to obtain the most efficient therapeutic effect. This involves the use of appropriate neurovascular nodes in local and adjacent area of the problem in conjunction with proximal and distal nodes (See Figure 1.3). The result is to direct descending control over a range that brings restorative actions the cover the area of the problem being treated (See Chapters 6 - 17 for treatment protocols).

## Anatomical Orientation and Nomenclature

Certain nomenclature systems applied to describing certain features of the human body were developed over the years to derive a standard method of reference when relating information from one practitioner to another. The Chinese may have been the first to use such a system. The West developed the idea of using imaginary orthogonal planes as a reference to describe body articulation.

### *Chinese Anatomical Position*

In very early times the Chinese identified the major vessels in the body by the regions to which they distributed. They used sun relative positions during the day and night to describe six longitudinal lateral and medial body regions for the upper and lower extremities (See Figure 1.2, and Table 1.2). Specifically identified longitudinal muscles, vessels, nerves, and neurovascular nodal (acupoint) were assigned to these pathways. Peripheral vessels are considered to form somatovisceral relationship since the vessels and related nerves supply both the superficial body regions and internal organs. However, the muscles are considered not to communicate with the internal organs and therefore musculoskeletal conditions are treated as external disorders.

### *Conventional Anatomical Orientation*

The Western anatomical positions are based on the prone position of a cadaver and hence the hands are rotated to upward. When applied to the human subject in the erect standing position the palms face forward. This position may not be consistent with the organization and function of body tissues, vessels, nerves and even sweat glands and pores of the skin. A set of three mutually perpendicular imaginary planes are used as a reference in describing orientation and articulation of body regions. One of the three planes is known as the frontal or coronal plane that divides the body into anterior and posterior sections. The second plane divides the body into right and left sections and is called the sagittal plane. If this plane splits the body down the midline, it is referred to as the midsagittal (median) plane. If it cut though the body away from the midline, then it is called a parasagittal plane. The third plane is horizontal and divides the body into upper and lower sections. This is also known as a transverse plane. The standard planes and axes of the body are summarized in Table 3.1.

Table 3.1. Planes and axes of body

| Plane | Description of Plane | Axis of Rotation | Description of Axis | Most Common Movement |
|---|---|---|---|---|
| Frontal (coronal) | Divides body into anterior and posterior sections | Sagittal | Runs anterior/ posterior | Abduction, adduction |
| Sagittal/ Parasagittal | Divides body into right and left sections | Frontal/ Transverse | Runs medial/lateral | Flexion, extension |
| Horizontal (transverse) | Divides body into upper and lower sections | Longitudinal (vertical) | Runs superior/ inferior | Internal rotation, external rotation |

## Review Blood Vascular System

The vascular system is fundamentally important in normal function and health since the perfusion of oxygenated blood and nutrients, and a host of other essential substances to all tissues is critically important. This includes arterial supply by the proximal capillaries to all the body cells comprising the nerves, brain, muscles, bones, skin, and internal organs with the distal capillaries carrying away metabolic waste products and carbon dioxide ($CO_2$) in the venous return blood return. The musculoskeletal system needs to be continually supplied with oxygenated blood and nutrients for proper function, consistent with the demand placed on muscular activities. Metabolic byproducts, including carbon dioxide, also need to be transported out of the muscular tissue.

Some musculoskeletal conditions are the result of local and temporary impairment of blood flow known as ischemia (holding back blood flow). Ischemic conditions affecting the peripheral vascular system are very serious, but even slight restriction of blood to the skeletal muscles, especially if it is sustained, can produce pain and dysfunction. One obvious example is when blood flow is restricted to cardiac muscular tissue; it produces significant pain known as angina. This pain often reflects in the left arm along the

Chinese posterior medial hand (PMH) anatomic division (See Table 1.2) related to the heart. If blood restriction to the heart muscle is significant, it is commonly fatal.

## Vessel Distribution Organization and Pathways

The single greatest discovery of the ancient Chinese is that the vessels in the extremities and superficial regions of the trunk follow along specific longitudinal pathways. It is now known that the vessels are accompanied by related sympathetic nerves. Collateral branches of the superficial vessels supply the skin area with a dense distribution of fine vessels along with sensory nerve fibers. This superficial branching of vessels and associated afferent and efferent nerve fibers give rise to the neurovascular nodes (acupoints). These are the nodes of needling therapy that distribute along the Chinese longitudinal pathways of the body. Muscles of the body are supplied by these vessel distribution and the muscles themselves are organized in a similar manner.

### *Vascular Control*

Blood flow is controlled by sympathetic influence on the heart and vessels and by parasympathetic influence on heart function. Sympathetic outflow increases heart rate, breathing rate, blood pressure, restricts blood flow to the gut and upper extremities, shunts blood to the lower extremities, and bronchial dilates the lungs. Parasympathetic outflow basically normalizes the impact of sympathetic stimulation. The vessels receive efferent motor signals and transmit afferent sensory impulses via sympathetic neural fibers. These are distributed to and from the vessels via the paravertebral sympathetic ganglia that lie on both sides of the thoracic and lumbar vertebra.

Neural control of the vessels is mediated mainly by contacting arteries and arterioles. Veins have less sympathetic control that does come into play when tissue is damaged, even by needling. The response increases blood flow to the area in question to bring in immune cells and activate restorative processes. The veins that drain the affected area are constricted to help force immune cell egress from capillaries in the damaged area. The overall effect is differential neurogenic control in to response tissue damage including that due to needling therapy.

### *Deep Transmission of Environmental Influences*

Because of superficial branching of blood vessels to the surface of the body, the Chinese determined that environmental factors, left unchecked, can transmit deeper into the body by virtue of influence directly on the vessels. These mechanisms are operative in many musculoskeletal problems as well as in visceral dysfunction. Environmental factors first attack the fine vessels in the skin and if left unchecked, the effect moves deeper along the vascular route. Certain hallmark symptoms including pain are noted at each penetration level. Extreme cases of environmental factors penetrating the body can result in either hypothermia and hyperthermia or heatstroke, both of which can be fatal. Sometimes the effect of cold impacts the sympathetic nerve fibers distributed to a particular area impairing blood flow to that area even after the body warmed.

# Review of Musculoskeletal System

Skeletal muscles represent complex structures of muscle tissue, fascia, and tendons that distribute across a joint and attach to the two bones making up the articulation. The attachment location to where the muscle contact is known as the "origin" while the other attachment on the bone that moves during contraction is known as the "insertion" point. Muscle tissue consists of fibers (cells) that are highly specialized to exert force by converting chemical energy into tension and contraction. As result of this characteristic, muscle tissue provides motion, maintenance of posture, and heat production. On the basis of certain functional and structural characteristics, muscles are classified into the three categories of: skeletal, cardiac, and smooth.

Skeletal muscle tissue is considered to be striated since the fibers (cells) contain alternating light and dark bands (striations) that are perpendicular to the long axis of the fibers. These striations are visible under a microscope. Skeletal muscle tissue is also considered to be voluntary in that it can be made to contract by conscious control. A single muscle fiber is cylindrical, and the fibers are all parallel to each other in a tissue. Each muscle fiber contains a plasma membrane, the sarcolemma surrounding the cytoplasm, or sarcoplasm.

Skeletal muscle fibers are multinucleate, having more than one nucleus, where the nuclei lie close to the sarcoplasm. The contractile elements of skeletal muscle fibers are proteins called myofilaments. They contain wide, transverse, dark bands and narrow light ones that give the striated appearance. Each of more than 600 muscles is served by nerves which link the muscle to the brain and spinal cord. Skeletal muscles are the body's most abundant tissue, comprising about 23% of the female body weight and about 40-45% of the male body weight.

## Review of Bone Physiology

Bones consist of the hard form of connective tissue that constitutes the skeleton of most vertebrates. They are the structural components of the skeleton which provides insertion and origin locations for muscular attachments across a joint which permits movement of the joint when the muscle is contracted. Bone, also called osseous tissue, consists of an organic component of cells and matrix, and an inorganic mineral component. The matrix, which imparts the rigid quality to bone, contains a framework of collagenous fibers and is impregnated with the mineral component which consists of 85% calcium phosphate and 10% calcium carbonate.

Although seemingly rigid, osseous tissue is very dynamic with some part of each bone continuously being broken down by the action of osteoclast cells (a large multinuclear cell associated with absorption and removal of bone) and reabsorbed. At the same time new bone growth take place by the osteoblast cells derived from fibroblasts, replacing that which was previously dissolved and reabsorbed. In this way the bones are viable and living structures that are continually renewed. These same processes are involved in the healing mechanisms of bone fractures.

Unfortunately, the body considers the bones to be a storehouse for calcium. Hence, many situations occur where the body breaks down bone tissue to provide needed calcium. Most common of these events is emotional stress which will trigger the release of parathyroid hormone which will promote the breakdown of bone. Smoking will also have the same effect. Diets chronically low in calcium or one that contains excess calcium phosphate (contained in many soft drinks) will result in impaired calcification of bone, resulting in weak bones and failure to heal fractures. The Chinese considered that the kidneys were responsible for controlling the bones. As it turns out this idea is true since the kidneys are responsible for maintaining a constant product of calcium and phosphorous. Consequently, any diet that is either deficient in calcium or provides an excess of phosphorous, can lead to problems and weakness of the bones.

Bones receive load signals when moving the body or working where external forces, such as the forces due to gravity, provide a load signal for the bones to develop sufficient strength to maintain viability. Lack of proper exercise will cause the body to lose bone strength. The most serious problem with space flight is that astronauts suffer serious calcium loss since they are basically operating in a zero gravity situation.

## Body Joints

The body contains a variety of immovable joints that basically hold critical parts of the skeleton together and moveable synovial joint articulations and their associated joint capsules for moving the body.

### *Immovable Joints*

Types of immovable joints include:

- Fibrous joints such as sutures and other joints of the skull
- Cartilaginous joints such as the pubis symphysis and the synchondrosis between the manubrium and the body of the sternum
- Osseous joints of the sacrum

### *Moveable Joints*

The moveable joints usually involves two of more bones with articular cartilage on their moveable contact surfaces that fall into to certain classifications based on their fundamental structure and mechanical function. Major joints of the arms and legs can be articulated to the end of their range of motion. The characteristics of this "end feel" provide diagnostic information about the joint function. Types of joints of the arms and legs are classified as follow:

- Shoulder joint which is considered to be a condyloid joint with the head of the humerus articulating with glenoid fossa of the scapula
- Hip joint which is a true ball and socket joint with the head of the femur articulating within the hip socket
- Wrist joint which is an ellipsoid joint where the radial bone and ulna articulate with the wrist bones
- Interphalangeal joints and the ulna articulation with the humerus are considered hinge joints

- Rotation of the radial bone on humerus that allows pronation of the arm is considered a pivot joint
- Articulation of the tibia and fibula on the talus is considered a cochlear joint
- Articulation of the carpo-metacarpal joint of the thumb is considered a saddle joint
- Articulation of the navicular with the intermediate and lateral cuneiform of the foot is considered a plane joint

### *Spinal Column*

The spinal or vertebral column is like a somewhat flexible rod held together by strong ligaments. It is perhaps the most important body structure and accounts for about 40% of person height. The spine consists of 24 vertebrae separated by 23 intervertebral discs, plus the fused bones of the sacrum and the coccyx (See Figure 3.1). The spinal column supports the weight of the upper body, and together with related muscles and ligaments, enables upright posture and walking. An interior opening (vertebral foramen) in the vertebrae provide a protective channel for the spinal cord which gives rise to spinal nerves distributed to the body at every segmental level between each vertebra. An intervertebral foramen is formed by features between two vertebra separated by an intervertebral disc, through which spinal nerves are distributed.

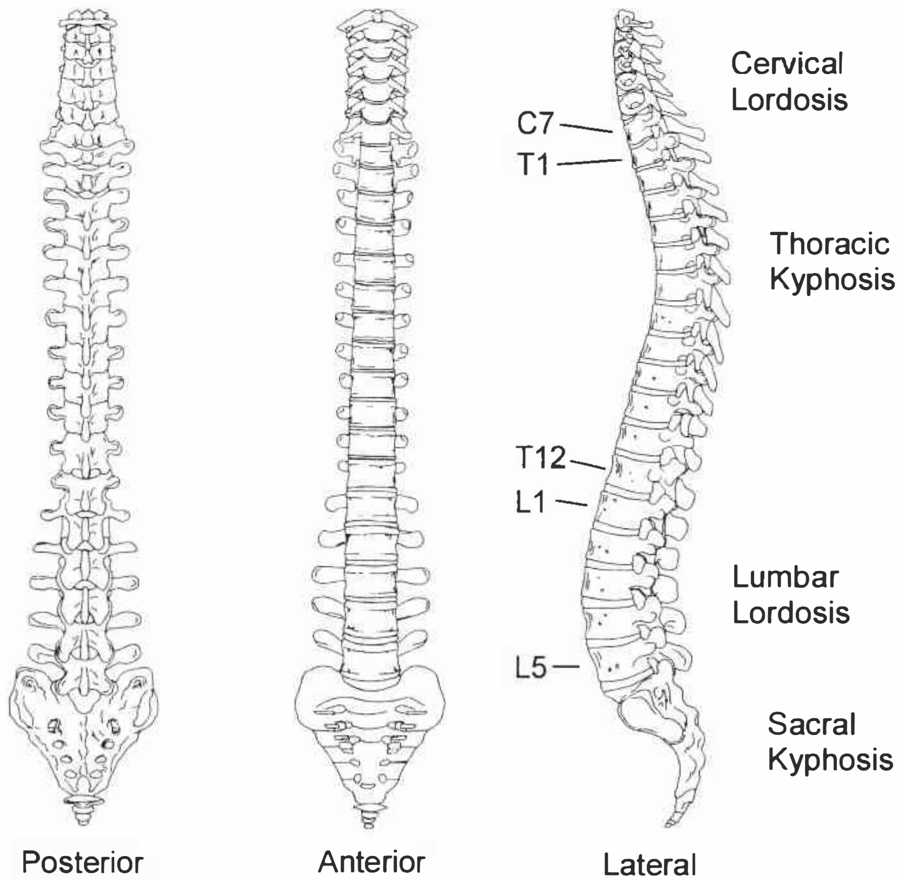



Figure 3.1. Posterior, Anterior, and Lateral View of Spinal Column showing Normal Curves.

The cervical region of the spine is comprised of seven vertebrae (designated as C1 through C7), the thoracic region has 12 vertebrae (T1 - T12) and the lumbar region has five vertebrae (L1 - L5). The sacrum consists of five vertebrae all fused together to form one continuous bone mass. The coccygeal region consists of four fused vertebrae to form the coccyx or tailbone.

**Vertebrae**

With the exception of C1 (the atlas which articulates with the occipital bone of the skull), all vertebrae have a strong load bearing body along with an intervertebral disc that carries the successive weight of the body above its location in the spine. Vertebrae also have other features including spinous and transverse processes, and a vertebral foramen through which the spinal cord and the cauda equina (in the lumbar vertebrae) distribute. Vertebrae C3 through L5 also have superior and inferior articular processes which form facet joints between adjacent vertebrae.

The vertebra in each area of the spine is somewhat different in nature and function. Cervical vertebrae are lighter in structure and movement of the cervical spine is more flexible, especially between the atlas (C1) and the axis C2). Cervical vertebrae also have transverse foramen through which the vertebral arteries and veins distribute (See Figure 7.2). Thoracic vertebrae are heavier than those in the cervical spine and they also have facets that articulate with the ribs (See Figure 12.1). Typically, there are two costal facets with one on the transverse process and one on the vertebral body (See Figure 12.2). Sometimes this latter facet represents only half of the articular process (demifacet) with the other half being on the vertebral body above or below. The lumbar vertebrae are much larger since they must carry all of the body weight above sacrum (Figure 13.1).

**Intervertebral Discs**

There is an intervertebral disc below the bodies of each vertebra from C2 (the axis) to L5 that provides spacing between the bony structures and contributes to the flexibility of the spine. Discs are composed of fibrocartilage material consisting of a fibrous outer lining or ring (annulus fibrous) and a pulpy gelatin-like inner core (nucleus pulposus). These discs are under constant pressure making them susceptible to "wear and tear" problems, and actual rupture due to traumatic events. The intervertebral discs also tend to dry out and shrink due to aging. This reduces flexibility and spacing between the vertebral bodies which results in orthopedic conditions including the formation of osteophytes and nerve impingement.

**Facet Joints**

The superior and inferior articular processes of the vertebrae form facet joints where they articulate on vertebrae above and below from C3 through L5. These facet joints are enclosed by a joint capsule. Purpose of spinal facet joints is to provide rotational stability of the spine, and hence they greatly restrict spinal rotation. The thoracic vertebrae also have costal facets where the ribs articulate. The costal-thoracic joint is also enclosed by a joint capsule.

### *Joint capsules*

The joint articulations are surrounded by a lose sac-like envelop of inert ligamentous tissue which encloses the cavity of a synovial joint. The capsule has an internal synovial membrane that contains synovial fluid. Some conditions of the joint capsule such as capsulitis can impair joint function.

## Muscular System Organization

One of the most unique organizational features of the muscular system involves longitudinal association and grouping discovered by the Chinese. Here the musculoskeletal system is organized into 12 distinct longitudinal distributions related to the nerves and blood vessels supplying the same regions. These distributions are discussed in detail in Chapter 2. Pain and pathology can reflect along the muscular distributions which allow a convenient approach for assessment and treatment.

### *Neuromuscular Attachments (Motor Points)*

Efferent motor signals to skeletal muscles are supplied by peripheral nerves (including some cranial nerves for the head and face) emanating at specific spinal levels. These motor nerves attach to particular sites of the muscles known as neuromuscular attachments or simply motor points. Specific muscles are supplied by discrete spinal root levels and the location of the muscle is viewed terms of a myotome with respect to the segmental level. The trapezius and sternocleidomastoid are supplied by the spinal accessory nerve (CN 11) portion that derives from the first five cervical segments of the spinal cord. The muscles of mastication are supplied by the trigeminal nerve (CN 5) while the facial muscles of expression are supplied by the facial nerve (CN 7).

### *Muscle Fiber Characteristics*

Muscles are composed of fast twitch phasic fibers and slow twitch tonic muscle fibers (See Table 3.3). Those that have a high percentage of the slow twitch fibers are the postural muscles and are resistant to fatigue. Tonic muscles have a tendency to developing tightness and contractures. Muscles with a high percentage of phasic fibers are quickly contracted and relaxed and are easily fatigued. Phasic muscles have a tendency to develop weakness. Many muscles have a somewhat equal distribution of both phasic and tonic fibers and are considered to be intermediate in terms of speed and fatigability. Many important neurovascular nodes (acupoints) are located in tonic muscles while the phasic muscles have few nodes.

### *Propagated Sensation along Vessel and Muscular Pathways*

The body's response to needling involves the activation of nociceptive (pain) fibers and proprioceptive (position and load sensors) fibers. Proprioceptive fiber participation is mainly required in order for muscle to contract in response to an upper motor neuron signal from the motor cortex. The proprioceptive fibers activated by needling also produce the phenomena of propagated sensation when threshold conditions are proper.

### *Formation of Sensitive/ Trigger Points*

The highly integrated system of muscular control and the related sensory functions give rise to the mechanisms that produce the spontaneous formation of a sensitive or painful location. These were later called trigger points to indicate that pathology in one muscle can cause a painful spot to occur in another location. These are basically somatosomatic referred pain locations that usually occur along a particular or related muscular distribution. Palpation of the sensitive areas are used in assessment and determining the success of treatment. Since both somatic and visceral pain signals integrate in the same spinal segments, somatovisceral and viscerosomatic relationships also exist. Hence, some painful phenomena are actually an indication of internal organ inflammation or dysfunction.

Table 3.3. Characteristics of fast, intermediate and slow twitch muscles fibers.

| Phasic (Fast Twitch) | Intermediate | Tonic (Slow Twitch) |
|---|---|---|
| • Pale in color | • Red in color | • Red in color |
| • Few mitochondria | • Many mitochondria | • Many mitochondria |
| • Poorly vascularized | • Richly vascularized | • Richly vascularized |
| • Anaerobic metabolism (uses glycolysis) | • Both oxidative (myoglobin) and anaerobic (glycolysis) metabolism | • Oxidative metabolism (myoglobin) |
| • Quick contraction and relaxation | • Intermediate range of contraction and relaxation | • Slow contraction and slow relaxation |
| • Fatigue easily | • Medium range of fatigability | • Resistant to fatigue |
| • Develop wide range of tensions | • Average tension range | • Develop tension over narrow range of displacement |
| • Suited for high intensity short-duration muscular activity | • Suited for muscles of motion where wide range of performance activity is crucial | • Suited for long-term contraction such as needed in maintaining posture |

## Conditions Affecting Musculoskeletal System

Most diseases, injuries, and problems affecting the musculoskeletal system have been described since ancient times. Many of these conditions are still denoted or designated by use of Greek terms, as are many problems identified in more recent times. The Chinese also described most musculoskeletal and traumatic conditions including fractures, dislocated joints, and even including broken neck and its treatment. They also described various forms of arthritis and rheumatism due to restricted blood flow to the musculoskeletal system. In addition, they described flaccid conditions including atrophic disorders, trauma, nutritional problems, and also includes rheumatoid arthritis. Ancient Chinese provided a clear description of pain due to rheumatic fever which they referred to as "wandering or circular pain," They described all types of strain, sprain, swelling, and pain conditions, including low back pain. Cerebral vascular accident (CVA) or stroke was described separately and noted to be the result of major blockage of vessels in the brain.

### *Present Day View*

Chinese orthopedics uses standard Western disease terminology including that for musculoskeletal conditions since this represents the World body of evidence based understanding. This allows practitioners to be able to communicate with the medical community to best serve patient needs. It also allows practitioners to communicate with patients using the same type of information they received from their physicians or diagnostic centers, or detailed information they may have obtained on the Internet. Some of the more commonly encountered conditions and terms applied in orthopedics include:

- Ankylosing spondylosis: indicates ankylosis of the vertebrae
- Ankylosis: indicates consolidation or immobility of a joint due to a disease, injury, or surgical procedures
- Arthritis: rheumatism in which the inflammatory lesions are confined to the joints manifesting as acute, rheumatic, osteoarthritis, and rheumatoid arthritis
- Bursitis: is an inflammatory lesion of a bursa; sometimes accompanied by a calcific deposit in its associated tendon, such as the supraspinatus tendon and other common tendons. Usually results in clinical signs of sharp pain along with impaired active and passive range of motion in the affected joint or region
- Capsulitis: is an inflammatory lesion of a joint capsule that can lead to capsular thickening and contraction with loss of internal joint volume resulting in clinical signs of pain and stiffness in the active and passive range of motion of the joint
- Common soft tissue injuries: involves lesions to muscles, tendons, tenosynovial sheaths, joint capsules, ligaments, and bursae
- Disc injuries and herniation: occur mainly in cervical and lumbar spine often involving a lateral herniation which compresses the nerve root below, such as a C5-C6 disc herniation compresses C6 nerve root. Acute disc herniation usually occurs in younger patients which may result in a soft disc protrusion from nuclear herniation. Chronic disc disease affects older patients resulting in a hard disc lesion associated with spondylosis
- Fractures: refers to broken bones, including vertebrae, which can be classed as a:
    - Simple fracture with single fracture line through a bone without breaking the skin
    - Comminuted fracture with the bone broken into two or more fragments; or
    - Compound or open fracture where the bone penetrates the skin
- Frozen shoulder: highly restrictive movement of the arm due tendinomuscular problems of the shoulder; or adhesive capsulitis
- Gout and pseudogout: are the two most common crystal-induced debilitating illnesses arthropathies in which pain and joint inflammation is caused by the formation of crystals within the joint space:
    - Gout is inflammation caused by monosodium urate monohydrate (MSU) crystals
    - Pseudogout is inflammation caused by calcium pyrophosphate (CPP) crystals and is sometimes referred to as calcium pyrophosphate disease (CPPD)
- Ligament sprains: a joint injury is which fibers of the supporting ligament are torn, classed as:
    - First degree sprain (1°) when few ligament fibers are torn
    - Second degree sprain (2°) when about half of ligament fibers are torn

  - Third degree sprain (3°) when all fibers of the ligament are torn
- Muscle strain: an injury in which contractile tissue is damaged, classed as:
  - First degree strain (1°) when few muscle fibers are torn
  - Second degree strain (2°) when about half of muscle fibers are torn
  - Third degree strain (3°) when all fibers of muscle are torn (rupture)
- Nerve injury and compression, graded as:
  - First degree (1°) neuropraxia involving transient physiological block caused by ischemia due to pressure or stretch of the nerve with no Wallerian degeneration
  - Second and third degree (2° and 3°) axonotmesis where internal architecture of nerve is preserved but axon is cut or crushed causing Wallerian degeneration in which the part of the axon separated from the neuron's cell nucleus degenerates. This is also known as anterograde degeneration.
  - Fourth and fifth degree (4° and 5°) neurotmesis where structure of nerve is destroyed by cutting, severe scarring, or by prolonged severe compression
- Osteoarthritis: is a degenerative joint disorder occurring mainly in older people characterized by degeneration of the articular cartilage, hypertrophy of bone at the margins, and changes in the synovial membrane, and is accompanied with pain and stiffness
- Osteopenia: is a condition where bone mineral density is lower than normal and often considered to be a precursor to osteoporosis. Osteopenia is defined as a bone mineral density T score between -1.0 and -2
- Osteoporosis: is a systemic skeletal disorder characterized by decreased bone mass and deterioration of bony microarchitecture. The result is fragile bones and an increased risk for fracture even with minimal trauma. Osteoporosis is a chronic condition of multifactorial etiology and usually is clinically silent until a fracture occurs
- Reflex sympathetic disorder (RSD): this is a serious degenerative disorder that is also known as "regional pain syndrome" of unknown etiology that has sympathetic neural involvement
- Rheumatoid arthritis: is a chronic systemic inflammatory disease of undetermined etiology involving primarily the synovial membranes and articular structures of multiple joints. Disease is often progressive and results in pain, stiffness, and swelling of joints. In late stages deformity and ankylosis develop
- Spondylitis: denotes inflammation of the vertebrae; also indicates hypertrophic changes in the vertebrae, including osteophytes (a bony excrescence or osseous outgrowth)
- Spondylolisthesis: a shifting or subluxation of one vertebra upon another, usually anteriorly; or could be degenerative deformities of the spine

- Spondylosis: a general term for degenerative vertebral changes due to osteoarthritis; or ankylosis of a vertebral joint
- Spondylolysis: a dissolution of a vertebrae; or aplasia of the vertebral arch and separation of the pars interarticularis
- Sprain and strains: involves injury to joints and muscles involving ligaments (inert tissue) and contractile tissue (muscle, tendons, and attachment) graded in terms of 1°, 2°, and 3° (see ligament sprain and muscle strain above)
- Tendonitis: indicates inflammation of tendon
- Thoracic outlet syndrome: is a brachial plexus peripheral nerve entrapment by the anterior scalene muscle or where the nerve traverses under the clavicle
- Vertebral artery syndrome: problem caused by affect on vertebral arterial flow into the brain possibly resulting in vertigo or visual problems

## Nervous System Review

The nervous system can be viewed in terms of the central nervous system (CNS) and the peripheral nervous system (PNS). Included within this system are components that mediate the motor and sensory functions of visceral systems including the blood vessels and is referred to as the autonomic nervous system (ANS). The ANS is further divided and classified into the sympathetic nervous system (SNS) and the parasympathetic nervous system (PSNS).

### Central Nervous System

The CNS consists of the brain and spinal cord which forms one continuous structure. The spinal cord contains various tracts of nerve cells that carry related or specific types of information. Neurons comprising the spinal cord mainly originate in the brain to provide (descending) signals to specific spinal segmental levels of the cord, or those that originate at spinal levels for sending signals to the brain (ascending) and other spinal cord areas. In addition there are numerous interneurons associated with the descending and ascending neurons.

### Autonomic Nervous System (ANS)

The sympathetic nervous system (SNS) branch and the parasympathetic nervous system (PSNS) branch of the ANS are the main functional innervation to all organs in the body. The SNS also innervates the blood vessels and presently there are no known distributions of PSNS fibers to the extremities. The auricle is the only place on the body where PSNS fibers in terms of small sprigs of the Vagus or 10th cranial nerve have a superficial distribution.

The ANS contains both autonomic sensory and motor fibers. The sensory nerves are afferent fibers that provide signals to the autonomic ganglia, spinal cord and brain on pain, pressure and temperature and information pertinent to vascular and organ function. The autonomic motor nerves are efferent fibers that provide control signals to the vessels and organs. The processes of acupuncture depend greatly on an interaction between these nerve fibers and those that innervate the muscles and superficial regions of the body.

Physiological responses of the PSNS and SNS can be viewed in terms of yin and yang qualities respectively, assigned to visceral characteristics by the early Chinese physicians. These classifications are valuable in understanding certain conditions or status of the internal organs.

## Peripheral Nervous System

The peripheral nervous system consists of cranial nerves directly from the brain and brainstem and peripheral nerves communicating with the spinal cord at specific segmental levels as described below. Except for the olfactory (CN I) and the optic (CN II) nerves, the nuclei of the cranial nerves are located in the brainstem. Cranial nerves I, II, and VIII are purely sensory while III, IV, VI, XI, and XII are motor nerves, and the last four, namely V, VII, IX, and X are mixed sensory and motor nerves.

### *Nerve Roots*

Nerve bundles connected to the dorsal and ventral horns of the spinal cord that combine close to the intervertebral foramen to form the 31 pairs of spinal nerves. The dorsal roots contain mainly afferent sensory fibers while the ventral roots contain both somatic and visceral efferent motor fibers. Specific nerve roots supply certain muscles to create a myotome. Lack of strength or dysfunction of key muscles then indicates possible problems at a particular root level (See Table 3.4.). Pain or dysfunction along peripheral nerve route emanating from a specific nerve root is referred to as a radiculopathy. Radicular pain is often produced in the distribution of a nerve root as a result of some sort of mechanical or irritation of that root.

### *Anterior and Posterior Rami*

After the spinal nerves exits the intervertebral foramen they divide into anterior and posterior rami to supply those regions of the body. The relationship of some neurovascular nodes (acupoints) rely on their anterior or posterior innervation, and the specific use of points to bring about certain responses.

Table 3.4. Key muscle function for representative nerve root levels.

| Root | Muscle Function | Root | Muscle Function |
|---|---|---|---|
| C1 | Head on neck flexion | C8 | DIP* flexion (flexor digitorum profundus) |
| C2 | Head on neck extension | T1 | Finger abduction (dorsal interossei) |
| C3 | Cervical lateral flexion | L2 | Hip flexion (iliopsoas) |
| C4 | Scapular elevation | L3 | Knee extension (quadriceps) |
| C5 | Shoulder abduction | L4 | Ankle dorsiflexion (tibialis anterior) |
| C6 | Elbow flexion (biceps) | L5 | Big toe extension (extensor hallucis longus) |
| C7 | Elbow extension (triceps) | S1, 2 | Ankle plantar flexion (gastrocnemius-soleus) |

*DIP: Distal interphalangeal joints

### *Spinal Nerves*

There are 31 pairs of nerves which connect with the spinal cord. Includes 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal. Spinal nerves are designated by their segmental level of the cord. Spinal nerves form plexuses where peripheral nerves are formed that distribute to various areas, especially the extremities.

**Cervical Plexus (C1 - C4)**

The cervical plexus is formed on both sides of the spine by the ventral rami of the first four cervical nerves (C1 - C4) with some contribution from the fifth cervical nerve (C5). This plexus supplies the skin and muscles of the head (not including facial muscles and muscles of mastication), neck, and part of the shoulders. Branches of the cervical plexus also connect with the spinal accessory nerve (CN XI) and the hypoglossal nerve (CN XII). The phrenic nerves are a critical pair of nerves rising from the cervical plexus that supply the motor function for the diaphragm. Paralysis of the diaphragm occurs when the spinal cord is damaged above the origin of the phrenic nerve. Without the ability to contract the diaphragm, the individual cannot breath.

**Brachial Plexus (C5 - T1)**

The brachial plexus is comprised of a network of nerves arising from both sides of the spine at the base of the neck. This plexus gives rise to the nerves supplying the arm, forearm, hand and some parts of the shoulder girdle. Anterior rami of cervical nerves C5 - C8 and first thoracic spinal nerves (T1) are the source input to the brachial plexus which runs between the spine and the upper arm just after the axilla.

Peripheral nerves formed by the brachial plexus innervate the shoulder, scapula, and upper extremity musculature can be injured through traumatic episodes and during athletic events. It is susceptible to blunt and penetrating trauma, traction injury, compression, and inflammatory conditions. In addition, peripheral nerves innervating the shoulder, scapula, and upper extremity musculature can be injured due to a fall, stretch injury, dislocation, or compression.

The general features of the brachial plexus involves spinal levels (C5 to T1) transitioning into 5 rami which subsequently divide into 3 trunks, which further divide into 3 cords. The cords then give rise to the peripheral nerves. The course of the brachial plexus nerves passes between middle and anterior scalene muscles, beneath clavicle, and passes beneath pectoralis minor (in axilla). The lower trunk (C8, T1) passes over first rib. Certain key sensory tests can give an indication if one of the peripheral nerves is involved in a particular problem (See Table 3.5).

Table 3.5. Major peripheral nerves of upper extremities with relevant motor and sensory indications.

| Nerve | Motor Test | Sensation Test |
|---|---|---|
| Radial | Wrist extension<br>Thumb extension | Dorsal web space between thumb and index finger |
| Ulnar | Abduction of little finger | Distal ulnar aspect - little finger |
| Median | Thumb pinch, opposition, and abduction | Distal radial aspect - index finger |
| Axillary | Deltoid | Lateral arm - deltoid patch on upper arm |
| Musculocutaneous | Biceps | Lateral forearm |

#### Intercostal (Thoracic) Nerves

The ventral rami of spinal nerves on both sides of the body from T2 - T12 do not enter into forming nerves plexuses. These are known as intercostal or thoracic nerves and distribute directly to the structures they supply in the intercostal spaces. The ventral rami of spinal nerve T2 supply the second intercostal space muscle and the skin of axilla and posteromedial aspect of the arms. Nerves T3 and T6 distribute to the intercostal muscles and skin of the anterior and lateral chest wall. Nerves T7 - T11 supply the intercostal muscles and abdominal muscles and overlying skin. The dorsal rami of the intercostal nerves supply the deep back muscles and the skin of the dorsal aspect of the thorax.

#### Lumbar Plexus

The lumbar plexus is formed by ventral rami of spinal nerves L1 - L4 on both sides of the body. This plexus differs from the brachial plexus in that there is no intricate interlacing of the fibers. The lumbar plexus passes obliquely outward behind the psoas major muscle (posterior division) and anterior to the quadratus lumborum muscle (anterior division). The resulting peripheral nerves supply the anterolateral abdominal wall, external genitalia, and part of the lower extremities. The femoral nerve is the largest nerve emanating from the lumbar plexus.

#### Sacral Plexus

The sacral plexus is formed by the ventral rami of spinal nerves L4 - L5 and S1 - S4 on each side of the body. This plexus is situated mainly in front of the sacrum and contains roots that form anterior and posterior divisions. The sacral plexus supplies the buttocks, perineum, and lower extremities. The largest nerve in the body, the sciatic nerve, arises from the sacral plexus. The sciatic nerve (L4 - S3) supplies the entire musculature of the leg and foot.

### *Dermatomes*

Cutaneous nerves are comprised of fibers from different spinal nerves at specific segmental levels and therefore patterns related to a particular spinal cord level reflect on the skin. These regions have significant diagnostic utility in differentiating symptoms to determine the affected root or spinal nerve level.

### *Cutaneous Nerve Distribution*

Cutaneous nerve distribute to unique regions of the skin, so loss of sensation in these specific areas can provide a clue to determine if only a specific cutaneous nerve is involved or if there a specific segmental level involved.

### *Myotomes*

Specific nerve roots carry fibers to groups or regions of muscle fibers. Pathology in an entire group of these muscles provides a clue concerning the affected root level. Myotomes in each of the areas covered in Chapters 6 - 17. A summary of root innervation to key muscles is provided in Table 3.6.

Table 3.6. Summary of spinal segment nerve root innervation levels for general muscles in the body

| Segment | Muscles |
|---|---|
| C1 - C4 | Neck Muscles |
| C3 - C5 | Diaphragm |
| C5 - C6 | Biceps |
| C5 -C8 | Shoulder Joint Muscles |
| C7 - C8 | Triceps and Long Muscles of Arm |
| C8 - T1 | Digit Movement and Small Intrinsic Muscle of Hand |
| T2 - T12 | Axial Musculature, Intervertebral, Respiration, and Abdominal Muscles |
| L1 - L2 | Thigh Flexors |
| L2 - L3 | Quadriceps Femoris |
| L5 - S1 | Gluteal Muscles |
| S1 - S2 | Ankle Plantar Flexors |
| S2 - S4 | Intrinsic Muscles of the Feet |
| S3 - S5 | Pelvic Floor Muscles, Bladder Sphincters and External Genitalia |

### *Sclerotomes*

A sclerotome represents an area of bone or fascia supplied by a specific nerve root. Sclerotomal pain is not well localized and has a deep seating characteristic. Sclerotomes are difficult isolate. Reflex tests and dermatome findings may indicate radicular involvement, but the sclerotomes may indicate referred pain.

### *Neurological Lesions*

Common neurological lesions are classed as to their source along the pathway including the spinal cord to the termination of a peripheral nerve. These include:

**Myelopathy:** a neurogenic disorder involving the spinal cord or brain resulting in an upper motor lesion. The symptoms and pattern of pain are different than that of radicular pain. Both the upper and lower limbs are often affected.

**Avulsion:** involves a severe injury where the nerves are pulled from the spinal cord as evidenced by a totally flaccid extremity.

**Radiculopathy:** a nerve root lesion that results in radicular or radiating pain due to a direct involvement of a nerve root or spinal nerve. Pain may be felt in a dermatome, myotome, or sclerotome.

**Plexopathy:** symptoms, dysfunction, and pain due to conditions including trauma that affect a plexus, especially the brachial plexus.

**Neuropathy:** is a lesion of the peripheral nerve.

### *Peripheral Nerve Injuries*

Because of their anatomical features, peripheral nerves are commonly affected by pressure, friction, traction (stretch), anoxia, and cutting. Peripheral nerves are also damaged by environmental conditions of cold or heat as well as electrical injury. These are classified as:

**Neuropraxia:** a transient ischemic physiological block due to pressure or stretch of the nerve with no Wallerian degeneration. Manifests with pain, no or little muscle wasting, numbness, with affected proprioception, and recovery is quick.

**Axonotmesis:** involves badly damaged axons resulting in Wallerian degeneration although the nerve internal architecture is preserved. Results of this injury manifests with pain, muscle wasting, and complete loss of sensory, motor, and sympathetic function. Recovery is slow with sensation restored before motor function.

**Neurotmesis:** is situation where the nerve has been destroyed by severe scarring, cutting, or prolonged severe compression. Symptoms include no pain, muscle wasting, with complete loss of motor, sensory, and sympathetic function. Recovery is prolonged and requires surgery.

## Sensory Function

Efferent nerves are those that transmit impulse signals from a nerve center to the periphery (e.g., motor nerve). Afferent nerves are those that transmit impulses from the periphery to a nerve center (e.g., nociceptive and proprioceptive fibers). The general scheme by which afferent sensory and efferent motor fibers interrelate are essential to the mechanisms involved in needling (acupuncture) stimulation.

### *Nociceptive (Pain) and Temperature*

Nociception is the process of detecting and transmitting signals in response to noxious stimuli such as pain, to provoke responses in the body. Temperature sensitive fibers detect changes in local temperatures. Both pain and temperature afferent fibers are dorsal root ganglia cells that synapse on crossed fibers at their entry cord level that ascend in the anterior lateral tract on the opposite side of the cord. They distribute to the reticular formation, periaqueductal gray, and the ventral posterolateral nucleus of the thalamus. From here, fibers distribute to the sensory cortex, excluding the portion related to the face.

Pain and temperature impulses from the face travel along fibers in different components of the spinal trigeminal tract which then sends fibers to opposite side ventral posteromedial nucleus of the thalamus. From here, fibers distribute to sensory cortex region representing the face.

### *Proprioceptive, Tactile, and Vibratory Impulses*

Complex system of detecting and transmitting afferent signals related to body and joint position, muscle loads, and acceleration. The propriospinal system is fundamental in controlling lower motor neurons, mediating spinal reflexes, and producing propagated sensation that travels along the muscular and vascular distributions.

Proprioceptive and tactile discrimination dorsal root ganglia cell impulses travel in the dorsal column to the cuneate nucleus where they synapse on fibers that cross over to the ventral posterolateral nucleus of the thalamus. From here, fibers distribute to the sensory cortex, except the area representing the face. Proprioceptive and tactile discrimination dorsal root ganglia cell impulses also travel in the dorsolateral funiculus.

Proprioceptive and tactile discrimination impulses from the face travel to chief sensory nucleus of trigeminal nerve which then sends fibers to opposite side ventral posteromedial nucleus of the thalamus. From here, fibers distribute to sensory cortex region representing the face.

#### *Touch and Pressure*

A secondary major pathway mediating impulses for tactile discrimination, including touch and pressure synapse on fibers in the dorsal horn that ascend in the dorsolateral funiculus to the lateral cervical nucleus at the upper cervical region. Axons from the lateral cervical nucleus cross over to the opposite side spinothalamic track. From ventral posterolateral nucleus of the thalamus, fibers distribute to the sensory cortex, except the area representing the face.

### Somatic Motor Control

Voluntary control of the striated skeletal muscles is mainly accomplished by signals originating in the motor cortex of the brain. The basal ganglia and cerebellum have important roles related to smoothness of control and coordination. Motor control relies on afferent feedback signals that provide information on load, position and acceleration, which are operative at the spinal segmental and brain levels.

#### *Upper Motor Fibers*

Upper motor neurons originate in the motor cortex and descend in the cord via the corticospinal tracts. A lesion of the cord anywhere above L1 level, affecting motor neurons, may cause upper motor neurons signs in the legs. Although the sensory and motor tracts of the cord are somatotopically organized, it is difficult to identify segmental levels of involvement associated with muscles of the thorax and trunk. Some obvious signs of upper motor neuron lesions include:

- Paralysis
- Exaggerated tendon reflexes
- Hypersensitivity

#### *Lower Motor Fibers*

These are the nerves that originate in the ventral horn of the spinal cord and connect directly with the muscle tissue at regions called the motor end-plate, neuromuscular attachment, or motor point. A single motor neuron and the muscles fibers its branches innervate are known as a motor unit.

Fibers of lower motor neurons are contained in the spinal nerves and therefore susceptible to external mechanical pressure either by compression, disc impingement, osteophytes, swelling, and soft tissue contractions. Lower motor neurons participate in deep tendon and other spinal mediated reflexes. Typical problems associated with lower motor neuron involvement include:

- Weakness
- Wasting (atrophy)

- Fasciculations
- Loss of deep tendon reflexes

#### *Propriospinal System*

The propriospinal system has a complex role of proprioception in terms muscular static load and joint positions. The lower motor neurons cannot contract in response to an efferent upper motor signal without participation of the proprioceptive function. Lower motor neurons have a feedback control system that is mediated by small sensory devices, containing load fibers, called muscle spindles. The spindles receive an efferent signal by means of motor gamma loop fibers in response to the upper motor signal. This results in the muscle spindle sending an afferent response back to the spinal cord. If loads on the target muscle are within normal range, then the muscle will contract in response to the upper motor signal. These features provide the mechanism for lower motor function and also participate in deep tendon reflexes. Impairment of the gamma loop can result in condition of flaccidity and atrophy.

The propriospinal system also sends numerous fibers up and down the spinal cord. Some of these only traverse over a few spinal segments or distribute over the entire length of the spinal cord. These spinal pathways send motor signal to other skeletal muscles in the body, both on the same and opposite side, in response to maintaining bodily balance and function when other muscles contract, especially to emergency situations or external stimulation.

#### *Basal Ganglia System*

This important region of the brain is involved in providing signals to make muscular control a smooth process. Problems in this area include Parkinson's disease and other movement anomalies. The basal ganglia are influenced by and participate in the needling induced (acupuncture) processes.

#### *Cerebellum*

Observation of patients with cerebellar diseases indicates that it is an important center for coordination of movement and postural adjustment. Cerebellum receives information from all parts of the body in order to regulate these functions including: interoceptive and proprioceptive impulses from muscles and joints and from visceral organs; signals from the skin and from the visual, auditory, and the vestibular system; and a variety of impulses from motor centers of the CNS.

#### *Somatic and Autonomic Relationships*

A significant integration of somatic and autonomic afferent fibers exists mainly to perform important reflex responses involving muscles, vessels and internal organs. Some of these interrelationships are important to understanding tissue and somatic responses.

### Clinically Important Reflex Tests

The organization of the spinal afferent processing system, including the propriospinal system, provides the mechanisms to mediate important reflex phenomena. Some of these reflexes are mediated at near the same segmental level that contains the structures involved. This is much the case for deep tendon reflexes. Other reflexes involve the participation of higher levels of the CNS and therefore can be used in conjunction with the tendon reflexes to help isolate a problem, such as determining if an upper or lower motor neuron was involved in the problem.

### *Deep Tendon Reflex Tests*

Several well known and applied deep tendon reflexes have been in use for some time, even by the ancient Chinese. One involving the mandible is used to determine proper supply to the temporalis muscle by the 5th cranial nerve motor fibers. Other deep tendon reflexes involve both the brachial plexus (See Table 3.7) and the plexuses of the low back (See Table 3.8). Deep tendon muscle reflexes that are below normal indicate possible problems affecting lower motor neurons. Hyperactive deep tendon reflexes indicate possible involvement of upper motor neurons.

Table 3.7. Nerve roots, cervical disc, motor and sensory levels, and reflexes of the mandible and the brachial plexus.

| Root | Disc | Motor Level | Reflex | Reflex Response | Sensory Level |
|---|---|---|---|---|---|
| | CN 5 | Mandible | Jaw | Mouth closes | |
| C5 | C4 - C5 | Shoulder abduction | Biceps | Biceps contraction | Lateral arm |
| C6 | C5 - C6 | Wrist extension | Brachioradialis | Elbow flexion and/or forearm pronation | Thumb, index finger and lateral forearm |
| C7 | C6 - C7 | Triceps, wrist flexion and finger extension | Triceps | Elbow extension | Middle finger |
| C8 | C7 - T1 | Finger flexion | (none) | | Ring and little finger, and medial forearm |
| T1 | T1 - T2 | Finger abduction | (none) | | Medial arm |

Table 3.8. Nerve roots, spinal disc, motor and sensory levels, and reflexes of the lumbar and sacral plexuses

| Root | Disc | Motor Level | Reflex | Reflex Response | Sensory Level |
|---|---|---|---|---|---|
| L4 (L2,3) | L3 - L4 | Tibialis anterior | Patellar | Leg extension | Medial leg and foot |
| L5 | L4 - L5 | Extensor hallucis longus | Tibialis posterior (weak) | Slight plantar inversion | Lateral leg and dorsum of foot |
| L5, S1 | L4 - L5, L5 - S1 | | Medial hamstrings | Knee flexion | |
| S1 | L5 - S1 | | Lateral hamstrings | Knee flexion | |
| S1 | L5 -S1 | Peroneus longus and brevis | Achilles | Plantar flexion: Gastrocnemius contraction | Lateral malleolus, plantar and lateral aspect of foot |

### *Pathologic and Sensory Reflexes*

Reflexes that are thought to involve higher levels of the CNS sensory and pathological tests. These reflexes are summarized in Tables 3.9 and 3.10.

Table 3.9. Normal superficial responses indicating CNS segment level

| Reflex | Normal Response | CNS Segment |
|---|---|---|
| Upper Abdominal | Umbilicus moves up and toward the region being stroked | T7 - T9 |
| Lower Abdominal | Umbilicus moves down and toward stroked region | T11 - T12 |
| Cremasteric | Scrotum elevates | T12 - L1 |
| Plantar | Flexion of toes | S1 - S2 |
| Gluteal | Skin tenses over gluteal region | L4 - L5, S1 - S3 |
| Anal | Contraction of anal sphincter muscles | S2 - S4 |

Table 3.10. Responses to pathological reflexes

| Reflex | How to Elicit | Positive Response |
|---|---|---|
| Babinski | Stroke lateral aspect of sole of foot | Extension of big toe and fanning of four small toes |
| Chaddock | Stroke lateral aspect of foot beneath lateral malleolus | Same response as above |
| Oppenheim | Stroke anterior medial tibial surface | Same response as above |
| Gordon | Squeeze calf muscles firmly | Same response as above |

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# 4

# History and Physical Examination

The principal objective in practice is to find a solution to the patient's problem. Also, it is important to determine the patient's expectations and what the practitioner's involvement will be to meet these expectations. It is important to gain the patient's cooperation and to work together with the practitioner to help resolve their problem. In order to accomplish this goal the nature and cause of the problem must be known before appropriate treatment and case management can be instituted. A logical step-by-step process to accomplish this task is detailed in this and Chapter 5 that follows.

Initially, this requires data collection and interpretation relying on information mainly supplied by the patient (Subjective signs) which constitutes the patient history. General observations and possibly a preliminary examination then takes place in order to determine a present health status of the patient (Objective signs). Results of these two functions then provides a general idea of the problem from which a general clinically impression is developed. A careful detailed and systematic examination is then necessary to understand the patient's problem which may verify or disprove the initial clinical impression (Assessment phase).

Responses to pertinent historical queries suggest how the examination should be planned, what course it should take, and what areas may require special consideration. Several methods of examination exist, however the process follows a logical sequence of procedures that are optimized to obtain valid diagnostic information without causing undue stress and discomfort of the patient. This sequence is followed in Chapters 6 - 17 for specific regions of the body that will provide the essential information from which a diagnosis can be developed and the treatment and case management plan (Plan: see Chapter 5) is finally formulated.

It is the initial patient contact that establishes the nature of the practitioner/patient relationship and determines the degree of confidence and trust involved in the case management. Certain definitions apply to the process of the history and physical examination as follow:

### *Consultation*

This involves any combination of history taking, physical examination, and explanation and discussion of the clinical findings and prognosis. A consultation can also be the service provided by a practitioner whose opinion or advise regarding evaluation and/or management of a specific problem is requested by another practitioner or other appropriate source. An outside consultation requires at least a verbal recommendation which should be followed by a written report.

### *Diagnosis*

This refers to a decision regarding the nature of the patient's complaint; the art or act of identifying a disease or condition from its signs and symptoms.

### *Examination*

Involves procedures conducted by the practitioner necessary to determine a working diagnosis or hypothesis concerning the problem. The goal of the examination is not to attain diagnostic certainty but rather reduce the level of uncertainty sufficient to make optimal recommendations for care.

***History***
A history represents the patient's account of the clinical problem(s) given in response to the practitioner's questions, including information obtained by the use of intake forms.

***Neurological Examination***
Most commonly refers to evaluation of motor function, deep tendon reflexes, sensation, and muscle strength. Special orthopedic test may also be conducted to provide confirmation of the neurological contribution to the problem. Most pain and neurological deficits emanate from an irritation or damage at a particular nerve root level of the spinal cord classed as a "radiculopathy" and hence most testing is directed to determining the specific segmental level of the problem.

## The History

The initial phase of trying to understand the patient's problem is to collect information provided by the patient themselves (subjective). This information is combined with general observation on the part of the practitioner (objective). This phase may also include a scanning examination of an initial clue on which region of the body the problem mostly affects, if this is not obvious by the information provided by the patient.

Early Chinese physicians recognized that the patient knows more about their problem than anyone else and thus the most important part of making an accurate diagnosis is to inquire about all aspects of the presenting complaint. Leading questions are to be avoided such as, "Does this increase your pain?" as opposed to, "Does this alter your pain in anyway?" The history process provides the patient an opportunity to provide their impression of their problem. It is important to listen carefully to the patient but also to keep the patient focused on describing their complaint and its onset. Determining the onset or factors that induced the problem or disability is most fundamental.

It is important to determine the location of the problem and if it radiates into other regions of the body. It is important to determine if there are any patterns associated with the distribution pathways of muscles, vessels, nerves and neurovascular nodal (acupoint) pathways. The severity of the condition and whether it produces impairment of any extent is next determined.

The quality or nature of the presenting symptoms provides additional clues as to its source as does considering factors that make the problem either better or worse. The behavior of the problem, especially related time of day patterns as well as how it affects joint function is also important. Many questions are directed to understanding the onset and history of the condition, including inquiry into previous disease history and family history. In the case of a trauma induced problem, many detailed questions are employed to determine the extent of the damage and details concerning specific regions of the body that were affected.

### Taking the History

This important process derives critical information by which one determines the initial impression of the presenting problem and should be adequately recorded and documented. Use of preprinted forms can greatly aid in the process of obtaining a consistent and well organized set of information. If the patient is allowed to fill out the history or some portion of a preprinted form, the practitioner must go over the information with the patient to clearly establish that both the patient and the practitioner have the same understanding of the problem. If a historian, other than the practitioner, is used to elicit the information from a patient, the practitioner is still obligated to go over the information directly with the patient. It is always advisable for the practitioner to take the history and conduct the subsequent detailed examination. A good history plays the most critical role in the assessment and diagnostic process and will appropriately identify the region to be examined. The history also provides the extent of the condition.

## Components of History

A history may include any or all of the following items, dependent on the presentation of the patient and the judgment of the practitioner. Those sections of a history or examination that makes use of preprinted forms that are not specifically used in the data gathering and diagnosis should be annotated with an appropriate designator. Abbreviations such as "NA" (not applicable) or "NT" (not tested) or other terms the practitioner might use. All abbreviations and terms need to have a key or be explained. This is important should the case need to be defended or if there is any dispute as to which test was or was not performed. Patients are often in a profound state of discomfort, disability or pain and frequently have poor recall concerning what was said or done. Patients often cannot accurately recall what areas of the body they were examined or even needled. The same comments apply to treatments, which have to be accurately documented as discussed later. It is critically important that the practitioner refrain from making any comments in the chart of a personal or suggestive nature.

### *Identifying Data*

Includes information on the identity of the patient such as name, age, gender, occupation and includes the date of the history. The chief complaint and its onset can also be identified and a provisional diagnosis, especially if the patient was referred by another practitioner. The hand and leg dominance should also be identified and what was the condition of the affected part before the present onset of problems.

#### Age

Knowing the patient's age is important since many orthopedic conditions occur within certain age ranges. A higher incidence of degenerative conditions such as osteoporosis and osteoarthritis may be seen in the older population. Various growth disorders such as Scheuermann's disease or Legg-Calve-Perthes disease can be seen in teenagers and adolescents. Shoulder impingement in people 15 to 35 years old is more likely the result of weakness in muscles controlling the scapula, while in those older than 40, it is more likely the result of degenerative changes to the shoulder complex.

#### Occupation

The ancient Chinese noted that prevalent conditions and treatment approaches varied based on one's occupation or status in life. Labors and farm workers tend to have stronger muscles and are less likely to suffer muscle strain, whereas individuals with sedentary jobs tend to have weaker muscles and hence more susceptible muscular strain. However, laborers are more susceptible to on-the-job injury due to the nature of their job and workplace. Farm workers primarily involved in stoop-labor tasks are susceptible to developing chronic low back problems. Sedentary workers usually have no need to maintain high muscle strength levels and therefore may be susceptible to overstrain injuries to muscles and joints, especially on weekends when they participate in activities they are not used to. Certain habitual postures and repetitive strain induced by certain occupational tasks may give an indication on the location and source of the problem.

**Chief Complaint**

This is the condition or reason that the patient is seeking help and is often referred to as the "history of the present illness." This part of the history gives the patient an opportunity to describe in their own words as to what is bothering them and the extent to which the condition bothers them. Gathering this information is important from a functional aspect which can help the examiner to determine if the patient's expectations for treatment are realistic.

**Onset**

Was the onset of the disorder slow or did it occur suddenly? Was there a specific incident in which the body part was traumatized or injured, or did the condition start as an insidious, mild ache, which then progressed to level of continuous pain? If inciting trauma is involved it is often obvious about the location of the problem. Was the problem caused by sudden trauma, or did it suddenly occur as result locking due to muscle spasm and/or pain?

**Provisional Diagnosis**

If the patient has been treated by other practitioners or has been referred by a practitioner it is important to note the findings of their efforts. This information can be considered as a "provisional diagnosis." This provides an important starting point or possible guideline for the history and examination efforts but the practitioner is still obligated to determine the cause of the patient's problem. This effort may confirm the provisional diagnosis or may result in an entirely different diagnosis or a deeper understanding or explanation of the original diagnosis. The examination and assessment may also indicate the need for further diagnostic imaging and testing.

***Description of Symptoms***

The patient is asked to describe the symptoms of their present complaint in terms of its location and possible radiation patterns on the body, severity, possible impairment, nature, and behavior. The patient is also asked about the characteristics of the joint in question as well as additional comments or other symptoms

**Location and Radiation**

The patient is asked to indicate location of the problem of their body. This information can also be noted on a figure representing the human body with an appropriate key to indicate pain, paresthesia, numbness, or other conditions such as atrophy. Patients often have difficulty in identifying various parts of the body of a figure, thus it important for the practitioner to carefully review this information with the patient. It is also necessary to indicate if the presenting symptoms radiates to other regions of the body.

**Severity**

The patient is asked about the severity of their pain, which could be ranked on a numerical range (1 - 5 or 1 - 10). However, this is highly subjective and a magnitude line (visual analog scale [VAS]) works just as well, if not better. The patient marks on a line where they consider the intensity of their symptoms to lie. The line can represent the range from none (no symptoms at all) to worst (the most severe the problem gets).

**Impairment**

In making an assessment of permanent disability, the process usually involves assigning numerical values derived from various guides such as the: *AMA Guides to the Evaluation of Permanent Impairment, Fifth Edition (Revised)* or latest recognized edition. For the purpose of the initial history it is only important to understand to what extent the presenting symptoms are impairing normal function. This can also be assigned numerical values (1 - 5 or 1 - 10), but a magnitude line (VAS) works just as well. The patient indicates a relative position on the line between indicating where the symptoms are only an annoyance to where they can be totally disabling.

**Nature**

The patient is asked about the nature of the symptoms which provides the practitioner clues as to the possible tissue or structures involved in the problem. Table 4.1 indicates a summary of types of pain responses that can be associated with certain tissues and structures.

Table 4.1. Pain characteristics and possible related structures.

| Pain Characteristics | Involved Structure |
|---|---|
| Cramping, dull, aching | Muscle |
| Dull, aching | Ligament, joint capsule |
| Sharp, shooting | Nerve root |
| Sharp, bright, lightning-like | Nerve |
| Burning, pressure-like, stinging, aching | Sympathetic nerve |
| Deep, nagging, dull | Bone |
| Sharp, severe, intolerable | Fracture |
| Throbbing, diffuse | Vasculature |

**Behavior**

There are several questions of the patient on the behavior of their symptom in terms of its constancy or lack there of, or when it occurs and what factors elicit a response, to provide additional clues. Palliative factors that relieve the symptoms or provocative factors that aggravate the problem are also noted. Rest, for example may make the condition better whereas walking aggravates the problem. Does the pain get worse as the day progresses? Does the problem show any diurnal variations (24 hour pattern)? Is the condition highly irritable, mildly irritable, or not irritable at all?

**Joint Characteristics**

The patient is asked to describe the characteristic of the affected joint. This provides important clues to possible pathology. Loose bodies in the joint, for example may cause it to catch or lock, while joints giving way may indicate tendon damage.

**Additional Symptoms**

The patient is then asked to describe any other symptoms or complaints not addressed in the preceding inquiries. Often the patient experiences other symptoms that may not seem related to anything obvious and they are encouraged to volunteer any items they want. Seemingly strange radiation patterns or referred pain patterns may not be recognizable by the patient but these are valuable observations for the examiner. One example may include bladder problems coincident with problems with the intrinsic muscles of the foot since both areas are supplied by nerves emanating from S2, S3 and S4 levels. Think of pathology in terms of how the bodily function and organization are viewed in Chinese medical theory.

### *Background and Associated Findings*

The second part of the history involves a set of questions that are pertinent to obtaining additional information on the extent and background on the present condition. Most of these inquires can be accommodated by a preprinted form. However, in case of trauma induced injury due usually to accidents, more detailed questions may be required. A good chart file should have a general "additional notes/comments" form that can be inserted anywhere to provide a means of recording additional information. An area on the page for making simple diagrams or sketches or taping photographs is useful as well.

#### Status of Present Injury/Condition

The patient is asked about the date of the present injury or condition, or the date of onset of the problem, and whether the symptoms are insidious or not. Dates of hospitalization/surgery, other health care, treatments and the results should also be obtained or indicated on preprinted form. Current medications being used for this condition are listed as well as recent radiographs or diagnostic images. It is always essential to avoid repeating diagnostic imaging procedures that involve exposure to radiation so it is important for the patient or referring practitioner to provide existing pertinent radiographs. Inquiry is also made on the present status of the condition in terms of its characteristics of either being acute or chronic, constant or intermittent, better or worse.

#### Nature and Mechanism of Injury/Precipitating Events

It is important to fully understand the nature and mechanisms involved in injuries, or events that precipitated the condition. The patient is therefore asked detailed questions with this regard. This is essential in order to understand the extent and likely damage to the patient. In case of trauma induced problems, more detailed information is needed as noted below for common categories of injury sources. Possible environmental factors, toxic fumes or material, or radiation exposure should also be taken into account. Condition of one's residence or work place that may be the source of the problem should be explored. Things such as poor furniture that does not properly support the body while seated (soft couches), environmental influences from air-conditioners or heaters, or lack thereof should also be considered.

##### *Slip and Fall Injury*

This common category of episodes can produce significant trauma and even permanent disability. The key to the inquiry process is to determine which parts of the body struck the floor, hard surface, or ground during the fall. Was a hand or leg extended to break the fall and did this part receive damage as result. Did the coccyx or tailbone strike first? The location and time of the fall are needed as well as what where the local conditions where the slip and fall took place. Was the surface wet or dry? Was it windy, raining, storming, or any other prevailing condition at the time. Did the fall involve a flat or inclined surface or were stairs involved? In case of stairs, was the tailbone impacted during the fall, if not what body part was, and how far down the stairs was the fall. Was the accident an up stairs falling? Was the fall from a ladder, and in which case did the shoulder, head, face, back or bottom strike the ground or hard surface first? Was the fall from a high region, such as a roof? If so, were safety restraints involved? What part of the body impacted the ground or hard surface first?

***Vehicular Incident***

Automobiles accidents account for most of vehicular induced trauma although motorcycle accidents produce significant injuries, as do trucks, pickup trucks, airplanes, hang gliders, bungee jumping, sky diving, boats, and trains. In case of a vehicle, was it in motion or stopped at the time of impact? Were seat belts being used or was an airbag deployed? Was the patient the driver or passenger, and if so what position were they seated in the vehicle? Were they riding in the back of pickup truck or passenger on a motorcycle? Did the vehicle cause the accident or was it struck by another? If struck, what was the direction of the impact such as head-on, right side, left side or rear end? What was the approximate speed of the vehicles involved? Did the patient's head strike the steering column, dash board, rear view mirror, windshield, back head rest, roof, other passengers or the driver? Did the vehicle roll over? Was the patient ejected from the vehicle during the accident?

One of the common results of vehicular accidents and falls is the significant side bending (lateral hyperflexion) of the cervical spine. This often results in a broken neck or significant trauma to the spinal cord that some degree of motor impairment or paralysis results. In less forceful accidents, excess flexing of the neck produces significant soft tissue damage affecting the ligament, muscles and tendons in the neck and shoulders. These later conditions frequently are resolved with proper management. However, these traumas often lead to deterioration of the cervical spine that manifests some years later as spondylitis. This involves osteophyte (bony outgrowth) formation develops where the vertebral edges sustained trauma in the original incident. The neck is quite flexible and any type of impact can result in hyperflexion, hyperextension, or excess side bending. Often the victim is unaware of the extent the head and upper body is flexing back and forth. Crashes from various directions can preferentially produce the following:

- Rear Ended - Hyperextension
- Head On - Hyperflexion
- Lateral Crash - Hyper side-bending to the side being struck

***Repeated Stress Injury (RSI) or Cumulative Trauma***

The advent of modern work environments and the repetitive nature of many industrial and clerical tasks produce a situation where injury eventually results. Stress fracture of the fibula, eventually leading a complete fracture, in professional dancer is one dramatic example. Others RSI cases may not seem so obvious since they involve wrist, elbow, shoulder and neck injuries just from doing what seems to be ordinary tasks like typing or operating a computer or a cash register. The slight trauma induced each day is not measurable, but eventually the accumulated effect causes a problem. Often the cause is simply performing the task too frequently, even though all other conditions are ideal. But, more frequently RSI results because of a posture problem or an equipment contribution.

Sometimes it is just working with the body and equipment interface not being aligned or adjusted. In these types of injuries it is important to ascertain as much information about the patient/equipment interface. What is the height of the desk, machine or computer keyboard? If a computer monitor is involved, what is its location in respect to the eye level of the patient? Is either the keyboard or monitor directly lined up with the patient's straight forward orientation or are they to one side or the other? What side? Does the patient work with the telephone held under ear by bending the neck or raising the shoulder? If involved in a repetitive agriculture or manufacturing process, what are the rest periods in relation to production? Is the patient paid on an hourly or piece-part basis? Are there environmental conditions in the work place that either makes the problem worse or better? Are there unrealistic work demands placed on the employees?

Treatment of this class of problem often involves remedial procedures to improving posture or stability of the back. After the patient starts to recover it may be necessary to analyze the worker/equipment interface to make certain that minimum stress is placed on the body by assuring that arms, hands and fingers are held in optimum positions to prevent recurrence of the problem.

***Sports Injury***

This is a common source of trauma for the young and adults of all ages. These injuries can be quite serious and often have a significant impact, especially on the professional athlete. It is important to understand the circumstances of incident that precipitated the injury, including the conditions of the sports area (playing field, court, track, swimming arena, etc.). Was the event recorded on film or video? It is also important to understand the history and experience of the individual in participating in the sport that provoked the injury. What is the training level of the patient, are they experts or beginners, and were they using proper equipment? These questions are essential to understand the extent of the injury and how best to formulate a treatment and management plan.

Difficulties arise when the athlete has pressure or economic necessity to return to action as soon as possible. Many other health conscious people are eager to get back on their fitness program as soon as possible and these people may sometimes ignore the activity restrictions recommended by the practitioner. It is essential that all such recommended restrictions and limitations be properly documented in the patients file under the treatment and management plan. The patient should be made aware that the recommendations will be noted in their file.

**Results of Injury**

If the presenting condition involves an injury it is important to ascertain if it resulted in deformity and whether it can be corrected, and if any disability resulted from the trauma. The patient is asked about any:

- loss in motion or strength and when this loss developed
- presence of swelling, edema, or bleeding and when these occurred as well

### *Relevant Past History and Family History*

The patient is asked about their past health history, especially if they have had similar problems. The health history of their families is also determined if the condition may have potential familial component.

#### History of Similar Conditions

If the patient has a history of similar problems it is important to determine when these occurred and the nature of the disorder. Inquiry is made concerning the treatment of these prior conditions as well as there outcome. Also, it is important to determine if the patient experienced other diseases relevant to their chief complaint.

#### Present Health Status

It is important to inquiry about the patient's health status irrespective of the presenting complaint. Has there been in color changes in the affected limb or other areas of the body? Ischemic changes resulting from restricted blood flow may include loss of hair, abnormalities in nails of the foot and hand, and white brittle skin areas. Conditions such as reflex sympathetic dystrophy (RSD)/ regional pain disorder, or Raynaud's disease can cause some of these symptoms. The patient is also asked about any bilateral spinal cord symptoms, fainting, or drop attacks. Is the bladder function normal? Have there been any episodes of dizziness, vertigo, or ataxia?

#### Health Problems of Immediate Family

Some diseases or conditions have a familial incidence. Hence, the patient is asked about any family health history that may be related their present situation such as tumors, cancer, heart disease, diabetes, allergies, and arthritis.

#### Relevant Past or Present Disease History

The patient is asked if they have any chronic or serious systemic or other disorders that might affect the course of treatment. A check off table can be utilized to list a range of diseases that either have an impact on musculoskeletal disorders or the general health condition of the patient. The following list contains common problems that influence the treatment musculoskeletal disorders and general health:

| | | | |
|---|---|---|---|
| ☐ Arthritis | ☐ Hyperthyroid Syndrome | ☐ Osteomyelitis | ☐ Urticaria (hives) |
| ☐ Cancer ___________ | ☐ Parathyroid Disorder | ☐ Osteoporosis | ☐ Vascular _________ |
| ☐ Diabetes Mellitus* | ☐ Multiple Sclerosis/ ALS | ☐ Rickets | ☐ Herpes** _________ |
| ☐ Gout | ☐ Myasthenia Gravis | ☐ Rheumatoid Arthritis | ☐ Hepatitis _________ |
| ☐ Hypothyroid Syndrome | ☐ Osteomalacia | ☐ Rheumatic Fever | ☐ HIV (date) _______ |

* Indicate if juvenile or mature onset; **Indicate if either herpes zoster, oral or genital.

### *Lifestyle*

Modern lifestyles contribute dramatically to wear and tear disorders as well as to degenerative diseases of all types, many of which manifest as pain, chronic pain, and musculoskeletal problems. Use of substances known to be counterproductive to maintaining proper health is quite common. This behavior is often accompanied with bad dietary habits, high stress jobs and financial worries, lack of proper exercise, and poor sleeping habits. Many patients are uneasy about discussing or recognizing the contribution that their daily habits have on the present condition or the impediment they represent in fully resolving their present condition. Certain inquiries are made about lifestyle habits and the patient is advised about those that have a possible effect on the outcome of their condition.

#### Substance Use

The patient is asked about smoking habits, alcohol consumption, drugs and medication, and use of steroids?

#### Dietary Habits

Inquiry is made about the dietary intake in terms normal, high fat content, or low fat intake, as well food preferences, and vitamin and mineral supplementation.

#### Stress Level

Does the patient have a high, medium, or low stress occupation, or financial burdens that cause stress?

#### Sleeping Habits

Poor sleeping habits contribute many disorders, including musculoskeletal problems and depression. The patient is asked about their daily sleep patterns. This problem is often aggravated for those individuals that work the night shift or those have very disturbed sleeping habits that they think they are "night people."

#### Health Promotion/Fitness Activities

Does the patient regularly engage in physical activities, including exercise? Are these directed developing strength, endurance, flexibility, or agility? Exercise routines may have to altered or discontinued during the course of treatment for the condition. Other movement and strength exercises may be required during the course of treatment or rehabilitation. Also, does the patient engage in any health promotion activities?

#### Patient's Goals or Expectations of Treatment

As the final part of the history, the patient is asked about their view or thoughts on the cause of their problem. In addition, it is important for the practitioner to gain the patient's confidence and their cooperation during both the examination and treatment process. This is an opportunity for the patient to express what their goals and expectations are for the outcome of the examination and treatment program. It is important to provide the patient with a realistic estimate of expected outcomes of the treatment program.

## Observation and Examination

General observations and examination are considered objective signs and involves an inspection of the patient's vitality and function. Observation and directly looking at the patient is an important aspect of the assessment process. The observation phase can also include a screening examination to evaluate active, passive, and resistive movement of either the cervical or lumbar spine, or a specific joint depending on the information derived from the history. Observation involves gathering information on vital signs, vitality, visible defects, alignment abnormalities, movement problems, and functional deficits. Ideally, the observation activities start while the patient is in the reception area where the seated posture can be noted. In addition, it is important to observe the patient's gate as they are walking into the examination and assessment area. The examiner needs to note how the patient is moving as well as their attitude, manner, willingness to cooperate, and any overt signs of pain behavior.

The patient is advised on the importance of the observation phase with respect to understanding their problem, and preparation for the more detailed examination that follows. However, in order to make valid observations the patient needs to be adequately undressed in a private assessment area. Male patients should wear shorts, while female patients should wear a bra or halter top and shorts. Informing the patients on the need for the state of undress should alleviate potentially embarrassing situations which can have possible legal implications. The initial observation of the patient's gate is only cursory. However, if obvious problems such as a Trendelenburg or drop foot gait which are easily noticed, a more detail examination can be made after the patient has undressed.

The examiner should compare both sides of the body simultaneously and should be positioned to make best use of their dominant eye. The examiner is only looking at the patient and does not require the patient to move. Also, the examiner does not palpate at this time, except to locate a particular landmark or to determine if an area is either warm or hot.

## Vital Signs

This part of the objective data collection can be performed by an assistant, but the pulse should be measured by the examiner. Measurement of signs includes: height, weight, pulse rate, pulse characteristics, blood pressure, and temperature.

## Observations and Inspection

These activities involves determining the patient's state of vitality, posture, gait, abnormal movements, shape, utilization, conditions of the skin, and the use of assistive devices.

### *Vitality*

The patient's vitality is reviewed with respect to a Chinese medical aspect which is valid for orthopedic and any other condition. Is the patient cheerful, dull, worried, irritated, or fearful? What is the patient's responsiveness in terms of being cooperative, hyper-responsive, or agitated or non-responsive?

### *Posture*

Observation of posture involves looking at the patient while seated and then standing. Seated posture provides more information on the patient's vitality and also reflection of abnormalities due to orthopedic conditions. Seated posture is assessed as being either normal, slumped, guarded, or painful. Standing alignment is viewed from the front, side, and back of the body. Normal anterior alignment exist when the tip of the nose, xiphisternum, and umbilicus are in straight alignment. Normal alignment of the lateral view exists when the tip of the ear, high point of the iliac crest, and the ankle are in straight alignment. Posterior alignment considers the alignment of the spine and comparative alignment or height of the iliac crest on each side, and perhaps the comparative alignment of the shoulders.

### Gait

By observing the patient's gait. the examiner can determine if it is normal or has certain characteristics indicative of specific problems. There are about fifteen pathological gait conditions.

### Movement

Here, the examiner is looking for unwanted and abnormal movements of the body or extremities which are involuntary. Normal movement would indicate the absence of any unwanted or involuntary movements, including: tremors, tics, chorea, athetosis, myoclonus, asterixis, and tardive dyskinesia

### Shape

Body shape is observed to classify the body type as being ectomorph, mesomorph, or endomorph. The body is also examined to determine if the patient has any deformities, asymmetries, swellings, masses, or atrophy.

### Utilization

This involves a cursory observation of some of the key concerns that are normally examined later in detail under activities of daily living (ADL). Does the patient handle clothing independently or require minimum or maximum assistance? How well does the patient transfer from one situation to another, such as ability to get in and out of a shower or tub, or get in and out of an automobile? This can be assessed in terms of normal, guarded, painful, or impossible.

### Skin

The skin is observed with respect to color or areas of discoloration, temperature, possible lesions, and scars.

### Aids

Inquiry is made concerning the patient's use aids including braces, orthotics, corsets, shoe lifts, and other assistive devices, including walkers. How long have they required such aids and what conditions were they prescribed for?

### Review of Sensory and Visceral Systems

In the presence of what appears to be involvement of sensory and visceral systems, or if the patient includes these problems within their main complaints, it is important to review these systems and determine if further examination may be required, perhaps by a medical specialist in each particular area. Also, in making an assessment of impairment it is necessary to factor in the contribution that the presenting problem or condition has on the sensory and visceral systems. This evaluation can be accomplished by the use of a special form that provides convenient tables which the patient reviews and checks off present and former symptoms. The examiner must then go over the information to discuss those items checked by the patient. The following area should be examined:

- Visual and Auditory Systems
- Nose, Throat, and Related Structures
- Respiratory System
- Cardiovascular System
- Digestive System

- Urinary and Reproductive Systems
- Mood and Behavior

## Assessment Process

The final phase of the assessment process involves a detailed evaluation of the patient from which a diagnosis is made in order to formulate a viable treatment plan. This effort consists of a logically ordered examination, including the screening examination previously discussed. Accurate assessment of the muscles, joints, and vessels involved in a problem is critical to isolating the cause or etiology of the problem. This relies on standard diagnostic methods, however, it is also necessary to determine which particular muscle, joint, tissue, and spinal elements are involved. A variety of approaches including muscle and reflex testing as well as palpation of sensitive points and body regions are involved.

The concept of diagnosis has been a matter of significant historical debate among all health care professionals. This is especially true in acupuncture where training and licensing standards are greatly varied from state-to-state. Additionally, different schools of thought in Chinese education promote different methods of diagnosis. Some practitioners use the full range of modes where a visceral problem might by evaluated and treated strictly in terms of the Chinese view while orthopedic problems are viewed in terms of both Western and Eastern concepts. It is a challenge to needling therapy to bring the Chinese concepts into the mainstream of science-based understanding using modern English to explain diagnosis and treatment so that any other health care professional and the patients as well, can understand the process involved.

A differentiation of the derived information is performed to focus on the most likely pathology involved in the presenting case. This diagnosis is critical in order to determine the most efficient treatment plan or decide to refer the case for additional studies. Guidelines for differential diagnosis are provided in Chapters 6 - 17 for those particular regions that are covered.

An assessment is made each time the patient comes into the clinic for treatments. This is necessary to evaluate the effectiveness of the treatment approach and determine if the situation is improving, getting worse, or is static. It is important to understand the patient's status before possible work, exercise, or physical activity restrictions are removed or further restrictions are instituted. Assessment, over time, also provides a basis for determining possible disability or impairment. The patient's status and progress, or lack thereof, is always written down in the patient record.

### Definitions

The following definitions are relevant to diagnostic and assessment efforts:

#### *Analysis*

This represents the act of separating the clinical evaluation of a condition or disease into component parts, in order to identify the clinical impression or determine the diagnosis.

#### *Clinical Impression*

A working hypothesis formulated from significant items in the history and the physical findings; a tentative diagnosis; or a working diagnosis.

### *Diagnosis*
Represents a decision regarding the nature of the patient's complaint and also refers to the art or act of identifying a disease or condition from its signs and symptoms.

### *Differential Diagnosis*
The determination of which one of two or more complaints or conditions a patient is suffering from by systematically comparing and contrasting their clinical findings.

### *Portal of Entry*
This represents the first level of contact for the patient with an intake into the health delivery system.

### *Utility*
This refers to a significant benefit to both the patient and clinician resulting from a reduction in uncertainty of the diagnosis, clinical impression, or analysis.

## Relevant Terminology
The practitioner always has certain responsibilities and obligation related to their encounter with the patient. The most common of these are described as follows:

### *Necessity*
Deriving a clinical impression or diagnosis, or diagnostic conclusion or analysis, is a necessary outcome of the patient encounter. Responsibility of the practitioner does not change because of the terminology used to describe clinical findings. The practitioner is required to assess the patient upon presentation and respond to the clinical situation in a manner consistent with the best interests of the patient, the practitioner's clinical judgment, and the law of the jurisdiction in question.

### *Initial Responsibility*
The initial responsibility of the practitioner is the immediate discernment as to the nature and status of the patient on initial presentation. A practitioner should be expected to recognize and respond to life-threatening situations in a manner consistent with the patient's best interest. Some clinical signs that may indicate a need for medical consultation include:

- Pale complexion, which may be accompanied with indigestion
- Pain in left shoulder that radiates along medial aspect of the arm
- Severe unremitting pain
- Pain unaffected by position or medication
- Pain that returns shortly after having been reduced by needling therapy or other modalities
- Severe night pain
- Severe pain with no history of trauma
- Severe spasm
- Possible psychologic overlay

### Subsequent Responsibility
After the initial evaluation has been completed the practitioner begins a series of differentiations that result in many clinical decisions being implemented. This process is not an end in itself, but merely designates suspected conditions that become the focus for prognostic judgments, further assessment, and patient management. Initiation of needling therapy care, additional studies, and referral with or without continuing treatments as well as cessation of needling therapy care is possible.

### Terminology
Terminology used to describe a clinical impression, diagnosis, diagnostic conclusion, or analysis should be consistent with appropriate usage in needling therapy and related health care communities. If a practitioner is required to use specific terminology, or is prohibited by law from the use of such terminology, then that legal requirement is the guiding factor.

### Content
Patients may have various conditions/symptoms/findings that result in a number of unrelated clinical impressions. The primary clinical impression, diagnosis, diagnostic conclusion, or analysis should address the chief complaint expressed by the patient. Secondary diagnoses should be prioritized and addressed as needed and may be of greater clinical consequence to the patient.

Information which constitutes the diagnostic data base should reflect a classification scheme that consists of statements reflective of severity, region, and organ/tissue involvement. In addition, this information should be related to the subjective and/or objective findings of the patient, and be consistent with evidence-based criteria.

### Process
When additional tests or studies are required to confirm the clinical impression, diagnosis, diagnostic conclusion, or analysis, it is the practitioner's responsibility to ensure that these are conducted in a timely fashion. Practitioners may perform such procedures consistent with their qualifications and the law, or they may seek to have such procedures performed by other qualified professionals.

Where procedures relevant to the diagnostic database process are not within the qualifications or competence of a practitioner, the practitioner should make appropriate consultations with others. The clinical impression, diagnosis, diagnostic conclusion, or analysis, should be recorded in the patient's record and qualified as to its certainty.

### Dynamics
The clinical impression, diagnosis, diagnostic conclusion, analysis or assessment should be a working hypothesis that may change over time, given additional information and/or changes in the condition of the patient as noted in the clinical progress.

### Communication
The practitioner should communicate the diagnosis, clinical impression, diagnostic conclusion, analysis or assessment and its significance, to the patient in understandable terms, and convey such findings to other providers or agencies as the patient requests and consents to, or as required by law.

## Examination Principles

The examination process requires certain tests that can possibly cause exacerbation of the patient's problem. Therefore the examination follows a fixed logical sequence to make certain that an early group of tests do not adversely affect the outcome of subsequent tests. For example, resistive muscle testing can possibly increase discomfort levels, so these tests must follow the active and passive movements which have a lower probability of increasing the patient's symptoms. Palpation of the joints and muscle, which is often conducted early in a Chinese medical examination, is scheduled as the last test since this activity can possibly aggravate the patient's pain condition in the affected joints. The examination sequence is as follows:

- Examination of movement
    - Active
    - Passive
    - Resistive
- Special tests
- Reflexes and cutaneous distribution
- Joint play movement
- Palpation of affected area(s)
- Diagnostic imaging

### *Patient Consent*

The examination portion of the assessment process involves touching the patient, which may in some situations cause the patient discomfort. Therefore, the examiner must obtain a valid consent to perform the examination before it begins. A valid consent has to be voluntary, must cover the procedure being done (informed consent), and the patient must be legally competent to give consent. The examiner must carefully tell the patient the purpose of the test and what is going to done during the examination process.

### *Examination Guidelines*

The examination is used to confirm or refute the provisional diagnosis or clinical impression derived from the history and observation. The examination involves a systematic effort of looking for a consistent pattern of signs and symptoms that leads to a differential diagnosis. Special care should always be taken in the situation where the condition of the joint is acute or irritable. The following guideline need to be considered in the examination effort:

The normal side is tested first unless bilateral movement is required. By testing the unaffected side first the examiner establishes a baseline for normal movement for joint in question. This also demonstrates to the patient on what to expect during the examination. This should reduce apprehensions on the part of the patient when the injured or affected joint is tested.

Active movements on the part of the patient are done first at which time range of motion (ROM) measurements are made. Passive movements by the examiner follow the active movements which are then followed by resisted isometric movements. This allows the examiner to have a good idea of what the patient thinks he or she can do before the structures are fully tested.

When possible, any painful movements are conducted last to prevent overflow of painful symptoms to the next movement, which in fact may be pain free.

Overpressure to measure end feel during passive movement is applied only with extreme care to prevent exacerbation of symptoms in the situation where the active ROM is not full.

If the ROM is full during active movements overpressure may be carefully applied to determine the end feel of the joint. In this situation, the passive movement test is often not needed.

Each active, passive, or resisted isometric movement may be repeated several times or sustained for a certain time. This is done to determine if symptoms increase or decrease, whether a change in movement pattern results, if there is an increase in weakness, or whether there is a possible change in vascular insufficiency. Assessing repetitive or sustained movements or resistance is important for those individuals that have complained that their symptoms are altered by repetitive motion or by sustained postures.

Resisted isometric movements are done with the joint in the resting or neutral position to minimize stress on the joint capsule (inert tissues). This is done to make certain that any symptoms that are produced by the movement are likely to be caused by the contractile tissue.

Although the amount of opening is important for ligamentous and passive range of motion (ROM) tests, the quality (end feel) of the opening is important as well.

When testing ligaments, the examiner gently applies and repeats the appropriate load several times. The load is increased up to but not beyond the point of inducing pain. This allows demonstration of maximum instability without inducing muscle spasms.

When testing muscles supplied by a particular myotome each contraction should be held for a minimum of 5 seconds to see if weakness results. Myotomal weakness takes time to develop.

A detailed examination often involves stressing different tissues. The examiner needs to alert the patient that he or she may experience possible exacerbation of their symptoms as a result of the assessment process. Otherwise the patient may think that the initial treatment made their problem worse and may be apprehensive to return for further treatment.

If the examiner has found, at the end of the examination that the patient has presented with unusual signs and symptoms or if the condition seems to be beyond the examiners scope of practice, he or she should not hesitate to refer the patient to an appropriate health care professional.

### *Scanning Examination*

Orthopedic examinations concentrate on the joints of the body, their movements, and stability. All appropriate tissues that comprise the joint and their function need to be examined in detail to delineate the affected area. Tension, stretch, or isometric contractions are applied to specific tissues to produce either normal or appropriate abnormal responses. These results allow the examiner to determine the site and nature of the symptoms and observe the patient's subjective reaction to these symptoms. The examination indicates if these activities provoke or change the patient's perception of their pain. When asked about changes in pain, the patient needs to be clear about changes in symptoms and not confuse movement induced pain with a query about their already existing pain. Hence, the examiner is looking for two sets of information: 1.) what the patient feels (subjective) and 2.) responses that can be measured by the examiner (objective).

By necessity, the examination is very extensive. In the upper part of the body it begins with the cervical spine, includes the temporomandibular joints, scapular areas, shoulder, and upper limbs to the fingers. In the lower body the examination starts at the lumbar spine and continues down to the toes. This phase, often referred to as a "scanning" or "screening" examination, may not be essential if there is a history of trauma to a specific joint. The scanning orthopedic examination should be considered when it is not clear where the primary injury is located, especially if it not obvious from the history and observation as to where the problem lies. The scanning examination is considered when:

- there is no history of trauma
- there are radicular signs
- there is trauma with radicular signs
- there is altered sensation in a limb
- there are spinal cord signs
- the patient presents with abnormal patterns
- there is suspicion of psychogenic pain

This general screening examination includes:

- Possible movement assessment of either the cervical spine, lumbar spine, or selected peripheral joint(s) scan
- Special orthopedic tests
- Myotomes
- Sensory tests
- Reflexes
- Identification of areas requiring further tests
- Recommendation for diagnostic imaging/laboratory tests
- Initial clinical impression

## Examination of Specific Joints

A systematic and unchanging approach is used in the examination effort to further evaluate clues uncovered in the history and observation. If the history clearly indicates a specific problem such as a disc lesion or a radiculopathy, the examination needs to be detailed concerning all the tissue that might be affected by either of these conditions. A brief examination can be used for all of the other joints to exclude contradictory signs. However, if the history indicates a possible muscle lesion, then it likely that pain will be provoked upon movement of the affected joint. But once again, all the other structures that appear normal are not excluded from the examination in order to eliminate possible contradictory signs.

During movement testing, the examiner must note whether joint restriction or pain predominates. If pain predominates, the condition may be more acute and gentler assessment and treatment is required. If the signs of restriction predominate, the condition may be subacute or chronic and a more vigorous effort in the assessment and treatment may be indicated.

### Active Movement

Active or physiological movements are dynamically performed by the patient. Since this involves use of the patient's voluntary muscles there is a combined effect of observing and testing range of motion (ROM), muscle control and strength, and the willingness of the patient to perform the movement. The physical impediment at the end of active movements is sometimes referred to as the "physiological barrier." Active movements involve participation of contractile, inert, and nervous tissues. One or more bones (rigid structures) participate when active movements take place. Hence, all attached or nearby structures to the bone move as well.

Active movement usually not performed during fracture healing or in the case of newly repaired soft tissue healing. Must note which movements elicits pain or increases pain or other symptoms and their quality. An acute irritable joint may manifest with intense pain during small unguarded movements. It may not be possible to test all movements when the symptoms are acute and highly irritable.

Examiner should observe the smoothness and rhythm of movement, painful arcs, and any limitations or pain. Also, need to look for trick movements or cheating where patient uses accessory muscles or posture to compensate for weakness in a target muscle. Abnormal active movements can be the result of:

- Pain, spasm, muscle weakness, or paralysis
- Joint-muscle interaction, tight or shortened tissue, change in length-tension relationships, or modified neuromuscular factors

The examiner usually performs active movements once or twice in each direction while noting any problems or possible cheating. When patient reports pain or difficulties in any specific movement, these should be tested last to prevent painful symptoms overflowing to other movements. If presenting problem manifests due to sustained posture or repetitive motions, these are repeated in order to induce symptoms. Depending on the history, movements can be repeated 5 - 10 times or sustained for 5 - 30 seconds until symptoms manifest.

Standard movements for each joint typically lie within the cardinal orientation planes. If patient reports problems outside these single plane movements symptoms may be elicited by multiple plane movements, or by repeated, quicker, or compressive movements. In situations where the joint is not too reactive, overpressure might be carefully applied at the end of active ROM. If the end feel is normal and no symptoms were produced, the examiner may forego passive movements for this joint.

### *Passive Movement*

In passive movement the joint is put through a range of motion by the examiner while the patient is relaxed. The movement must proceed through as full range of movement possible. Although the movement must be gentle, the examiner must find out whether there is any limitation of range (hypomobility) or excess range (hypermobility) and, if so, whether it is painful. Hypermobility joints tend to be more susceptible to ligament sprain, joint effusion, chronic pain, recurrent injury, tendonitis resulting from lack of control, and early osteoarthritis.

Hypomobile joints are more susceptible to muscle strains, pinched nerves syndromes, and tendonitis resulting from overstress. For any given individual, evidence of either a hypermobility or hypomobility condition does not necessarily indicate pathology. The examiner should also attempt to determine the cause of joint limitation (e.g., pain, spasm, adhesions, or compression) and the quality of movement (e.g., lead pipe, cogwheel). The feel at the end of range of each passive motion is observed in order to help understand the pathology present. There are three to four standard normal end feels and five to six patterns considered abnormal end feels.

#### Normal End Feel

**Hard (bone to bone):** Characterized by a painless, abrupt, hard stop to movement when bone contacts bone, such as occurs in hyperextension of the knee joint or in case of passive elbow extension when the olecranon process contacts the olecranon fossa.

**Soft (soft tissue apposition):** Occurs when two body surfaces come into contact that result in tissue compression, such as occurs in passive flexion of the knee when the posterior aspects of the leg and thigh come together, or in the case of hip flexion where the thigh comes in contact with the abdominal region.

**Firm (soft tissue stretch):** Provides a firm or springy sensation that has some give when muscle is stretched such as occurs when passive ankle dorsiflexion, performed while the knee is extended, is stopped by tension in the gastrocnemius.

**Firm (capsular tissue stretch):** Characterized by a firm arrest to movement with some give when the ligaments of the joint capsule are stretched, such as occurs in passive shoulder external rotation. Feeling is similar to stretching a piece of leather.

#### Abnormal End Feel

**Hard (bone to bone):** Indicated by abrupt hard stop to movement when bone contacts bone, or a bony grating sensation when rough articular surfaces move pass each other. This occurs in situations where a joint may contain either loose bodies, degenerative joint disease, dislocation, or fracture.

**Soft:** Produces a boggy sensation indicating possible synovitis or soft tissue edema.

**Firm (tissue and capsular):** A springy sensation or a firm arrest of movement with some give, indicating either muscular, capsular, or ligamentous shortening.

**Muscle Spasm:** Is characterized by a firm sudden stop to passive movement that is often accompanied by pain and is indicative of acute or subacute arthritis, the presence of a severe lesion, or fracture. If pain is absent, a spasm at end feel may indicate a lesion of the central nervous system with resultant increased muscular tonus.

**Empty:** This end feel is detected when considerable pain is produced by movement, which is almost impossible because of the pain, although no real mechanical restriction is detected. Examples might include an acute subacromial bursitis or a neoplasm. It is difficult for the patient to describe the empty pattern since no muscle spasms are involved.

**Springy Block:** This is similar to a tissue stretch, and occurs where one would not expect it to occur; it tends to be found in joints with menisci. There is rebound effect, and it usually indicates and internal derangement within the joint. A springy block might be found associated with knee joint with a torn meniscus when it is locked or unable to go into full extension.

### Capsular Patterns

With passive movement the full range of motion must be carried out. A short, too-soft movement in the mid range will not achieve the proper results. In addition to looking at the end feel, the examiner must look at the patterns of limitation. These result due to problems that arise in the joint capsule structure which can include a variety of pathology. A predictable set of recognizable patterns are manifest, some of which are summarized in Table 4.2.

Table 4.2. Capsular patterns for selected joints.

| Joint | Pattern of Limitation |
|---|---|
| Temporomandibular | Limitation in opening mouth |
| Cervical Spine | Side flexion and rotation equally limited, extension |
| Sternoclavicular and Acromioclavicular | Pain at the extremes of range |
| Shoulder | Given a limitation of abduction, there will be a greater percentage loss of external rotation and a lessor percentage loss of internal rotation |
| Elbow | More limitation of flexion than extension |
| Wrist | Equal limitation of flexion and extension |
| Thumb and Fingers | More limitation of flexion than extension |
| Thoracic Spine | Side flexion and rotation equally limited, extension |
| Lumbar Spine | Side flexion and rotation equally limited, extension |
| Hip | Gross limitation of flexion, abduction, and internal rotation; slight limitation of extension; and little or no limitation of external rotation |
| Knee | Gross limitation of flexion; slight limitation of extension |

### Noncapsular Patterns

The examiner must be aware of limitations in movement which do not correspond to classical capsular patterns for a particular joint. These are called noncapsular patterns. In the shoulder for example, abduction may be restricted without any or, at least little, restriction in rotation. Thus, the total capsular pattern is absent. Possibilities for the observed difference could be ligamentous adhesions in which only part of the capsule is involved. Other causes of noncapsular patterns include internal derangement of the joint, which the elbow and knee joints commonly exhibit. Loose bodies within the joint are another category of possible causes in restricting motion.

#### Inert Tissue

Noncapsular patterns are also apparent in the situation that restricted motion is the result of inert tissues. This can manifest with pain in both active and passive movement in the same direction, whereas resisted isometric movements are not painful. Inert tissue refers to all tissue that is not considered contractile. Patterns involving inert tissue may include:

- **Pain and limitation of movement in every direction.** The entire joint is affected in this pattern, indicating arthritis or capsulitis.
- **Pain and limitation or excessive movement is some directions** but not others, such as in a ligament sprain or local capsular adhesion.
- **Limitation of movement that is pain free**, often with abnormal bone-to-bone end feel. This usually indicates symptom-free osteoarthritis.
- **Pain free full range of motion** because there is no inert tissue lesion in the movement being tested, however, there may lesions in the other directions or around the joint.

### *Resisted Isometric Movement*

Resisted isometric movements are tested last in the examination of the joints. Principal goal is determine the condition of the muscles and to identify involved myotomes. These techniques involve strong, static (isometric) voluntary muscle contraction. If movement is allowed to occur at the joint permitting inert tissue around the joint to move as well, it will not be clear then if pain that results is due contractile or inert tissue. A neutral or resting position (loose pack position) the joint is selected to minimize tension on inert tissue (See Table 4.6). The patient is asked to strongly contract the muscle while the examiner prevents movement by resisting the patient's effort. Isometric resistive tests are first tested in anatomical positions of full gravity reacting on the patient's body. In case of significant weakness, the test is conducted that zeros out the influence of gravity. The purpose of this test is to determine which myotome is involved in the problem, and to determine the degree weakness of the affected muscle or muscles.

#### Muscle Strength Grading

Muscle strength can be graded 5 - 0 with 5 being normal, or given a letter grade with the letter "A" representing normal strength (See Table 4.3). In case of weak contractions it is important to determine if it is due either to pain or patient's fear or unwillingness. Muscle weakness may be due to:

- upper motor neuron lesion
- injury to a peripheral nerve
- pathology of neuromuscular junction
- muscle tissue problems

Table 4.3. Use of number (No.) or letter grade to indicate muscle strength under gravity and with gravity eliminated

| No. | Letter | Description of Range of Motion |
|---|---|---|
| | | **Against gravity tests** |
| 5 | N (normal) | Full available ROM against gravity and maximal resistance |
| 4 | G (good) | Full available ROM against gravity and moderate resistance |
| 4- | G- | Greater than one-half of available ROM against gravity and moderate resistance |
| 3+ | F+ | Less than one-half of available ROM against gravity and moderate resistance |
| 3 | F (fair) | Full range of ROM against gravity |
| 3- | F- | Greater than one-half of available ROM against gravity |
| 2+ | P+ | Less than one-half of available ROM against gravity |
| | | **Gravity-eliminated tests** |
| 2 | P (poor) | Full available ROM with gravity eliminated |
| 2- | P- | Greater than one-half of available ROM with gravity eliminated |
| 1+ | T+ | Less than one-half of available ROM with gravity eliminated |
| 1 | T (trace) | Absence of ROM with gravity eliminated, with palpable or observable flicker of muscle contraction |
| 0 | None | Absence of ROM with gravity eliminated without palpable or observable flicker of muscle contraction |

### Contractile Tissue

Resisted isometric testing examines possible problems of the contractile tissue, including muscles, tendons and attachments. It is further needed to examine the muscle tissue involvement which can be facilitated by considering both the strength and degree of pain associated with movement. Often the passive movements are full and pain free, except perhaps at the end-feel. The following conditions of pain and strength are noted:

- **Strong and Pain Free:** Indicates no lesion in the muscle being tested, regardless of how tender the muscle may be when touched. Muscles function painlessly and are not source of patient's discomfort.
- **Strong and Painful:** Indicates a local lesion of the muscle or tendon, such as first- or second-degree muscle strain. Usually there is no primary limitation in passive movement, except in case of gross muscle tear with hematoma and muscle spasm.
- **Weak and Painful:** Indicates a severe lesion around that joint, such as a facture. Weakness results from reflex inhibition of muscles around joint.
- **Weak and Pain Free:** Indicates a rupture of a muscle (third-degree strain) or involvement of the nerve supplying that muscle.

### Tonic and Phasic Muscles

One view is to consider that postural muscles (tonic) tend to develop tightness and contractures while the phasic muscles develop weakness. Thus the examiner carefully notes the range of motion available (active movements) as well as strength (resisted isometric movements) when testing the muscles. A general grouping of primary postural muscles and phasic muscles are noted as follow with all others considered neutral:

- Postural (tonic): soleus, rectus femoris, thigh adductors, hamstrings, iliopsosas, tensor fasciae latae, trunk erectors, quadratus lumborum, pectoralis major (sternal portion), upper trapezius, levator scapulae, and triceps
- Phasic: tibialis anterior, gastrocnemius, vastus medialis, vastus lateralis, gluteal muscles, abdominal muscles, upper limb flexors, lower stabilizers of the scapula, and deep flexors of the neck.

## Functional Assessment

The key to bodily movements is to perform all normal functions of daily living. Hence, some degree of functional assessment of the affected joint(s) should be performed during the examination process. This could simply involve observation of certain activities of the patient or may involve a detailed task analysis effort using certain tests or information derived by means of a questionnaire. Functional assessment is essential to determine the impact that the condition or injury has on the patient's daily life, including their sex life. In addition to being an annoyance, functional impairment may be completely disabling.

Functional assessment testing that should be considered when appropriate includes self care activities such as daily hygiene (e.g., showering, bathing, shaving, and combing hair), going to the bathroom, dressing, walking, and eating; hobbies or recreational activities such as gardening, playing a musical instrument, reading, sewing, going to movies, and watching television.

## Special Tests

After the examiner has completed movement evaluation, special tests may be performed on the target joint. These joint-specific special tests provide additional information to understand the type of disease, condition, or injury affecting the join in question. There are perhaps some 600 specialized orthopedic tests have been devised over the years to provide additional means to evaluate the status of major joints or neurological involvement. These tests are mostly used to sort out nerve root or radicular involvement. They are usually designed to either provoke or lessen presenting symptoms. Several different tests are discussed in Chapters 6 - 17 that are appropriate to each specific region of the body.

## Reflexes and Cutaneous Distribution

The deep tendon, superficial, and pathological reflexes are tested after completion of any special orthopedic tests, to obtain an indication on the nerve or nerve root supplying the reflex. The reflex tests are not performed if it is determined that the neurological system is normal.

### *Deep Tendon Reflexes*

Deep tendon reflex testing is a familiar routine that usually involves sharply striking a particular tendon with a small rubber hammer to provoke a spinal mediated jerk response. This provides information on the various neural pathways involved and to a lesser extent the health of the muscular tissue. The most common deep tendon reflexes tested are summarized in Table 3.7 for the temporomandibular joint and brachial plexus and in Table 3.8 for the lumbar and sacral plexuses. The ancient Chinese employed reflex testing as well by snapping or striking certain tendons, joints, or particular critical neurovascular nodes (acupoints). Reflex testing is used to assess muscular dysfunction, isolate particular nerve roots, and also to help differentiate between various symptoms. The speed and magnitude of the particular reflex is used to judge the condition and its prognosis. Deep tendon reflexes can be graded from 0 - 4 as noted in Table 4.4.

Table 4.4. Grading deep tendon reflexes

| Grade | Reflex Quality | Possible Indication |
|---|---|---|
| 0 | Absent | Lower motor neuron |
| 1 | Diminished | Lower motor neuron |
| 2 | Average | Normal |
| 3 | Exaggerated | May indicate upper motor neuron problem |
| 4 | Clonus, very brisk | May indicate upper motor neuron problem |

### *Superficial Reflexes*

Superficial reflexes are stimulated by stroking particular regions of the skin. A sharp object is used that doe snot break the skin. Some degree of practice is needed to develop proficiency in testing superficial reflexes. Expected responses are noted in Table 3.9. With respect to superficial reflexes, abdominal and cremasteric reflexes may be absent in both upper and lower motor neuron disorders.

### *Pathological Reflexes*

Pathological reflexes (See Table 3.10) may indicate possible lesions in upper motor neurons if they are present on both sides. If they are present only one side, this may indicate problems in the lower motor neurons. Voluntary withdrawal may be seen in normal individuals if too much pressure is used to stimulate the reflex. In order to be of clinical significance there should be an asymmetric response to the bilateral reflexes, unless there is a central lesion.

### *Sensory Examination*

This involves a scanning examination to check the cutaneous distribution of peripheral nerves and dermatomes associated with the target joint to determine:

- Extent of sensory loss and if result of nerve root or peripheral nerve lesions, or compressive tunnel syndrome
- Degree of functional impairment
- State of nerve recovery after injury or repair

## Joint Play Movements

There is a small ROM in synovial and cartilaginous joints beyond that which is achieved by active movements. This movement is called joint play or accessory movement which is not under voluntary control. These movements are necessary for pain free full ROM joint function. Joint dysfunction usually signifies a loss of joint play movement (See Table 4.5).

Assessment of joint play is an essential part of the examination. If joint play is found to be decreased or absent, it needs to be restored before full voluntary movement can be accomplished. Joint play movements may be similar to same movement as examined during passive movements or ligamentous testing.

Table 4.5. Grading accessory joint movement

| Grade | Joint Status |
|---|---|
| 0 | Ankylosed |
| 1 | Considerable hypomobility |
| 2 | Slight hypomobility |
| 3 | Normal |
| 4 | Slight hypermobility |
| 5 | Considerable hypermobility |
| 6 | Unstable |

### *Loose-Packed Position*

The examiner places the joint in its resting or loose-pack position in order to test joint play. The loose-pack position is any position of the joint other than the full congruent close-pack position, where the joint capsule is lax. The position of least stress and least congruency of joint surfaces and the greatest laxity of the capsule and ligaments is the resting position of the joint. The loose-pack positions may be used to prevent joint pain when testing isometric muscle strength in the region of a painful joint. This reduces tension on the joint capsule and ligaments and decreases intra-articular pressure. The loose-pack (resting) positions of selected joints are noted in Table 4.6.

### *Close-Packed Position*

When a joint is in the close-packed position the joint surfaces are fully congruent. In this position maximal tension exists in the joint capsule and ligaments; the joint surfaces are firmly pressed together and the joint surfaces cannot be pulled apart using traction.

The close-packed position needs to be avoided when testing muscle strength. The patient can lock and hold the joint in position against resistance in the presence of a weak prime mover resulting in an inaccurate strength test. The practitioner should be careful of close-pack positioning at the elbow, knee, and ankle joints. Close-pack positions are noted in Table 4.6 for selected joints.

## Palpation

Palpation for tenderness plays no part in the initial phase of the assessment since referred manifestations of tenderness and pain can be misleading as to its exact source. Hence, palpation is not considered until the tissue at fault has been identified and the extent of the lesion within that tissue determined. Palpation is then only considered if the affected tissue is superficial and can be easily touched with the fingers. Palpation has long been an essential Chinese assessment tool which requires much practice to be effectively applied. Signs of tenderness, along with results of the movement and neurological assessment, do provide the examiner sufficient information to identify the likely ligament or area of tearing or bruising.

Effective palpation requires a systematic approach to make certain that all structures are properly examined. Procedure should start at one location and works into surrounding tissues ascertain normalcy or pathological involvement. The examiner starts slowly by carefully applying light pressure and then applying deeper pressure feeling for pathological conditions and tissue changes. Examiner palpates the uninvolved side first to determine how the normal side feels, and to demonstrate what the patient to expect during the examination.

The area being palpated needs to be relaxed and hence the body part may need to be supported. The following areas and conditions are examined during the palpation effort.

Table 4.6. Loose-packed and close-packed and positions of selected joints

| Joint(s) | Loose-Packed (resting) Position | Close-Packed Position |
|---|---|---|
| Facet (spine) | Midway between flexion and extension | Extension |
| Temporomandibular | Mouth slightly open | Clenched teeth |
| Glenohumeral | 55° abduction, 30° horizontal adduction, rotated so that the forearm is in the transverse plane | Abduction and external rotation |
| Acromioclavicular | Arm resting by side, shoulder girdle in the physiological position | Arm abducted 30° |
| Sternoclavicular | Arm resting by side, shoulder girdle in the physiological position | Maximum shoulder elevation |
| Ulnohumeral (elbow) | 70° elbow flexion, 10° forearm supination | Extension |
| Radiohumeral | Full extension, full supination | Elbow flexed 90°, forearm supinated 5° |
| Proximal radioulnar | 70° elbow flexion, 35° forearm supination | 5° supination |
| Distal radioulnar | 10° forearm supination | 5° supination |
| Radiocarpal (wrist) | Midway between flexion-extension (so that a straight line passes through the radius and third metacarpal) with slight ulnar deviation | Extension with ulnar deviation |
| First carpometacarpal | Midway between abduction-adduction and flexion-extension | Full opposition |
| Metacarpophalangeal (fingers) | Slight flexion | Full flexion |
| Metacarpophalangeal (thumb) | Slight flexion | Full opposition |
| Interphalangeal | Slight flexion | Full extension |
| Hip | 30° flexion, 30° abduction, and slight external rotation | Full extension, internal rotation and abduction |
| Knee | 25° flexion | Full extension and external rotation of the tibia |
| Talocrural (ankle) | 10° plantar flexion, midway between maximum inversion and eversion | Maximum dorsiflexion |
| Subtalar | Midway between extremes of inversion and eversion | Full supination |
| Midtarsal | Midway between extremes of ROM | Full supination |
| Tarsometatarsal | Midway between extremes of ROM | Full supination |
| Metatarsophalangeal | Neutral | Full extension |
| Interphalangeal | Slight flexion | Full extension |

***Tissue Tension***

Regions are examined for effusion (escape of fluid into a part or tissue), tight and spastic muscles, and flaccidity.

***Tissue Texture***

Distinguish texture in terms of small bands of contracted muscular fibers, and fiber direction.

***Shape***

Identify differences in shapes, structures, and tissue types, including bones, to detect any abnormalities.

***Tissue Characteristics***

Note tissue thickness and whether it is resilient, pliable, and soft, and if there is an obvious presence of swelling.

### *Joint Tissue and Tenderness*
Assess joint tenderness by applying firm pressure to the joint. Application of pressure always performed with care, especially during the acute phase. Examiner should also determine pathological conditions of tissue around the joint, noting any thickening or other signs.

### *Temperature and Moisture*
Note possible variations in temperature often by using the back of the hand, and also comparing temperature of the uninvolved side. Also, feel for dryness or the presence of excess moisture.

### *Pulses*
Pulses tested for rhythm and strength to determine circulatory sufficiency, including palpation of the carotid, brachial, radial, ulnar, femoral, popliteal, posterior tibial, and dorsalis pedis locations.

### *Tremors and Fasciculations*
Tremors are the result of agonist and antagonist muscle groups contracting at the same time to cause rhythmic movements of a joint. Foot tremors can be the result of the tibialis anterior and posterior contracting at the same time, which the Chinese attribute to the stomach related muscular distribution. Signs of fasciculations indicate the involvement of several muscle cells innervated by a single lower motor axon.

### *Abnormal Sensation*
Note any abnormal sensations including diminished (dysesthesia) or increased (hyperesthesia) sensations or lack of sensation (anesthesia). Also note possible joint crepitus, creaking, or snapping of tendons.

### *Skin and Subcutaneous Tissue*
Note skin lesions, scars, discoloration, ulcers, nodules or lumps under the skin and deformities.

### *Sensitive Locations*
Chinese orthopedics places importance on palpating sensitive or painful spots which develop (sensitive or trigger points) which indicate possible dysfunction or pain in muscles above or below the spot. Distribution of sensitive spots or tight muscular tissue bands is consistent with the Chinese muscular pathways. These small sensitive regions can be treated using most modalities, including cupping, massage and pressure. Normally these locations are not needled unless the area is coincident with a known neurovascular node.

### *Muscles and Tendons*
Consider palpation along the longitudinal Chinese muscular distributions to determine if problem mainly related to a particular distribution. Isolating problem area to particular distribution provides clue to treatment using acupuncture.

## Diagnostic Imaging

Special imaging, instrumentation testing and laboratory tests may be necessary to confirm the initial clinical impression. Practitioner needs to determine if imaging and laboratory tests are essential to confirm the diagnosis or if there is a suspicion of more serious pathology that requires attention. The following procedures may be considered:

### *Plain Film Radiography (X-rays)*

Radiography or plain film X-ray is the oldest and most frequently used form of medical imaging. Discovered on November 8, 1895 by the German physics professor Wilhelm Conrad Roentgen (1845-1923), X-rays can produce diagnostic images of the human body on film or digitally on a computer screen.

X-ray imaging is the fastest and easiest way to view and assess broken bones, such as skull fractures and spine injuries. At least two images (from different angles) are taken and often three images are needed if the problem is around a joint (knee, elbow or wrist). X-rays also play a key role in guiding orthopedic surgery and in the treatment of sports-related injuries. X-ray may uncover more advanced forms of cancer in bones, although early screening for cancer findings requires other methods.

#### Advantages

Plain x-rays are still the primary means of looking for trauma to bones. They have the advantages of low cost, wide availability, and good anatomic resolution. X-rays do not give a good image of soft tissue structures (muscles and ligaments). The actual reading of radiographs and other diagnostic imaging results is a science in itself and may be performed by any knowledgeable practitioner with critical evaluation by a radiologist.

#### Common Uses

Probably the most common use of bone radiographs is to assist the physician in identifying and treating fractures. X-ray images of the skull, spine, joints and extremities are performed every minute of every day in hospital emergency rooms, sports medicine centers, orthopedic clinics and physician offices. Images of the injury can show even very fine hairline fractures or bone chips, while images produced after treatment ensure that a fracture has been properly aligned and stabilized for healing. Bone x-rays are essential tools in orthopedic surgery, such as spinal repair, joint replacements or fracture reductions.

X-ray images can be used to diagnose and monitor the progression of degenerative diseases such as arthritis. They also play an important role in the detection and diagnosis of cancer, although usually computed tomography (CT) or MRI is better at defining the extent and the nature of a suspected cancer. On regular x-rays severe osteoporosis can be visible, but bone density determination for early loss of bone mineral is usually done on specialized, more sensitive equipment (See discussion on Bone Densitometry below).

### *Magnetic Resonance Imaging (MRI)*

Magnetic resonance imaging (MRI) is a technique that uses a magnetic field and radio waves to create cross-sectional images of the head and body. The process produces detailed, clear images of soft tissue (not detected by X-ray) to identify and diagnose a wide range of conditions. MRI cannot be used for people with implanted or other metallic foreign bodies not firmly fixed to bone but is reportedly safe with prosthetic joints and internal fixation devices. It is often preferred over myelography for the assessment of disk disease because it is noninvasive. Its principal disadvantages include cost and lack of availability. There are no known harmful effects from exposure to the magnetic field or radio waves used in making MRI images.

The MDI data can be used to create a composite, three-dimensional representation of the body. Any two-dimensional plane (slice) can be selected electronically from this representation and displayed on a television-type screen for examination. Photographic images also can be produced from the screen for further viewing and analysis. These images are especially helpful for evaluating joint, ligament, muscle and bone problems. MRI images are also very useful for examination of the brain, neck, spinal cord and soft tissues. MRI often is used in the diagnosis of central nervous system disorders, such as multiple sclerosis, because of its high-resolution images of the brain and spinal cord's white and gray matter.

***Computerized Tomography***

Computerized tomography is often referred to as CT, CT scan and CAT scan. This is an X-ray technique that produces more detailed images of the internal organs than do conventional X-ray exams. X-rays are a form of energy radiation. Conventional X-ray exams produce two-dimensional images. But CT uses an X-ray-sensing unit, which rotates around the body, and a large computer to create cross-sectional and axial images (like slices) of the inside of the body.

Unlike the conventional X-ray a CT scan can reveal the bones as well as soft tissues of joints and organs such as the pancreas, adrenal glands, ureters and blood vessels, all with a higher degree of precision. CT is used to help:

- Diagnose muscle and bone disorders, such as osteoporosis
- Pinpoint the location of a tumor, infection or blood clot
- Guide procedures such as surgery, biopsy and radiation therapy
- Detect and monitor diseases such as cancer or heart disease, and monitor the progression of a disease
- Detect internal injuries and internal bleeding

Unlike MRI, CT exams can be done even if the patient has a pacemaker or cardioverter defibrillator, devices implanted in the chest to help regulate heartbeat. However, if the patient is pregnant or suspects they might be, they must inform the radiologists or practitioner. The procedure may be postponed or an alternative examination that doesn't involve radiation, such as ultrasound or MRI may be considered.

***Arthrography***

Arthrography is the radiographic examination of a joint after the injection of a dye-like contrast material and/or air to outline the soft tissue and joint structures on the images. This procedure is done most commonly to identify abnormalities associated with the shoulder, wrist, hip, knee and ankle. Patients who undergo this procedure usually have complained of persistent, unexplained joint pain or discomfort. Arthrographic images may allow identification of problems with a joint's function or indicate a need for a joint replacement.

Joint fluid is removed and replaced with injected contrast material or air and sometimes both. A series of radiographs, sometimes called "arthrograms," are obtained before the joint tissue absorbs the contrast material. Occasionally, the examiner will take additional x-rays as he or she pushes and pulls on the patient's joint.

### Myelography

This is a technique that involves spinal cord imaging by use of a water-soluble contrast dye is injected into the epidural space via lumbar puncture and allowed to flow to different levels of the spinal cord. Plain x-rays, or more commonly CT scan, are then performed, to indirectly visualize structures outlined by the dye. This technique is very sensitive at detecting disk disease, disk herniation, nerve entrapment, spinal stenosis, and tumors of the spinal cord. Side effects of the procedure include headache, dizziness, nausea, vomiting, and seizures.

### Diskography

This involves the injection of radiopaque dye into the center of an intervertebral disk (nucleus pulposus), using radiographic guidance, and may be used to determine disk disruptions. This procedure is not commonly performed but is sometimes used in cases where the precise cause of the presenting symptoms is difficult to ascertain to see whether the injection brings on exacerbates symptoms.

### Radiography-Based (X-ray) Bone Densitometry

Radiologists use x-rays to view and evaluate bone fractures and other injuries of the musculoskeletal system. However, a plain x-ray test is not the best way to assess bone density. To detect osteoporosis accurately, an enhanced form of x-ray technology called dual-energy x-ray absorptiometry (DXA or DEXA). DEXA bone densitometry is today's established standard for measuring bone mineral density (BMD). DEXA is a quick, painless procedure for measuring bone loss. Measurement of the lower spine and hips are most often done. More portable devices that measure the wrist, fingers or heel are sometimes used for screening, including some that use ultrasound waves rather than x-rays.

DEXA bone densitometry is used most often to diagnose osteoporosis, a condition that often affects women after menopause, but may also be found in men. Osteoporosis involves a gradual loss of calcium, causing the bones to become thinner, more fragile, and more likely to break. The DEXA test can also assess risk for developing fractures. If bone density is found to be low a treatment plan is needed to help prevent fractures before they occur. DEXA is also effective in tracking the effects of treatment for osteoporosis or for other conditions that cause bone loss.

### Radionuclide Scanning

Radionuclide scanning (nuclear medicine) is a subspecialty within the field of radiology. It comprises diagnostic examinations that result in images of body anatomy and function. The images are developed based on the detection of energy emitted from a radioactive substance given to the patient, either intravenously or by mouth. Generally, radiation level to the patient is similar to that resulting from standard X-ray examinations.

Nuclear medicine images can assist in diagnosing diseases. Tumors, infection and other disorders can be detected by evaluating organ function as well as conditions and disorders affecting the skeleton. Specifically, nuclear medicine can be used to:

- Evaluate bones for fractures, infection, arthritis or tumor
- Analyze kidney function
- Image blood flow and function of the heart
- Scan lungs for respiratory and blood-flow problems

- Identify blockage of the gallbladder
- Determine the presence or spread of cancer
- Identify bleeding into the bowel
- Locate the presence of infection
- Measure thyroid function to detect an overactive or underactive thyroid

employed to prevent irritation. In some situations special oils are used to stimulate the skin. Some massage techniques even involve the use of hot water in conjunction with the massage activity. There are some methods that employ only hands and could be considered superficial or light massage and some involve application of the fists, knuckles, arms or elbows to provide a deeper stimulation. Massage therapy is employed to treat pain and a wide range of musculoskeletal problems, as well as to regulate tissues, relax muscles and tendons, restore blood and vital nutrient flow and remove blockages in the superficial vessels. Common massage techniques generally consist of: 1) rolling, 2) kneading, 3) rubbing, 4) scrubbing, 5) pushing, 6) grasping, 7) flat-pushing, 8) patting, 9) tapping and 10) vibrating methods.

### *Mobilization and Manipulation*

Therapies classed as joint mobilization and manipulation includes a variety of techniques that involve manipulation of the joints of the body including the fingers, toes, arms, legs, head, neck and body. Some of the maneuvers are called "glides" because of the type of joints involved. Manipulation therapy often includes specialized and general massage to specific areas or to the entire body. Sometimes the specific approaches involve controlled mobilization or practitioner-guided articulation of the extremities, head, neck and the spine.

The main purpose of manipulation is to remove obstructions in the superficial vessels; improve the circulation of blood and vital nutrients; regulate tissues; and to relax muscles and tendons. Manipulation is also used to lubricate the joints, reduce swelling, alleviate pain, restore normal joint function, treat soft tissue injuries, reduce dislocated joints, enlarge joint spaces, relieve nerve compression, reduce adhesions, or increase range of motion. There are many specialized manipulation methods that focus on specific effects or are directed to particular joints. Common techniques generally include: 1) rolling-kneading, 2) holding-twisting, 3) shaking, 4) wiping, 5) rotating, 6) pulling, 7) compressing, 8) stretching, and 9) traction-countertraction manipulations. The last two manipulations of stretching and traction-countertraction are also employed as part of active treatments used during rehabilitation.

Although mobilization and manipulation are in the same category they are sometimes thought of in terms of slow and gentle for mobilization and faster or more forceful techniques for manipulations. These refinements are arbitrary but are used to distinguish between a high thrust maneuver, which may be counter-indicated for certain conditions, and a low risk mobilization. Some practitioners assign grades to the techniques to indicate what specific therapy was applied in certain cases. These grades are summarized in Table 5.1. Generally, Grade V movement is to be avoided.

Table 5.1. Grading passive movement treatment.

| Grade | Movement | Use |
|---|---|---|
| Grade I | Small amplitude oscillation at the beginning of range | Reduce pain |
| Grade II | Large amplitude oscillation within range without moving into resistance or the limit of range | Reduce pain |
| Grade III | Large amplitude oscillation from middle to end of range that reaches limit of range | Increase mobility |
| Grade IV | Small amplitude oscillation at the limit (end) of range | Increase mobility |
| Grade V | Sharp thrust beyond the pathological limitation of range | Increase mobility |

## Needling and Essential Modalities

Chinese needling therapy is the key and perhaps most unique treatment method and involves the insertion of very fine needles into specific locations on the body. The Western term "acupuncture" denotes the idea of puncturing something with a needle but does not convey any hint of something that may be therapeutically useful. However, when the practice of needling therapy was first legalized in Oregon and California the proponents used the term "acupuncture" to include needling and related modalities that are a critical part of Chinese needling therapy. This includes moxibustion, heating therapy, cupping, scraping, and massage. Training in these areas is not generally covered in undergraduate programs and therefore instruction on these methods is not specifically addressed in this text. Dietary and herbal remedies are also part of Chinese medicine and not discussed herein as well. The Chinese also employed therapeutic bathing, use of splints, and orthotic devices which are also not discussed in this text.

### *Needling Therapy*

There are several hundred neurovascular node (acupoint) locations on the body, primarily related to the peripheral and superficial distribution of blood vessels, related nerves, and the longitudinal muscular distributions. In addition to being needled, nodes can be massaged, scraped, pressured, cupped, heated by moxibustion, heated by other means, or even pricked to release a few drops of blood. Nodes can be palpated for sensitivity, numbness or minute temperature differences for diagnostic purposes and to assess effectiveness of treatment.

Insertion of needles into the superficial body requires knowledge of the location of the nodes as well as the underlying anatomical features. Each node has a nominal insertion depth that is adjusted for the size, shape and condition of the patient. Needles are typically inserted perpendicularly to the skin but some node locations require insertion to be at a certain angle. This is necessary because of local anatomical considerations. Although node locations are found in association with nerves and blood vessels, under no circumstances are needles to be inserted into these structures. Likewise, needles are never inserted into the internal organs.

Other considerations on needle insertion involve how long the needles are left inserted, how strongly they are manipulated, and the depth of insertion. Needle insertion time and strength of manipulation are related to the type of therapeutic response that is needed to address the presenting problem in terms of whether inflammatory or anti-inflammatory reaction is desired. Consideration of either shallow or deep insertion, within the safe limits of each node nominal depth, depends on what aspect of the needling reaction is needed in terms of somatovisceral, defense system, or neuromuscular responses.

Neurovascular nodes can be sensitive to touch and other spots can develop on the body as well. These latter locations are now often referred to as trigger points but the Chinese called them "Oh yes!" Sensitive points can spontaneously develop in muscle and tendon locations throughout the body. They are not usually needled if they are not coincident with a known Chinese neurovascular node location, but they can be treated by application of heat, pressure, cupping, massage, ointments, liniments, plasters, poultices, etc. Needling is usually only applied to well-established node locations because some non-nodal muscle locations produce muscular fatigue when needled and thus the condition might become worse by needling certain types of muscles in the body. Presence of sensitive nodes is very useful for diagnosis and assessment of treatment progress.

### *Electroneedling (EN)*

Nodal locations can also be stimulated electrically by means of either electric nerve stimulation to inserted needles (EN) or by transcutaneous conductive pads (TENS). In this text EN is only applied to needles inserted into established neurovascular nodal sites and therefore more properly referred to as electroneedling (EN). Application of EN is often considered where profound analgesia is desired, such as in surgical use. It is also employed in treating nerve dysfunction, paralysis, and substance abuse. Even though EN seems to be quite modern, it has the longest history of any electrical therapy with its introduction in Europe and the United States in the early 1820 - 1830 (See Chapter 1). Practical guidelines for electroneedling are presented in Appendix B.

### *Moxibustion*

Moxibustion involves igniting a stick or ball containing the wooly fibers of Artemisia Vulgaris (moxa) to apply heat to specific areas or nodes to promote warming, usually in localized areas. Sometimes this procedure is referred to as cauterization. It is employed to treat the effects of cold attacking or invading the body, or to strengthen the body's immune or defensive system. Balls of moxa can be ignited on the metal handles of needles to direct heat into specific nodes. Lighted moxa sticks are used to provide heat over a greater area of the body by holding them a safe distance above the skin and then moving them back and forth over the area being treated.

### *Heating Therapy*

Heating therapy, which is different than moxibustion, is used in clinical situations where it is necessary to heat larger areas of the body, or sometimes where the heat needs to be applied in deeper regions of the muscles. Sometimes heat is applied to induce perspiration. Heat therapy can involve the use of heat packs, infra red lamps and ultrasound stimulation. These devices are in common use in Chinese medical clinics in present day China, Japan, Europe, and to some extent in the United States.

#### Heat Packs

Use of heat packs, including those containing herbs, has continued from ancient time's right up to present day. They are applied in treatment of many musculoskeletal problems, especially where cold conditions are involved or in the situation where there is impairment in the flow of blood, oxygen and essential nutrients. Heat packs are also used for a variety of other conditions.

#### Radiant Heating

Present-day heat lamps are safely and efficiently used to provide radiant heat therapy that is equivalent to traditional methods. Use of these devices provides greater uniformity and control of radiant heat than is possible with the ancient approach of seating a patient close to a fire.

#### Ultrasound

Application of this technique also provides a modern means and can be considered to safely duplicate some of the traditional heating approaches. It induces heat by mechanical vibration of the tissue and can be thought of as a combination of heat and deep massage. In cases where it is important to achieve a deeper heat penetration, ultrasound may be a more efficient and safer consideration. To accomplish this same effect with either heat packs, radiant heat or moxibustion would require the affected area to be heated longer; ultrasound is more comfortable and safer for the patient and is a more efficient therapy. This modality, just as the other described in this text requires proper training and certification on the part of the practitioner that is consistent with appropriate state laws.

#### *Cupping*

Cups of various sizes are employed to treat a wide range of disorders. Application of a cup results in a suction contact with the body causing a local vasodilatation and mechanical expansion of the underlying tissue. This physically increases the flow of blood and nutrients in the muscular and superficial regions and also activates needling response mechanisms. Small cups may be applied to the face in treating facial paralysis whereas large diameter cups placed in the lumbar region are used to treat lumbago. Cupping is frequently applied over nodes but they can also be used in non-nodal regions as well. Cups can also be applied over inserted needles but in some cases this can result in blood oozing into the cup space. The occurrence of such an event requires the proper handling and disposal of blood products.

#### *Scraping Therapy*

This is a technique involving scraping the skin with a smooth sided objects, employed in conjunction with an oil. The side of a typical Chinese porcelain spoon or other small and smooth objects is used. The oil contains certain herbs that, along with the scraping action, enhance superficial vasodilatation. This technique is used to remove stagnations and improve circulation in the superficial regions. It often produces a reddening of the skin that may last from several hours to a full day.

#### *Baths and Water Therapy*

Although these therapies are to be found in modern physical therapy clinics, these skills are not routinely taught in Chinese schools in the United States. Modern therapeutic bathing equipment is now available in most hospitals and physical therapy clinics. Therapeutic bathing therefore is not normally used in modern Chinese clinics and is usually limited to instructing the patient on self-help use of bathing. Some therapeutic bathing included the addition of herbs.

#### *Orthotics and Restraints*

Simple splints, restraints, and taping are sometimes necessary to temporarily immobilize a joint to allow the healing process to proceed. Some of these involve making temporary soft casts of herbal material to promote healing. Modern devices are employed as well and emphasis is placed on very short duration of use. Use of orthotics and restraints, just as the other described in this text, requires proper training and certification on the part of the practitioner that is consistent with appropriate state laws.

## Medicines for Internal and External Use

Foods (including vitamins and minerals), herbal remedies, and medicated diet make up the complete category of what would be considered as medicines. Medicated diet and foods are all consumed internally as are most herbal remedies. Some herbs however are only used externally to apply to the superficial body. The therapeutic use of foods is perhaps most fundamental to the practice of Chinese therapeutics. Considering the flavors of both foods and herbs is important to understand how they are used to treat or prevent certain conditions.

As a rule, severe and acute disorders are treated with needling and herbs and possibly the combination of both food and herbs or medicated diet (contains herbs). In long term chronic ailments, both Chinese and modern dietetics are considered most important. All herbs have the potential of producing unexpected and unwanted side effects and so long term use of any formulation is usually inappropriate. Dietary therapy, on the other hand, is more forgiving and safe and so it can be maintained for longer time periods without risk of adverse reactions.

Foods and herbs are also considered based on their essential properties of either being hot, cold, warm, cool or neutral. This property does not refer to the temperature of the food or herb, but to the effect it has on the body when consumed. The property of the herb or food is used in opposition to the nature of the disease. Specific diseases may manifest as being either hot or cold, or deficient or excess in nature.

Cold foods or herbal remedies are considered in case of a hot disease which is severe, whereas, cool foods or herbal remedies are considered in case of a hot disease which is mild. Hot foods or herbal remedies are considered in case of a cold disease which is severe, whereas, warm foods or herbal remedies are considered in case of a cold disease which is mild. The properties of food and herbs are also considered with respect to the prevailing climatic conditions. Certain cold foods are avoided during cold seasons and certain hot foods are avoided during hot seasons. Also, the actual temperature of an herbal decoction, to be consumed, is considered with respect to the nature of the disease.

### *Dietary Therapy*

Use of dietary means in treating orthopedic conditions are appropriate where metabolic disorders may be involved in the problem or in situations where poor diet or dietary habits are directly affecting the condition. Modern dietary supplementation with minerals and vitamins are appropriate to consider when indicated although emphasis is usually on consumption of proper foods. Chinese dietetics first described in the *Neijing* involves a highly sophisticated system where consumption of foods, classed as certain flavors, are considered to exert interrelated dynamic influences on the organs and tissues of the body, and even emotions as well. Foods are consumed based on a well balanced daily diet and avoiding the over consumption or under consumption of any particular flavor. Excess consumption of most flavors has impact on the musculoskeletal system (See Table 2.1). In addition, flavors are used in treating prime visceral symptoms, promoting certain visceral tendencies or used during different seasons to treat either excess or deficiency conditions.

### *Herbal Remedies*

Many effective, traditional herbal formulas are applied in treating orthopedic conditions including trauma, arthritis, rheumatism, inflammation, swelling, pain, and stiffness. Most of these herbal remedies are consumed for internal use although they are also used externally as a liniment, poultice, plaster, crème, paste, ointment, powder or suppository. Several types of over-the-counter herbal plasters are in common use of orthopedic conditions. Some of the well known liniments are use to promote bone healing and relieve pain. In addition herbs are available in ready-to-use herbal products that are frequently referred to as patent medicines. Ready-to-use products are usually in the form of either pills, powders, extracts, pellets, soluble granules, tablets, capsules, tinctures, dilutions, syrups or oral liquids. Recommendations for herbal formulas, remedies, and medicated diet are beyond the scope of this text.

#### *Medicated Diet*

The Chinese add herbs to various food products to create a medicated diet. Medicated diets are used to treat both acute and chronic disorders. Both the foods and the introduced herbs are selected based on their inherent flavors and basic properties as well as their known therapeutic effects. Rice gruel is frequently used as a vehicle to introduce a variety of different herbs to treat certain conditions. Gruel can also be made with wheat, millet, or maize, but these are considered inferior to rice.

Many additional food products are used to introduce herbs for the treatment of acute and chronic disorders. The type of food is selected for its ability to work in harmony with the herbal component and bring about the best therapeutic result. Different forms of medicated diets or the materials used in their production are generally in the following categories: 1) gruel or porridge, 2) thick soups, 3) drinks, 4) medicated tea, 5) stable foods, 6) specially cooked dishes, 7) medicated wine and liquor, 8) decoctions, 9) juices, 10) honey paste, 11) honey extract, 12) preserved fruits and vegetables and candy, and 13) miscellaneous items.

## Movement Therapy, Exercise, Prevention and Rehabilitation

This aspect of treatment constitutes the active phase where the patient takes a participative role in restoring or improving their health. The basic ideas in health preservation and rehabilitation include living a calmer life, reducing stress, avoiding excess physical and mental activity while considering remedial steps to promote health. Some of these strategies rely on dietary changes, medicated diet, movement therapy and remedial exercise, breathing exercise, relaxation techniques to calm the mind, and protecting oneself from harmful environmental exposure.

In case of rehabilitation, it is also necessary to consider needling therapy, moxibustion, heat therapy, sometimes even hot baths, cupping, pressure, massage, and manipulation. In addition, the practitioner has a major task in paying attention to the patient's lifestyle and provides advice, guidance and counseling where necessary. The primary requirement however, is that the practitioner themselves, conduct their lives by the same principles. Otherwise the practitioner has little or no credibility.

### Movement Therapy and Exercise

Prescribed exercise includes practitioner directed routines to strengthen specific muscles or general health promoting programs. The initial emphasis however is directed to restoring pain-free range of motion through movement therapy before strengthening exercises are considered. The Chinese developed diverse and excellent exercise approaches, some of which involve guided stretching of tendons and muscles. Many of these are taught to patients to address specific muscular or articulation joint problems. Sometimes the therapy is directed to strengthen particular muscle groups or those associated with a particular joint or muscular distribution. Remedial exercises are included as part of the therapeutic approach in treating many musculoskeletal problems during rehabilitation. Some exercises are directed to general problems, such as tight tendons or general weakness. Remedial exercise programs can be considered in different categories as follow:

***Passive Stretch***

Passive stretch consists of a gentle sustained muscle lengthening process applied by the practitioner or therapist. Numerous variations of passive stretching exist with some using distractors or techniques to inhibit afferent nociceptive and vasodilatory fibers contributing to the pain. Some of these include: 1) cryotherapy (ice, cold packs, coolant sprays); 2) analgesic balms (tiger balm, blue ice) and: 3) needling therapy.

***Mobility and Stretching Exercise***

Active mobility maintenance and stretching by the patient are encouraged by the practitioner. Training, counseling and advice in stretching and mobility exercises are provided to assure safe and effective use of these procedures. Sometimes the exercises are performed in conjunction with needling treatment to relieve acute spasms, especially of the low back, neck and shoulders.

- ➔ **Caution:** No exercising or stretching is permitted in conjunction with or after electroneedling (EN) treatment. This modality usually produces profound analgesia putting the patient at potential risk of self injury if active exercise is undertaken or is at risk of practitioner induced problems in case of passive exercise and stretching.

***Stretching-Contraction Exercise***

In certain situations, especially if it involves a foreshortened muscle condition, the process of stretching the muscle prior to each contraction exercise is employed. Exercising the muscle without prior stretching may only aggravate the condition. The exercise routine then consists of stretching followed by contraction for each repetition.

***Flexibility and Stability***

These exercise and training strategies concern the axial muscles of the body involved in posture. The long term goal of rehabilitation is to restore the patient to pre-injury function and reduce the chances of recurrent episodes. Repetitive microtrauma due to poor or weak posture, superimposed on a previous injury can lead to advanced degeneration. Spinal stabilization is used to teach the trunk muscles recruitment as an effort to control and reduce flexion and torsional stresses on the joint segments. Through the use of voluntary muscles, pain-free regional postures can be maintained while the patient carries out normal daily activities. The necessary posture and combination of muscle actions determined experimentally are specific for each case. Once the comfortable position is found, the patient is assisted while rehearsing progressively more complex tasks, keeping the body part in its neutral, pain-free position.

***Strength, Conditioning and Endurance***

Active conditioning exercises are helpful in bringing about a resolution of the patient's problem and help prevent its recurrence once strength is recovered or even improved over the pre-injury status. Some problems cannot be successfully resolved without the inclusion of exercise therapy.

Early during the recovery phase, isometric exercises and stretching within the pain-free range of motion may be used to limit the effects of deconditioning. Once the case has successfully passed the remobilization phase, progressively increasing loads throughout the full range of motion are initiated. These may be accomplished through use of free weights, weight stack machines, or the same computerized isokinetic or isoinertial machines that aid in assessment of muscle strength and function.

## Exercise Planning

Patient compliance is extremely poor if they are only advised concerning certain exercises. Thus, prescribed exercise plans during the initial stages need to be supervised by the practitioner or other responsible health care provider (i.e., physical therapist, kinesiologist). Usually an exercise training plan begins with direct supervision, three to five times per week, of assigned exercises tasks intermixed with rest periods. Many progressive-resistance protocols are available, some using isometric force and slow speed movements. The combination of multiple sets of repetitions with increasing or decreasing increments of weight or force results in benefits for both strength and endurance. The maximum resistance is progressively increased as strength improves over a course of four to six weeks for a typical case.

Computerized instruments are available that are used as the prime exercise equipment which also provides objective strength measurements. These devices, found in some modern orthopedic rehabilitation clinics, provide instant feedback on progress and help maintain the patient's interest in the program. However, such equipment is not essential to assure a good clinical outcome.

Patients who fail to comply with the exercise/treatment/care schedule or who are insincere in their efforts should be advised about being discontinued from the program and discharged from care if minimal compliance cannot be maintained. The other patients are reassessed near the completion of the treatment plan to determine the outcome.

### *Kinesiology*

This term refers to the study of human motion and is derived from "kinesis" meaning motion and "logy" meaning "study of" or "logic." When considering exercise therapy it is important to understand the basic kinesiology involving the role of each muscle in the articulation of each joint or body region. Muscles that play a major role in articulating a joint are referred to as prime movers (PM). Several other muscles may also be involved in the same joint and have an assisting role and are referred to as assistant movers (AM). The prime movers are usually stronger and can compensate for the assistant movers. A table is provided in Chapters 6 - 17 that lists all muscles that participate as prime and assistant movers in each degree of movement for each major joint articulation. This kinesiology information is essential in the assessment and treatment of muscular problems and for exercise planning.

### *Elements of Reconditioning Program*

Possible weakness, dysfunction and pain in particular muscles and joints are determined by the appropriate orthopedic testing. Weak muscles are sometimes difficult to isolate since strong muscles involved in the same articulation compensate for the weak muscle. In this case isometric exercises may be used to strengthen the suspected weak muscle. Restoring an impaired muscle to pre-injury status requires special attention. The practitioner must decide on the type of exercise needed as well as how many times it should be performed with respect to repetitions and sets. These elements are discussed below.

A therapeutic exercise program is considerably different than simply exercising a normal muscle to gain strength. Care has to be taken not to cause the musculoskeletal problem to worsen. Consequently, loads applied in rehabilitating an impaired muscle are much less than required to build strength. As movement improves and strength increase, the conditioning load can be increased as well. Often this is accomplished by use of light-weight dumbbells or strap-on weights. Under no conditions are exercises permitted to push into the painful range of motion. Likewise, weights are never increased to the point of inducing pain during an exercise.

One general consideration is that humans are bipedal with the lower leg extensors (quadriceps) and hip extensors (gluteal muscles including maximus, medius, and minis) being the most important muscles to maintain function. Hence, restoring these critical muscles to normal function has an overall impact on the rest of the body, especially the lumbar and thoracic spine. With respect to the upper body, functions of muscle that control the arms and shoulder likewise have an influence on total body performance.

***Patient Instructions***

Patients are instructed in how to take special care when standing up from the seated position, or how to roll out of bed without putting undue load on the affected area. Any positive means of reducing mechanical loads on the injured or impaired body region helps the recovery process. In addition, only one side of body typically has the presenting problem. For example, shoulder, elbow, wrist, hip, knee and foot problems are often ipsilateral. Consequently, as in the case of resistive strength testing, the good side is exercised first. Afterwards, the problem area is subjected to the same exercise routines.

Most of the exercises are performed either while the subject is seated in a chair or on the floor, lying prone or supine, side lying, or while standing. The examination table may be used to demonstrate or teach the routine but most patients do not have such equipment at home and thus exercises have to be conducted with the minimum of amount of equipment. It is advisable that practitioners use an exercise mat or towel to teach and supervise the exercise program and to observe the patient's progress.

Many exercises basically use the force of gravity as the main resistive load. Light weights can eventually be brought into the routine when progress permits. Self-applied external dynamic resistance (EDR) or internal dynamic resistance (IDR) is also employed to provide the main force to challenge muscle contractions (See following discussion). Some clinics have modern exercise equipment to address each specific muscle group. In this case, the patient must come to the clinic for supervised and monitored exercise. Even in these situations it advisable to still teach the patient all the necessary manual exercises to be used in maintaining and improving strength once they have completed the initial program.

***General Terms Applied to Exercise***

A few common terms are frequently used with respect to exercise. These are described by Greco-Latin elements and found in almost all literature associated with exercise. These are mainly of Western invention as are most medical terms because of the efficiency and compactness of ancient Greek and Latin. The three most common terms are:

#### Isotonic

This term denotes exercise involving fixed weights and is derived from "isos" meaning "equal" and the Greek "tonikos" which refers to tone. The Latin equivalent "tonus" refers to "stretching," and hence tone generally applies to the contractile condition of muscles. A dumbbell is a dead weight of particular magnitude and is good example of an isotonic load. Various parts of the body that are moved during exercise also represent isotonic loads as well. Isotonic loads are commonly used in most therapeutic exercises.

#### Isometric

This term is applied to a certain type of exercise and derives form the Greek "isos," which means "equal," and "metron," which means "measure." It refers to subjecting a muscle or muscle group to a resistive force at a fixed length or position. A force is applied while the joint or extremity is constrained not to move by increasing the load to counteract the muscle contractive force. Hence the muscle contracts, but is held at some constant length or position. This is the technique used in orthopedic muscle strength assessment. When used as an exercise technique, the strength of the muscle can increase.

#### Isokinetic

This term is derived from the Greek "isos," meaning equal and "kinesis," meaning motion. Thus, it refers to equal motion, or equal velocity. It is used to describe exercise involving equal motion which is typical of certain strength measuring instrumentation devices or machines, and also pertains to certain movement exercises.

## Features of Rehabilitation Movement

Therapeutic and rehabilitation exercises are different than normal strength building exercises as found in sports training or normal physical fitness efforts. The target muscles for rehabilitation may involve impairment, weakness, and pain. This requires a certain amount of care to slowly and systematically rehabilitate the affecting area by increasing range of motion, reducing pain, and eventually restoring strength to the fullest amount possible. Certain protective movements may be involved as well as stretching to prepare for the rehabilitation exercises.

### *Protective Movements*

Some protective movements were previously discussed in teaching the patient how to perform certain daily activities without aggravating their condition, such as getting out of bed or standing up from a seated position. Other protective movements involve stabilizing the back and cervical spine to provide a posture that prevents further deterioration in these areas.

### *Pre-Exercise Stretches*

It is important to subject the muscle group being reconditioned, to passive stretch prior to the exercise routine. If a planned workout includes several different muscle groups, a series of related stretches can be performed before exercising.

### *Strengthening Exercise*

The primary means of strengthening an impaired muscle or muscle group is to apply light loads (isotonic) over the pain free portion of the range of motion. The joint, extremity or muscle is moved under load, just to the point of pain. No attempt should be made to push into the region of pain. No exercise should be continued if it results in producing pain.

Strength is restored by subjecting the muscle to loads that result in contractions. These can be concentric, where the muscle shortens in the process of contracting. Contractions can also be eccentric, where the muscle lengthens while developing tension. Exercises are repeated in groups or sets (see below) to progressively increase the intensity of the routines as strength is developed.

## Load Consideration

Muscles operate through contractions to shorten the distance between its origin and its insertion on two bones across a joint or body region. In order to move an articulation, the contraction must produce sufficient force to overcome any mechanical loads being subjected to the body part in question. Loads additional to one's body weight can be added such as picking something up or just due to normal human daily activities involving movement. All of this basically takes place under the influence of the forces of gravity. However, there are some orthopedic and pain problems where the patient does not have sufficient strength to move some articulation, and hence gravity-eliminated exercises are indicated. Also, loads can be judiciously added to challenge muscle contractions such as using isotonic loads, or by application of external and internal dynamic resistance.

### *Gravity-Eliminated*

In some situations the patient's muscle strength is measured to be less than Grade 3 (See Table 4.3). Thus, they have insufficient strength to initially perform the reconditioning exercises which are performed in the configuration where gravity provides the primary resistive force. In this case, the exercise is modified to place the patient in the gravity-eliminated position used to perform the initial orthopedic assessment. Exercises are modified so the principal plane of motion is at 90° to the gravitational field, basically the plane of motion is parallel with the ground.

### *Isotonic Loads*

Most exercise routines involve the use of isotonic loads such by use of dumbbells or barbells. Most fitness centers are equipped with numerous machines that provide an isotonic load for a specific degree of motion. The load can be adjusted consistent with the capability and goal of the individual.

### *External Dynamic Resistance*

This involves self-application of external dynamic resistance (EDR) by using one hand placed on a particular body part or area to provide a load to challenge muscle contraction. The load is basically isotonic in nature as the articulation is moved through its normal range of motion. Use of EDR eliminates the need for using any dead weight devices or machines. One advantage of EDR is the fact the person's own efforts are employed to resist their own muscular contraction, and hence risk of overloading the muscle is unlikely. The other advantage is being able to exercise at the patient's own time and location convenience. Disadvantages include the limitation on the exercises that can be performed.

### *Internal Dynamic Resistance*

This refers to self-application of internal dynamic resistance (IDR) by contracting the antagonist muscles of a particular degree of motion to apply a resistance to contraction of the agonist muscles. The IDR load is applied through the full range of motion possible.

Advantages of using IDR are that all body motions can be exercised and strengthened. Also, since the individual is resisting movement by contraction of their own muscles, there is little likelihood of self injury. The main disadvantage is that individuals need to learn how to contract the correct antagonist muscles. Many training and conditioning exercises related to Gongfu and other martial art practices make use of IDR.

#### *Peak or Maximum Contraction*

Muscles need to contract in order to shorten the muscle length which then results in motion of a joint by normal lever action with respect to the bones. The force of contraction can vary over the range of motion, depending on the differences in load as result of the effects of gravity with respect to joint position. Heavier loads can cause the muscles to produce maximum contractive force. Muscles can also be consciously contracted using IDR to produce maximum contraction throughout the full range of motion to enhance reconditioning effect.

### Frequency of Exercise

Certain terminology is used to describe the features of an exercise program in terms of how often a program is performed and how often exercises are performed. This information is expressed in terms exercise repetitions, sets, and workouts.

#### *Repetitions*

This refers to how many times a specific exercise is to be performed basically without resting between each completion. The frequency of repeating a particular exercise is related to the maximum strength and condition of the muscle or muscle group performing the motion. Estimation of how much load to use for a given set of repetitions is derived from the maximum load or weight that an individual can move through just one repetition. This number is referred to as the one-repetition maximum (1RM) load and is used determine how much weight is appropriated for a given number of repetitions.

For example, if a patient can perform a biceps curl with a 20 pound dumbbell one time only without being able to immediately repeat the exercise, then 20 pounds is their 1RM for that exercise. The appropriate weight and number of repetitions can be derived from the 1RM value. Here repetitions relate to percentage of 1RM load approximately as follow: 2 reps, 94%; 3 reps, 86%; 4 reps, 78%; 5 reps, 70%; 6 reps, 60%; and 7 reps, 50%. If a person has a biceps curl 1RM of 20 pounds, they potentially could perform 6 repetitions of the biceps curl with a 12 pound dumbbell, or 7 repetitions with a 10 pound dumbbell, etc.

In experienced adult and late-teen athletes, 1RM values for different muscle groups can be determined by adding weights until 1RM is reached. In individuals untrained in exercise and weight training, or in the case of prepubescent and midgrowth-spurt athletes, a conservative estimate is made concerning the appropriate load. The resisted isometric orthopedic test for an affected muscle group or articulation provides an estimate of the maximum load that should not be exceeded. The indicated exercise load should be about 50% of the maximum to assure that several repetitions can be achieved.

➔ Prepubescent individuals should not perform maximum load exercises.

### *Exercise Sets*

This indicates a preplanned number of repetitions or the maximum times a specific exercise is performed. The strength of most muscles increases when subjected to a fixed number of repetitive exercises performed in groups consisting of sets. Maximum benefit occurs at about 4 to 5 sets. A brief rest period is provided between sets. Duration of the rest period depends on the condition the patient and the load being applied in the exercise. Usually, in therapeutic exercise, the load is light and the rest period between sets is short.

Repetitions and sets can be varied over a considerable range. Typically, up to 6-8 repetitions of a particular exercise is planned to be conducted over 3-5 sets. Use of light loads in therapeutic exercises assures that at lease a few sets can initially be completed. As strength increases, the number of repetitions and sets are, likewise, increased. Building up to eight repetitions, repeated for up to 5 sets, is ideal for most muscle groups. Some exercises that inherently place light loads on the muscles can be performed for sixteen repetitions. Certain types of muscles, such as the abdominal group, improve better with higher numbers of repetitions, but not as many sets.

In heavy weight training, the load used in each set may vary depending on different approaches to training. Often two or three warm-up sets with use of light loads are followed by three or four intense sets using constant resistance. Individuals in this category are usually serious weight trainers, athletes, or professional sports figures. Rehabilitating patients in this category often proceeds quicker, since they are generally in good condition, except for their particular presenting problem.

The number of repetitions per set can also be progressively decreased to account for possible fatigue that develops with repeated exercise. The initial set may have 12 repetitions while the second set has 11, and the third set has 10, and so on.

### *Workouts*

This term describes the total period of the exercise program for any given time period. Several exercise routines involving different muscle groups are usually addressed during any particular workout. Typically, three to five workouts are performed each week, depending on the condition of the patient and the particular exercises involved. Most workouts can be scheduled on consecutive days unless it involves high intensity training or performance. In this latter situation, a rest period of 48 hours is required to regain normal strength after a high intensity workout.

## Time Dependencies

The nature and efficiency of exercise therapy is influenced by certain time dependencies, such as speed of movement and hold time. Faster movements have a lower potential for increasing strength while slower movement are more efficient in producing stronger muscles. A well balanced rehabilitation and conditioning program will employ exercises over the full range of time relationships in the following categories:

### *Fast Movement (Ballistic)*

Fast movements produce momentum which in-turn helps power the articulation through its full possible range of motion. Faster movements are sometimes referred to as "ballistic" because once a limb is put into motion little energy expenditure is needed to continue the movement through to completion. Calisthenics ("kalos" beautiful +

"sthenos" strength) are in this category and consists of light gymnastics to promote strength, maintain conditioning, and improve grace of carriage. One of the more important uses of fast movements is to restore the full range of pain-free motion.

#### *Normal Routine*

Movement will normally proceed at a fairly constant rate when exercising any particular articulation if the level of resistance (usually an isotonic load) is within an appropriate range for patient's condition and the muscle group in question. A single repetition of the movement should only take a few seconds, usually 2 seconds up and 2 seconds down in a bicep curl. Determining the proper load or resistance in rehabilitating a weak or injured muscle requires careful attention. In a normal individual, load value and number of repetitions for a particular movement are determined by the maximum weight the individual can move in one repetition only (See preceding discussion on Repetitions). This may be too severe in case of rehabilitation so lighter than normal weights are initially considered. Weight has to be light enough not to induce pain on movement.

#### *Super Slow Exercise*

It has recently been rediscovered that exercising a muscle at a much slower rate can produce greater strength using lighter weights, reduced repetitions, and fewer workouts over the same period of time for normal speed exercise. The lifting period is 10 seconds as opposed to the normal 2 seconds. The lowering time can also be 10 seconds although some studies have recommended 4 - 5 seconds. Although lighter weights are employed, this workout is demanding. Patients have to be coached to correctly perform the super slow exercises. It also requires mental stamina to stay focused on maintaining the slow speed. Normal routines involve 10 - 12 exercises with three sets of 10 - 12 repetitions each with three or more workouts per week. The super slow routines usually involve 10 - 12 exercises of one set with 6 - 10 repetitions no more than twice a week. No significant exercise is recommended for 48 hours after a super slow workout.

Using lighter weights is an advantage for rehabilitation and older patients since increasing weights to increase strength can often produce pain. Also, the super slow routine does not result in sore muscles the day after the exercises which is fairly normal after regular speed exercises. Research efforts showing the benefit of super slow exercise gives credence to the purported benefits of slow movement involved in Taijiquan and Daoyin routines, and many other similar approaches developed by the ancient Chinese.

#### *Isometric Exercise*

Isometric contractions are applied to a joint by restricting its motion and hence the speed of movement is zero. Basically, the muscle is contracted at its full or nearly full strength, and this may be why isometric contractions can be used to develop considerable strength in muscles. The mechanisms may be similar to how super slow movements work. There is some question as to whether strength is developed over the total range of motion, or just only for the position to which the joint is being held. Recent information however suggests that the total muscle is strengthened especially if it is held in its fully contracted position.

Isometric contractions are applied to the target muscle or muscle group by moving the joint to its fully flexed, extended, or rotated position and contracting the particular groups of muscles responsible for the specific movement. In the case of the biceps brachii, the forearm is flexed to the maximum extent possible while holding the biceps in full isometric contraction. The contraction is held for 8 - 10 seconds and then released. The muscle is contracted again and held for the same period of time and this is repeated for the desired number of repetitions. It is important to breathe normally while holding the isometric contraction and not to constrict the chest. One disadvantage of isometric contraction is training an individual in how to contract the target muscle or muscles to be strengthened.

Isometric contraction can be accomplished at any angle along the range of motion by using one hand to restrict motion of particular joint while isometrically contracting the appropriate muscles responsible that degree of freedom of motion.

- ➔ Care must be considered in using isometric exercises with hypertensive patients since some people cause their blood pressure to increase by isometric contractions.
- ➔ Isometric contractions applies sustained and often maximum loads on the tendons, these structures may develop soreness.

## Breathing Exercises

Remedial breathing therapy involves teaching, guiding or instructing the patients in certain breathing exercises appropriate to their condition. Often the breathing routines are performed coincident with physical or movement exercises, although in some forms of breathing techniques the patient remains seated or is in the prone position. Some of the procedures are similar to guided imagery where the patient is trained to mentally direct vital breath to certain areas of the body or extremities. Sometimes it is directed to areas of chronic muscular disorders or pain.

## Relaxation Routines

A wide range of different procedures are used to train the patient in relaxation skills. These are employed in prevention, health preservation, or rehabilitation. Routines involving slow body movement or breathing exercises may be suitable for this purpose, but sometimes the patient needs a simple and speedy method of calming, that only requires a few minutes to accomplish.

### *Passive Techniques*

Passive relaxation approaches are similar to meditation routines. The person is usually seated or lying down, although they can be standing as well. No relaxation techniques should be attempted while operating a vehicle, airplane, or while doing anything of a critical nature.

### *Active Techniques*

Active relaxation routines differ in that they are performed along with body motion, usually with slow deliberate movements similar to many slow movement routines. Several specialized exercises can be employed while controlling the breathing in concert with the body motion. Some specific exercises may be recommended, if it is important to concentrate on a particular problem.

## Lifestyle Counseling

The main focus in counseling is basically non-psychological. Even though emotional problems are treated with needling therapy and herbs, they are mostly considered in terms of being either physically induced by organ dysfunction, influenced by dietary habits, related to seasonal effects, or are stress related. Counseling can involve advice on eating habits, alcohol and drug use, sleep patterns, physical and emotional stress, environmental stress, and condition of one's residence. Many of these factors have profound influence on calcium utilization in the body and can impair bone healing.

Major factors considered in work related stress are time demands, overwork, and unrealistic goal setting. The impact of the work environment includes interaction with machines and equipment, office equipment, lighting, air conditioning, heating, dampness, and possible toxic exposure. Repeated activities that may lead to physical stress injury are also considered with remedial steps suggested to avoid or reduce incidence of re-injury.

## Frequency and Duration of Care

Determining the frequency and duration of care is the most essential part of treatment planning. Guidelines for this aspect of the treatment plan rely mainly on clinical experience. Normally this is tempered with the latest scientific information to understand the processes of treatment or by data derived from valid evidenced-based clinical outcome studies.

Unfortunately, for the American practitioner of Chinese needling therapy, the historic base and modern clinical studies mostly exist only in China. More effort has to be made in the future to document clinical effectiveness based both on subjective and repeatable objective results to refine the historic data base. Nevertheless, the guidelines provided by the early Chinese practitioners are quite useful and are consistent with modern clinical experience. Standards in patient management require close attention to fundamental aspects of the treatment plan including:

- Criteria for selecting treatment/care procedures
- Close monitoring of the therapeutic response in relation to expected outcome of natural history
- Flexibility of the treatment/care protocol when less favorable or unexpected responses are encountered

### Definitions

A common set of terms and definitions are often used across many professions treating pain and orthopedic problems, as follows:

#### *Active Rest*

Also called relative rest, it involves the resting of a tissue or body part only to the point of restriction of the deforming and pathological forces during the healing period, while at the same time allowing normal physiological stresses.

#### *Adequate Trial of Treatment/Care*

This refers to a course of two weeks each (four weeks total) of two different types of care modes, including manipulations and needling therapy, after which, in the absence of documented improvement, these modes are no longer indicated.

***Chronicity***
Stages of progress of a disorder that are related both to severity and duration: acute, subacute, chronic, and recurrent.

***Complicated Case***
Involves the situation where the patient, because of one or more identifiable factors, exhibits regression or retarded recovery in comparison with expectations from the natural history.

***Elective Care***
Treatment/care requested by the patient designed to promote optimum function to alleviate subjective symptomatology in cases having reached maximum therapeutic benefit.

***Essential Procedures***
This involves the standard treatment modalities of needling therapy, electroneedling (EN), moxibustion, heat therapy, and cupping.

***Manual Procedures***
Include a variety of physical techniques including massage, joint mobilizations, manipulation, and therapeutic exercise.

***Maximum Therapeutic Benefit***
Return of the patient to pre-injury/episode status or failure to improve beyond a certain level of symptomatology or disability, despite the treatment/care approach. This is also referred to as Maximum Medical Improvement (MMI).

***Natural History***
This denotes the anticipated clinical course of recovery for uncomplicated disorders either without treatment/care or with conservative treatment/care.

***Preventive/Maintenance Care***
This involves the care given to reduce the incidence or prevalence of illness, impairment, and risk factors, and to promote optimal function.

***Stages of Treatment/Care***
This includes four categories with specific goals for passive and active care as follow (See Table 5.2):

1. **Acute Intervention:** Initial therapeutic intervention to assist and promote anatomical rest, reduce muscle spasms, inflammatory reactions, alleviate pain, and to restore visceral and somatic function.

2. **Remobilization:** Continuing intervention to increase the pain-free range of motion and to minimize de-conditioning.

3. **Rehabilitation:** Efforts to restore strength and endurance in the pain-free range of motion, and increase physical work capacity.

4. **Lifestyle Modification:** Modify social and recreational activity, diminish work environment risk factors, and adapt psychological factors affecting or altered by the musculoskeletal or orthopedic disorder.

### *Supportive Care*
Refers to the treatment/care for patients having reached maximum therapeutic benefit, in which periodic trials of therapeutic withdrawal fail to sustain previous therapeutic gains that would otherwise progressively deteriorate.

### *Treatment Necessity*
This situation exists in presence of an impairment/illness/injury evidenced by recognized signs and symptoms, and likely to respond favorably to a planned treatment approach.

### *Treatment/Care Terms*
Common terminology applied to treatment and care includes:

1. **Intervention:** The process of providing either passive (practitioner applied) or active (patient participation) care to intervene in an ongoing disease process or condition.

2. **Modality:** Refers to a particular or specific therapeutic mode of care.

3. **Frequency:** Refers to how frequently treatment/care is provided necessary and sufficient to maintain effects while healing occurs. This is not to be confused with stimulation frequency in Hz. used in electroneedling (EN).

4. **Interval:** Minimum treatment/care period to obtain a stable response.

5. **Duration:** Is the time that needles are left inserted or time period that heat, cold, or electroneedling (EN) are applied. Also is used to denote length of time of presenting condition from the time of onset.

6. **Combination:** The potentiation or competition of response by simultaneous treatment/care applications.

### *Treatment/Care Goals*
This consists of written short term and long range expectations of patient response to the treatment plan.

### *Treatment/Care Type*
Type of care is broadly divided in two categories with specific goals for each (See Table 5.2):

1. **Passive Care:** Application of treatment/care modalities by the care-giver to a patient who "passively" receives care.

2. **Active Care:** Modes of treatment/care requiring "active" involvement, participation, and responsibility on part of the patient.

### *Treatment Plan*
A written description of intended therapeutic actions divided according to relevant treatment/care goals and prognosis.

### *Uncomplicated Case*
Refers to a case where the patient exhibits progressive recovery from an illness or injury at a rate greater, or equal to, the expectation from the natural history.

## Reducing Variables in Practice

Contributing to problem of establishing standard guidelines for treatment planning is the great variability among practitioners on their diagnostic skills and what they think is most important in analyzing the patient's problem. Another complication concerns different opinions on what modes of care are best applied in the treatment of certain conditions. One of the goals of this text is to provide an organized approach by which an accurate diagnosis and treatment plan can be accomplished. The various modes of care can then be applied with a clear understanding on how these processes work on the body in bringing about tissue repair and promote healing.

## Principles of Case Management

The primary goal of health care is to provide adequate treatment to restore health, maintain it, and prevent the recurrence of injury, disability, and illness. The practitioner uses a myriad of procedures and skills that are grouped into the categories of passive intervention, active intervention, and patient education. The practical boundaries on what constitutes sufficient planning is situational, with the outcome judged on previous clinical experience on a case-by-case basis. Basic considerations in case management concern the following ideas:

A. Early return to activity is associated with reduced disability and symptoms.

B. Based on the experienced gained from comparing the response of patients having no treatment and those with treatment, there is a natural history of recovery for uncomplicated cases that can be used as a time frame from which to judge and formulate a successful treatment plan.

C. Chronicity should be prevented wherever possible. Those at risk of doing so show characteristic behavior patterns involving their illness and life situation. Warning signs can include:

- Somatic or visceral complaints that remains static longer than 2 - 3 weeks
- Anxiety or depression
- Functional or emotional disability
- Family turmoil
- Drug dependence: recreational, non-prescription or prescription

## Process of Treatment Planning

A number of questions are usually considered in formulating a fundamental approach to treating a given problem or category of problems, once the diagnostic process provides a reasonably clear picture of the presenting condition. As in former times, it is important to understand the factors involved in causing the disorder. The early Chinese physicians always looked at the situation in terms of external and internal factors. The external factors mainly include environmental conditions, such as wind, cold and damp which are thought to be directly damaging to the body. Strain, sprain, overwork and injury are also included in factors that directly cause trauma to the body. Internal sources mainly involve emotional factors of worry, fear and anger which were thought to harm the functional activity of the body which then results in damage.

The modern understanding of the effects of emotions and stress on bodily function is well documented and shows that these factors are still a major source of problems, particularly how they affect the utilization of calcium and other minerals.

These factors are presently known to be important in the development of arthralgia, joint problems, and degenerative problems of the spine. Poor diet and lack of exercise are also important in the Chinese view and these problems are addressed in the preventive and rehabilitation phase of the case.

Many pain and orthopedic problem have an associated natural history where they will resolve on their own without passive treatment/care. All that is applied is rest and relaxation. Other problems can become worse, eventually becoming chronic without treatment/care intervention. The purpose of treatment in the first situation is to relieve pain and suffering and promote resolution of the problem as quickly as possible to return the patient to the pre-episode work and functional status. It is also essential to prevent establishing chronicity.

The treatment plan for therapeutically necessary care can be viewed as containing 4 phases with each having objectives for both passive and active care (See Table 5.2)

Table 5.2. Stages of treatment/care with goals and objectives for passive and active care

| | **Passive Care** |
|---|---|
| 1. | Acute Intervention (Chinese orthopedics modes of care)<br>A. To promote anatomical rest<br>B. To diminish muscular spasm<br>C. To reduce inflammation<br>D. To alleviate pain<br>E. To restore somatic function<br>F. To restore visceral function and homeostasis |
| | **Active Care** |
| 2. | Remobilization<br>A. To increase the range of pain free motion<br>B. To minimize deconditioning |
| 3. | Rehabilitation<br>A. To restore strength and endurance<br>B. To increase physical work capacity |
| 4. | Lifestyle Adaptations<br>A. To modify social and recreational activity<br>B. To diminish work environment risk factors<br>C. To adapt psychological factors affecting or altered by the disorder/ musculoskeletal problem/orthopedic condition |

### *Short and Long Range Planning*

At the onset of treatment/care, a written estimated time frame for reaching intermediate functional milestones and treatment outcomes should be made. The functional milestones represent short term goals and can consist of activities such ability to move the affected part, exert force or to walk. Outcome expectations are long term goals and may include the ability to return to work, renew sports, and regain full activity. The length of time to reach these objectives can be affected by specific historical factors of the condition. Some of these include the following factors:

1. **Pre-consultation Duration of Symptoms:** In the situation that pain duration is less than nine days: no anticipated delay in recovery. Pain more than nine days, but less than thirty days: recovery may take 1.5 to 3.0 times longer.

2. **Typical Severity of Symptoms:** Mild pain: no anticipated delay in recovery. Severe pain: recovery may take 2 times longer.

3. **Number of Previous Episodes:** 0 - 3: no anticipated delay in recovery. 4 - 7: recovery may take 2 times longer.

4. **Injury Superimposed on Preexisting Condition(s):** Skeletal anomaly: may increase recovery time by 1.5 - 2.0 times. Structural pathology: May increase recovery times by 1.5 - 2 times.

***Treatment /Care Frequency***

The basic question on the part of the practitioner usually involves, how many treatments are needed and how frequently should they be applied to bring about maximum therapeutic benefit? If the practitioner has an established protocol for certain disorders that consistently produce clinical success, then they can be confident in using a tried and tested approach. Although Chinese medicine has been in full use for many more centuries than any other system, few modern studies provide guidelines for establishing treatment/care frequency and total time period of treatments. Part of the problem has been a lack of standardized objective data. One of the goals of this text is to educate the practitioner about the need to use consistent data gathering means so that exchange and review of useful information will eventually lead to establishing a modern data base.

The ancient Chinese addressed this perplexing problem as well and provided some general guidelines in the *Neijing Lingshu Treatise 6: Longevity, Premature Death, Firmness, and Suppleness*. The main external and internal factors of disease are noted and acknowledged that the number of treatments for a given disorder depends mostly on how long the person has had the problem and whether only external factors are involved or if the problem is complicated by internal factors (emotional factors). Diseases that persist for one month or longer are considered more difficult to treat and here the key is to consider both the internal and external factors involved. Guidelines from the *LS 6* are summarized as follow:

- An acute somatic disorder (musculoskeletal/orthopedic condition) of less than 9 days duration should be given 3 treatments.
- A somatic disorder of 1 month duration should be given 10 treatments.
- If the somatic problem of 1 month duration has not yet affected the internal organs the treatment plan can be reduced by half, namely, it can be given 5 treatments.
- If the somatic disorder of 1 month duration is first preceded by an internal condition (emotion, stress, diet, etc. induced) then the number of treatments should be doubled, namely, 20 treatments are provided.

These guidelines are reasonably consistent with modern day clinical experience and consistent with the observation that the duration of symptoms of the case history is a good predictor of response to treatment/care. Uncomplicated acute disorders of less than nine days duration, usually respond in 3 to 5 treatments. Those of one month or less duration usually respond in 5 to 10 treatments. Conditions of one month or less duration, involving internal factors, usually are resolved in 10 to 20 treatments.

A typical case in this latter category, that is expected to take up to 20 treatments, could be scheduled over a ten week interval as follow: 3 treatments for each of the first two weeks followed by 2 treatments per week for the next six weeks and finally 1 treatment per week for the last two weeks. The clinical response is always evaluated each time the patient returns for the next treatment. If response is greater than anticipated, then the number and frequency of treatments is correspondingly decreased. Conversely, poorer response may indicate the need for spreading the treatments over a longer time period.

In general, an assertive in-clinic intervention of up to three treatments a week for one or two weeks is typical early in the case. Treatment frequency then progressively declines or levels out until discharge of the patient from passive care or they continue treatment on an elective care basis.

Chronic disorders, often of long duration, or those involving significant trauma or those involving CNS complications usually take more treatments spread out over a longer time period. The ancient Chinese noted that in treating patients suffering from stroke, if they have lost ability to speak along with paralysis, that full recovery is unlikely, but those whose speech is unaffected, that recovery is possible. In either case Chinese needling therapy is applied to bring about significant therapeutic benefit. Additional recommendations on treatment/care time periods is given below for uncomplicated and complicated cases.

***Patient Cooperation***

It is essential to explain the purpose and strategy in the treatment/care plan to address the patient's disorder. The rationale for the treatment/care approach should be shared with the patient, in addition to answering all the patient's inquiries about how and why the plan is expected to bring about clinical success. Patients who are either non-compliant to the treatment/care recommendations or prove to be insincere, should be considered for discharge from care, with referral when it is appropriate.

***Failure to Meet Treatment/Care Objectives***

Failure to meet treatment/care goals is frequently due to not having an accurate diagnosis or true understanding of the problem. The other complication is not to provide an adequate number of treatments during the early course of the case. Normally, the process of reviewing the case each time the patient returns for the next treatment in a planned course of care is to keeping refining the diagnosis to better understand the dynamics of the recovery process. Despite this continued effort, some cases fail to meet treatment/care expectations and it is necessary to consider additional steps, including discharging the patient. Several steps can be considered that possibly include the following:

1. **Acute Disorders:** After a maximum of two trial needling therapy series over a course of two to four weeks, without documented improvement, alternative care including manual procedures should be considered.

2. **Unresponsive Acute, Subacute, or Chronic Disorders:** Repeated use of passive treatment/care normally designed to manage acute conditions should be avoided as it tends to promote physician dependence and chronicity.

3. **Complicating Factors:** Systematic interview of the patient and immediate family should be carried out in search for complicating or extenuating factors responsible for prolonged recovery.

4. **Record of Goals:** Specific treatment/care goals should be written to address each issue.

5. **Continued Failure:** Continued failure should result in patient discharge as inappropriate for Chinese orthopedics, or that the case has achieved maximum therapeutic benefit/maximum medical improvement (MMI).

### *Uncomplicated Cases (acute episode)*

The consistency in clinical practice of Chinese needling therapy, provided as passive care, shows that only acute episodes can truly be considered uncomplicated. Acute episode refers to the first occurrence, recurrent, or exacerbation of a chronic condition. The following are characteristic of an uncomplicated case:

1. **Symptom Response:** Significant improvement within 10 - 14 days with two to three treatments per week.

2. **Activities of Daily Living (ADL):** The promotion of rest, elevation, active rest, and remobilization, as needed, are expected to improve ADL followed by a favorable response in symptoms.

3. **Return to Pre-episode Status:** Accomplished in six to eight weeks with up to three treatments per week.

4. **Supportive Care:** Inappropriate.

### *Complicated Cases*

Implementation of up to two independent treatment plans relying of repeated use of passive care is usually acceptable in the management of cases undergoing prolonged recovery. Complicated cases manifest some of the following characteristics:

1. **Signs of Chronicity:** All episodes of symptoms that remain unchanged for two to three weeks should be evaluated for risk factors of pending chronicity. Patients at risk for becoming chronic should have treatment plans altered to de-emphasize passive care and refocus on possible active care approaches.

2. **Subacute Episode**:

    a. **Symptom Response:** Symptoms have been prolonged beyond six weeks, and passive care in this phase is as needed but generally does not exceed two treatments per week to avoid promoting chronicity or physician dependence.

    b. **Activities of Daily Living (ADL):** Management emphasis shifts to active care, dissuasion of pain behavior, patient education, and flexibility and stabilization exercises. Rehabilitation may be appropriate.

    c. **Return to Pre-episode Status:** Approximately 6 - 16 weeks.

    d. **Supportive Care:** Inappropriate.

3. **Chronic Episode**:

    a. **Symptom Response:** Symptoms have been prolonged beyond 16 weeks, and passive care is for acute exacerbation only.

    b. **Activities of Daily Living (ADL):** Supervised rehabilitation and life style changes are appropriate.

c. **Return to Preinjury Status:** Possibly may not return. Maximum therapeutic benefit using needling therapy may have been reached.

d. **Supportive Care:** Supportive care using passive therapy may be necessary if repeated efforts to withdraw treatment/care result in significant deterioration of clinical status.

***Elective Care***

Therapeutic necessity is absent in elective care by definition. Under specific circumstances for individual cases, elective care is usually considered safe and effective. Presently this is the most common avenue of care for Chinese needling therapy. Elective care must be designed to avoid physician dependence and chronicity.

## Disability and Permanent Impairment

Most states have some sort of workers' compensation plan where employers pay insurance premiums that provide them protection from being sued by an injured worker, if the employer offers adequate compensation to cover the problem. Compensation can be for time loss from the job, possible retraining if the employee is no longer able to do their normal function, or long term compensation for permanent impairment where it leads to disability. In many situations, especially involving either job related or accident caused injuries; the patient does not fully recover to the pre-incident condition. Consequently, these individuals are left with some degree of possible impairment, which may be either slight or significant, and may either be temporary or permanent.

- Impairment is generally viewed in terms of what impact that a problem or injury has on activities of daily living (ADL)
- Disability, on the other hand, considers what impact the problem has on a person's ability to perform their work activities

It is essential that practitioners treating musculoskeletal and pain problems be able to perform permanent impairment evaluations. The evaluations may then be used by designated specialists to determine the degree of disability resulting from a specific injury or disease condition. Injuries or conditions that result in necessary amputation of either digits or limbs, or in the case of injuries directly causing the loss of a limb or body part, the degree of impairment may self evident. However, in the more common situation, the person is left with chronic pain and dysfunction, making it more of a challenge to accurately assess the degree of impairment. The practitioner further needs to determine if the impairment is either temporary or permanent. As a general rule, a condition is considered to be permanent if it has remained static, showing no improvement, for at least 12 months. At this point the patient is considered to have reached their maximum medical improvement (MMI). If there is some continued improvement in the case, even though the individual displays some degree of impairment, then the case may be considered temporary.

Unfortunately, there are many cases of malingering and even out right fraud in both the workers compensation plans and the personal injury automobile insurance cases. This places an additional burden on the practitioner in making a reliable assessment of impairment. This problem is partly resolved by utilizing a rational and technical approach to impairment assessment, such as is provided by the American Medical Association

*Guides to the Evaluation of Permanent Impairment, Fifth Edition* (*AMA Guides*). Key to this process involves making a thorough and systematic use of medical records and reports. This includes gathering and evaluating all of the documentation pertinent to any given case. Some states do not rely on the *AMA Guides* and have their own approach to permanent impairment and disability evaluation.

## Approach to Impairment Evaluation

The main emphasis on impairment assessment by an acupuncture orthopedist involves evaluation of dysfunction of the musculoskeletal system. This requires significant attention to the nervous system and other features affecting special regions, such as the head and neck. A necessary framework is provided by the *AMA Guides* to evaluate any medical impairment, including the musculoskeletal system and all of the other body areas, and the internal organs. In situations where an accident or condition results in injury or impairment of the internal organs or other systems outside the expertise of any practitioner, the subject should be evaluated by the appropriate medical specialists for those portions. Successful and consistent use of the *AMA Guides* relies on a good understanding of their intended approach and the concepts on which the rules and procedures have been developed. Following these basic rules should result in an objective, fair and reproducible assessment of impaired subjects.

## Basic Terms

Many terms, including "impairment," "disability," and "handicap," is used in laws, regulations, and policies, throughout the country, with no prior consensus on what they mean or the ways in which they are to be used. Some states require the practitioner to perform an "impairment rating" in relation to a workers compensation claims, while other states require a "disability evaluation." The degree of dysfunction is the underlying physical or mental basis of medically assessed impairment.

Accurate evaluation of this parameter (impairment) will produce the necessary information from which to make all other assessments, including possible disability. It is essential to understand the context in which the terms "impairment," "disability," and "handicap" are applied. A practitioner's assessment of the patient should generally be understood to mean a medical evaluation of the subject's health status in relationship to accepted rules and standards (*AMA Guides*). Any types of losses, including economic or industrial losses, that give rise to awarding disability payments, are not determined by the practitioner.

### *Impairment*

The term "impairment" indicates an alteration or change in an individual's health and functional status, which can be assessed by medical methods. Impairment is what is wrong with a body part or organ system that alters its normal function. If the impairment is supported by medical findings, case history and impairment evaluation, and has been unchanged or static for at least 12 months, it is considered to be "stable" and "permanent." Both impairment and disability can also be classed as either "temporary," "partial," or "complete."

### *Disability*

The term "disability" means an alteration of an individual's capacity to meet occupational, personal, or social demands or meet statutory or regulatory requirements.

Disability is assessed by non-medical methods and represents the disparity between what an individual needs or wants to do and what they actually can do. A medically established impairment leads to disability only when the subject has a loss in capacity to meet the demands of normal living. Thus, a person who is impaired may not necessarily be disabled, if they can meet the demands of daily activities. Impairment in a digit, limb or joint, for example, may be disabling to people of certain professions or labor categories, but not affect individuals involved in other types of work.

***Handicap***

The term "handicap" is used in reference to barriers or obstacles to functional activity. Although this term is related to and frequently interchanged with "impairment" and "disability," it is also independent of these two terms. Laws of various states have different interpretations of this term. Federal law uses such a broad definition of "handicap" that any individual who has a documented impairment that substantially limits one or more of life's activity, can qualify as being handicapped. A functionally impaired person could be considered handicapped when there are barriers to accomplishing their daily activities, which can be overcome only by compensating in some way for the impairment. Such "accommodation" to compensate for the impairment often involves use of assistive devices such as wheel chairs, crutches, hearing aids, optical magnifiers, prostheses, or special tools and equipment, modification of the work environment or work tasks.

If there are no accommodations that permit an individual to complete needed tasks, or if the person is not able to accomplish an activity, despite accommodation, then that individual is both handicapped and disabled. However, if an impaired subject is able to accomplish a task, with or without accommodation, he or she is not considered to be either handicapped or disabled, with respect to that task.

# 6

# Head and Face

Assessment and treatment of the head and face covers the regional and surface anatomy, physiology, pathology, assessment, and treatment of problems associated with this area of the body. Many injuries and problem affecting the head and face, including fractures and severe trauma, are typically addressed in emergency care facilities immediately after the initial incident causing such problems. X-rays and other diagnostic imaging studies are often undertaken as part of the emergency care. These patients then present in the normal clinical setting for follow-up and rehabilitation care. Many other conditions affecting the head and face occur due to wear and tear distress as well as other environmental and work related factors. Assessment and treatment of head and face problems may cover a wide range of conditions.

## Head and Face Regional Anatomy

The skull or cranial vault which houses and protects the brain is the most prominent feature of the head along with the facial bones. Several cavities of the facial skull include those of the eye orbits, nasal cavity, and oral cavity. The mandible is the only moveable bone of the head which is articulated by means of the temporomandibular joint (TMJ). Muscles of the head and face including the mandible are controlled by 12 bilateral pairs of cranial nerves including sensor and motor functions.

### Face and Skull Bones

The skull or cranial vault is composed of several bones held together by suture joints. This includes one frontal, one occipital, two parietal, two temporal, and two sphenoid bones (See Figure 6.1). The occipital bone is the strongest of these while the two temporal bones are the thinnest and the weakest. There are 14 facial bones including: the mandible forming the lower jaw; the maxilla forming the upper jaw on each side; the zygomatic bones forming the cheek bones; the nasal bones forming the bridge of the nose; and the ethmoid, palatine, and lacrimal bones. The two sphenoid bones also form part of the orbital cavities that accommodate the eyes. The mandible is a single bone that contains the lower teeth and the support structure of the neck and head of the condyle which articulates with skull by means of the temporomandibular joints (See Figure 6.2)

### Temporomandibular joint (TMJ)

The temporomandibular joints are the most frequently used joints in the body. The TMJ is a synovial, condylar, hinge type joint with an articular disc (intra-articular meniscus) that is moved anteriorly by the lateral pterygoid (ALH) muscle as the jaw opens. The joint has fibrocartilaginous surfaces rather than hyaline cartilage. The disc divides each joint into two cavities referred to as the superior and inferior compartments. Rotation or hinge movements occur in the inferior compartment during the initial phase of opening the jaw. A gliding-sliding movement occurs in the superior compartment as the disc is moved anteriorly over the articular eminence as the jaw is opened widely.

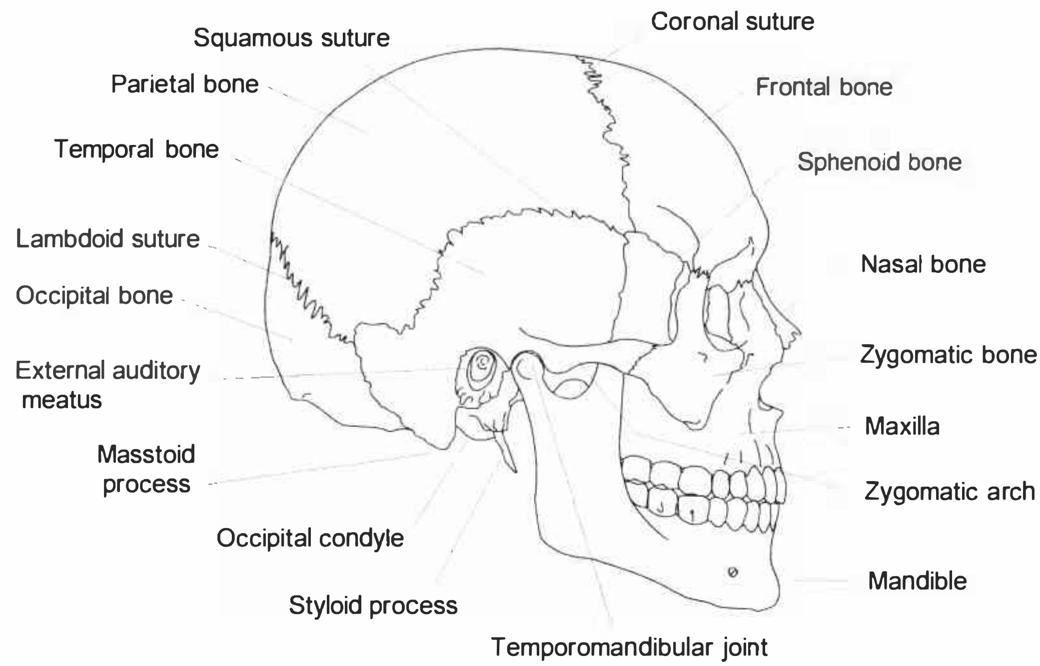


Figure 6.1. Major Bones of Skull

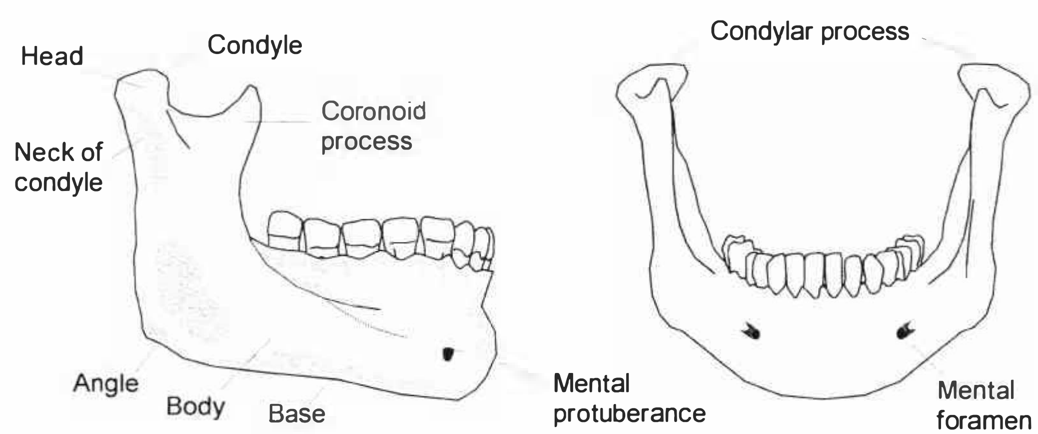


Figure 6.2. Anterior and lateral view of mandible

## Nerve Supply to Head and Face

Both sensory and motor function of the head and face is provided by 12 pairs of cranial nerves as follow:

I. Olfactory: Sense of smell

II. Optic: Sense of sight

III. Oculomotor: Voluntary levator of eyelid; voluntary motor function of rectus superior, medial, inferior; and obliquus inferior muscles of eyeball; autonomic motor of smooth muscles of eyeball

IV. Trochlear: Voluntary motor function of obliquus superior muscles of eyeball

V. Trigeminal: Sensory function of face and deeper structures of head; voluntary motor function of mastication

VI. Abducens: Voluntary motor function of rectus lateralis of eyeball

VII. Facial: Voluntary motor function of muscles of expression; motor function of stapedius muscle; sensory function of taste for anterior 2/3 of tongue; autonomic function of lacrimal, submandibular, and sublingual glands

VIII. Vestibulocochlear (acoustic nerve): Sensory function of hearing and balance

IX. Glossopharyngeal: Sensory function of touch and pain for posterior tongue and pharynx; sensory function of taste for posterior tongue; voluntary motor function of pharynx muscles; autonomic function of parotid gland

X. Vagus: Sensory function of touch and pain for pharynx, larynx, and bronchi; sensory function of taste for tongue and epiglottis; voluntary motor function of palate, pharynx, and larynx; autonomic motor function for thoracic and abdominal viscera

XI. Accessory: Voluntary motor function of the sternocleidomastoid and trapezius muscles

XII. Hypoglossal: Voluntary motor function of muscles moving the tongue

### Blood Supply

Blood vessels supplying the head and face include the major arteries supplying the brain and return flowing veins as well as those supply other areas as follow:

- Internal carotid artery and internal jugular vein
- Vertebral artery and vein
- External carotid artery and external jugular vein
- Cervical artery and veins
- Lingual artery and vein
- Sublingual vein
- Facial artery and vein

## Head and Face Physiology

Physiological function of the muscles and tendons that articulate the temporomandibular joint, tongue, anterior neck, and muscles of expression are presented below. Each specific muscle is grouped by the Chinese longitudinal muscular distributions by logical regions of the head and face.

## Muscles of the Face, Scalp and Tongue

Muscles of the face have little to do with articulation of joints in head region, except for function of mastication. Main purpose of these muscles is for facial expression (See Figures 6.3 and 6.4), moving the lips and tongue, and closing the eyes. Muscles moving the scalp have some function involving expression and the elevation and retraction of the ears. Muscles of the face, scalp and tongue are all important since they are the focus of many disorders including: headache, facial paralysis, deviation of tongue, and dysfunction in jaw.

### Muscles of Facial Expression

Muscles of expression innervated by the Facial nerve (CN 7) mainly involve the anterior lateral foot (ALF) distribution including: the zygomaticus major and minor, orbicularis oris, mentalis, depressor labii inferior and orbicularis oculi (lower parts) (See Figure 6.3 and Table 6.2). Also includes the buccinator, risorius, depressor anguli oris muscles assigned to the anterior lateral hand (ALH) distribution (See Figure 6.4 and Table 6.2) and the orbicularis oculi (upper parts) belong to the posterior lateral foot (PLF) muscle distribution (See Figure 6.4 and Table 6.2).

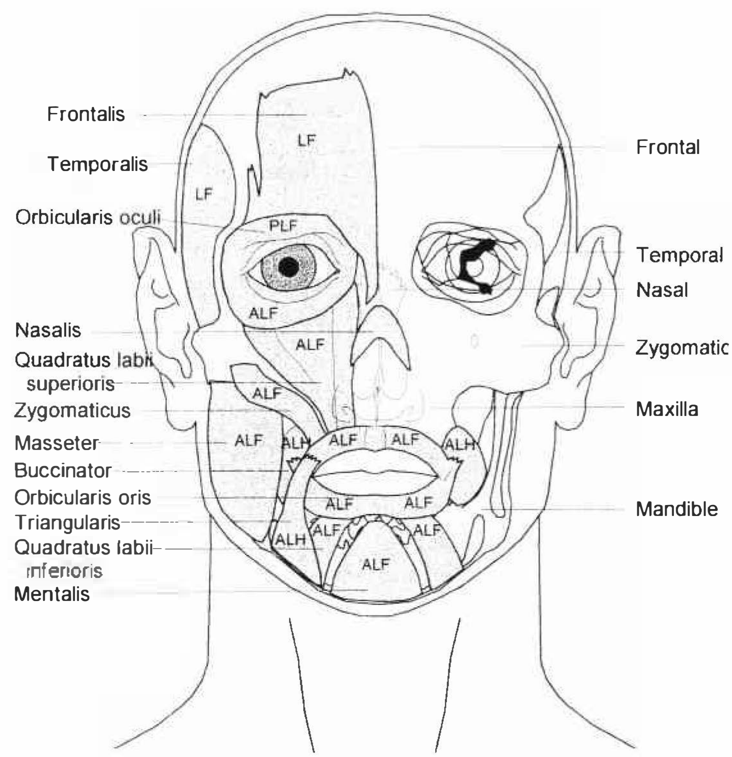


Figure 6.3. Facial muscles, anterior view

### Muscles of the Scalp

Four principal muscles move the scalp by tying into the galea aponeurotica ligamentous fascia to form the epicranius system. These consist of the occipitalis (PLF) and frontalis (LF: See Figure 6.4 and Table 6.2) that attach to the galea aponeurotica at the occiput and forehead respectively, and the temporoparietalis (LH) muscles located on each side of the head. The temporoparietalis muscle overlies the temporalis (LF) muscle. Other muscles associated with the scalp are related to moving the auricle consisting of the auricularis superior, anterior and posterior muscles belonging to the posterior lateral hand muscle distribution (See Table 6.2). These muscles overlie the temporoparietalis muscle.

## Muscles of Mastication

One of the more important functions of muscles of the head includes articulation of the temporomandibular joint which is critical to the function of mastication. This involve four muscles including the masseter (ALF), temporalis (LF), and medial pterygoid (ALH) and lateral pterygoid (ALH). The first three of these function to close the mouth by raising the mandible while the lateral pterygoid muscle functions to open the mouth. All four of these muscles are innervated by the Trigeminal nerve (CN V).

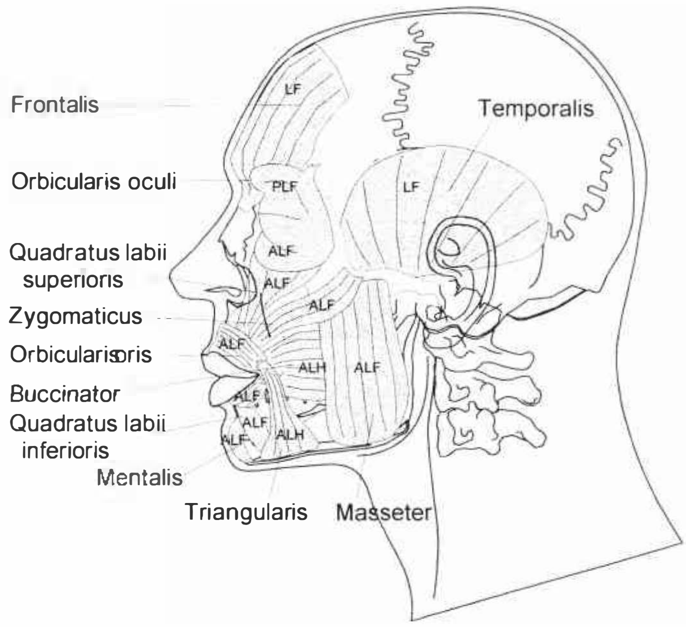


Figure 6.4. Facial muscles, lateral view

## Muscles Moving the Tongue

Both the PLF and LH muscular distributions tie into root of tongue via the styloglossal (PLF) and stylohyoid (LH) muscles. The styloglossal muscle draws tongue upward and backward, is one of three extrinsic muscles that move tongue. The LH muscle distribution also includes the hyoglossus muscle which depresses tongue and the genioglossus muscle which depresses tongue as well, and also thrusts the tongue forward. The intrinsic muscles of tongue are responsible for controlling its shape. All the muscles that move tongue are innervated by the Hypoglossal nerve (CN XII) and the stylohyoid muscle is innervated by Facial nerve (CN VII).

## Suprahyoid and Infrahyoid Muscles of the Neck

Muscles tying into the hyoid bone from above (suprahyoid) include the digastric, anterior belly (ALH) and posterior belly (PLH); stylohyoid; and mylohyoid and geniohyoid (ALF), all of which raise hyoid bone. With the exception of the geniohyoid, these muscles assist in the function of opening the mouth by depressing the mandible. This action is secondary to that of the lateral pterygoids and comes into play when there is resistance to overcome in opening the mouth or if it is necessary to open the mouth wide.

Muscles below the hyoid bone (infrahyoid) include the omohyoid, which originates at the superior border of the scapula and belongs to the Large Intestine distribution and the sternohyoid, sternothyroid and thyrohyoid belonging to the ALF distribution. These four muscles are antagonists of suprahyoid muscles. These muscles function to hold hyoid bone in place when suprahyoid muscles are involved in opening the mouth. They also combine in fixing hyoid bone during tongue motion.

## Problems of Head and Face Muscles

It is important to consider the historic indications for disorders of specific muscular distributions when making a more detailed assessment and examination. This is extremely useful because the formation of sensitive points and the development of muscular dysfunction follow along these pathways. In addition, treatment protocols also consider selection of candidate neurovascular nodes with respect to the muscular distributions.

### *Disorder in Muscles of the Scalp*

Posterior lateral foot (PLF) and lateral foot (LF) distributions:

- Muscular spasms in occipital region and forehead.
- Frontal, occipital and vertical headaches.

Lateral hand distribution (LH) distribution:

- Acute cramps and spasms along lateral side of head.

Posterior lateral hand (PLH) distribution:

- Pain and ringing in the ears leading to pain in chin.
- Heavy sensation in the eye after having been closed for some time.

### *Disorders Involving Muscles of Facial Expression*

Facial paralysis can involve the upper or lower motor neurons of CN VII with slightly different manifestations as discussed later. This condition was described by the ancient Chinese with specific reference to a specific dysfunction related to anterior lateral foot (ALF) distribution:

- Unexpected or sudden deviation of the mouth, with acute condition that eye cannot close

### *Disorders Involving Muscles of Mastication*

Lateral foot (LF) distribution (temporalis):

- Acute cramps, spasms and pain in jaw and parietal region including TMJ syndrome
- Conditions can include clenched jaw (trismus), one-sided parietal headache, migraine, dizziness, vertigo or retroauricular pain

Anterior lateral foot (ALF) distribution (masseter):

- Acute cramps, spasms and pain in region of jaw and cheek
- Conditions can include either trismus, toothache, swelling of face and cheek, tinnitus or motor impairment of the jaw

Anterior lateral hand (ALH) distribution (lateral and medial pterygoids):

- Pain, spasms and acute cramps under angle of jaw, possibly including toothache
- Pain, spasms and acute cramps under angle of jaw when opening or closing mouth

#### *Disorders Involving Muscles Moving the Tongue*

Pathology related to region of tongue associated with the posterior lateral foot (PLF) and lateral hand (LH) distributions include:

- Acute cramps, spasms and swelling along the lower jaw
- Acute cramps and spasms that cause the tongue to curl up

Other apparent conditions include stiff tongue, tremulous tongue and deviation to one side when the tongue is thrust forward. These conditions usually indicate some fault associated with the Hypoglossal nerve. Deviation of tongue to one side indicates lesion on same side.

#### *Disorders Suprahyoid and Infrahyoid Muscles*

Anterior lateral foot (ALF) distribution:

- Stretching sensation from supraclavicular fossa reaching jaw.
- Pain and spasms along anterior aspect of neck and throat.
- Difficulty or inability to open mouth widely.

Posterior lateral hand (PLH) distribution:

- Spasms in muscles below lateral anterior aspect of jaw.
- Swelling below lateral anterior aspect of jaw.

Lateral hand (LH) distribution:

- Acute cramps and spasms along lower margin of mandible.

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps below the chin.

## Disorders of Head and Face

Problems affecting the head and face are viewed in terms of pain and pathology manifesting in the specific muscle distribution as well as other pathological conditions. Common conditions affecting the head and face include sensory and motor impairment as result of cranial nerve dysfunction. This includes deficits in vision, hearing, and equilibrium; facial paralysis; and facial pain. Other problems include temporomandibular joint disorders as well as herpes zoster that can affect the face.

### Temporomandibular Joint (TMJ)

Pain in the TMJ and face along with joint dysfunction occur more frequently in women. TMJ problems occur in two age groups involving young adults with all their teeth or middle-aged people who are edentulous (have no teeth). Pain radiates widely into the head, face, and neck. Main findings include abnormality of movement, deviation of jaw to painful side on opening, and clicking of joint. Tenderness and thickening can be detected by palpation over the joint.

### *TMJ Dysfunction*

Pain is common complaint in TMJ problems, especially with younger patients. It can be associated with spasms in the muscles articulating the jaw or due to hypomobility lesions. Pain can also be the result intermittent claudication in muscles during mastication. TMJ pain can also manifest as occipital headache, burning sensation in throat, deafness, tinnitus, vertigo, nystagmus, and sensation of fullness in ear.

Although TMJ pain is a common complaint it must be differentiated from other sources of facial pain such as unerupted 3rd molar, carcinoma of tonsils or pharynx in the elderly, or trigeminal neuralgia. Pain can be referred from the cervical spine including traumatic cervical spine syndrome.

### *Osteoarthritis*

Degenerative arthritic changes in the TMJ are seen in 40% of people over 40 years of age and in women over 50. Is common source of problems in the elderly and can result from inflammatory synovitis. Osteoarthritis of the TMJ may also follow a traumatic incident, such as an intra-capsular fracture.

### *Ankylosis*

Ankylosis of the TMJ may follow an incident of inflammatory arthritis and childhood infectious diseases. This was once a complication of scarlet fever that led to deformation of the jaw (often called bird face).

## Facial Paralysis

Paralysis of the facial muscles of expression can involve upper (UMN) or lower (LMN) motor neurons of facial nerve (CN VII). Cranial nerve VII supplies voluntary motor function to facial, scalp, and anterior neck muscles; and parasympathetic motor to lacrimal, sublingual, submandibular, nasal, and palatine glands. In addition, CN VII supplies motor input to the stapedius muscle which functions to dampen the movement of the stapes in the ear in response to loud sounds. When this muscle is flaccid or paralyzed sounds become louder and annoying which is referred to as "hyperacusia." Cranial nerve VII also conveys taste sensory function to the anterior 2/3 of the tongue, and afferent proprioceptive signals from muscles of the face and scalp.

### *Paralysis due to UMN*

Characteristics of facial paralysis as result of lesions in the UMN of CN VII provide important clues to help distinguish it from the LMN problems, which include:

- Muscles of forehead and around eyes have UMN supply from both sides of brain
- Unilateral cortical lesions have relatively little effect on upper part of face
- Can close eye on affected side but with weakness
- Can raise eyebrows and wrinkle forehead
- Paralysis of lower face on affected side
- Causes flat nasolabial fold or groove

#### *Paralysis due to LMN*

Facial paralysis due to the LMN of CN VII usually occurs the morning after being exposed to cold air blowing on one side of the face. This exposure can be the result of driving or riding in a car while the window is rolled down; sleeping with a close window being open; or even due to exposure to air conditioners or cold work environment. The cause and typical symptoms that slightly different from UMN problems and can include:

- Due to wind or cold exposure affecting vessels and collaterals and facial paralysis occurring on side exposed to wind
- Often involves inability to close eyelid (ALF and PLF distributions)
- When attempted to do so eye to rotates upward and outward
- This condition is known as "Bell's" palsy
- Causes flat nasolabial fold or groove
- Cannot raise eyebrow to wrinkle forehead on affected side

### Trigeminal Neuralgia

This involves facial pain that can manifest in one or more branches of the trigeminal nerve. This includes the ophthalmic, maxillary, or mandibular branch of the trigeminal nerve.

### Herpes Zoster of Face

Herpes outbreak on the face is particularly painful condition that often manifests in the nerves related to one branch of the trigeminal nerve. Patterns may be apparent that follow the ophthalmic, maxillary, or mandibular branch of the trigeminal nerve. The outbreak can also affect more than one trigeminal nerve branch.

## Assessment of Face and Jaw

Pathology affecting the head reflects in the face and jaw, or in the cervical spine region. Therefore, these areas are examined and evaluated separately with face and jaw described below and cervical spine follows in Chapter 7. Problems can develop in the face and jaw that are the result of cervical spine pathology and thus examination of this area is accomplished while maintaining awareness of possible influence from the neck. Some problems affecting the face and jaw are also the result of dental related problems and therefore some conditions may require dental evaluation as well.

Difficulties are also manifest as result problems related to the cranial nerves such as deficits in vision, hearing, and equilibrium; problems moving the eyeball and in closing the eyelid; loss is sensory function of smell and taste; facial paralysis and weakness in the trapezius and sternocleidomastoid muscles.

### Inspection and Observation

Subjective findings are considered first by identifying the location of either pain, paresthesia, numbness, flaccidity or other manifestations. These are usually indicated on a figure in the examination form. Nature of the symptoms is also noted as cramping, aching, shooting, burning, throbbing, tingling, and stabbing or soreness to help identify the most likely structures or tissues involved.

Areas of possible swelling, heat, coldness or deformities are also identified. Deformities should be described. The face and jaw as well as other regions of the body, develop sensitive and painful sites. Certain radiation patterns may also be apparent and these pathways, including direction that pain seems to radiate are noted.

## Cranial Nerve and Facial Muscle Assessment

Assessment of muscles of the face, head and neck can provide a general condition of the cranial nerves. This information can help determine if problems are associated with either peripheral or central lesions. Many conditions that affect the head can manifest with certain conditions that indicate possible cranial nerve involvement. Patients may also present with complaints that directly implicate a specific cranial nerve. Cranial nerve assessment should be considered when symptoms suggest their involvement, but also in cases involving problems affecting the head and brain.

### *Cranial Nerve Assessment*

A series of routine tests can be performed that test the sensory and motor function of the twelve cranial nerves. Most of these tests derives information on possible pathology in one particular cranial nerve, or can isolate the problem to one particular area of involvement. The following represent initial tests that can be performed to derive important clinical data or to indicate the need for more comprehensive testing. The function of each of the twelve cranial nerves is listed below, indicating their function and possible tests of these functions.

CN I. Olfactory: Sense of smell.

- Inquire about any changes or impairment in their sense of smell
- Have patient identify common odors like coffee and pungent substances
- Test conducted with patient's eyes closed

CN II. Optic: Sense of sight.

Visual acuity:

- Vision checked by eye chart or having patient read something; in acute head trauma subject attempts to identify number of finger being held up
- Patient asked to read something held close and then further away

Visual field:

- Visual field checked by wiggling two fingers that are passed across various levels of visual field on both sides moving first from periphery to center
- Examiner wiggles two fingers and passes hand across visual field starting from the far right or left at upper, middle, and lower levels

CN III. Oculomotor: Voluntary levator of eyelid; voluntary motor function of rectus superior, medial, inferior; and obliquus inferior muscles of eyeball; autonomic motor of smooth muscles of eyeball. Eye muscles mediated by CN III include the superior rectus that rolls the eyeball upward; inferior rectus that rolls the eyeball downward; medial rectus which rolls the eyeball medially; and the inferior obliquus that rotates the eyeball on its axis directing the cornea upward and laterally.

Pupillary reaction:

- Measure pupil accommodation with penlight obliquely shined into eye
- Compare pupil size and measure "direct" and "consensual" response in both eyes

Eye movement:

- Six cardinal directions of gaze (See Figure 6.5) are measured by patient eyes following finger tip, 45 cm from patient's nose, moved in space to form a capital "H" pattern first to one side then up and down and back to start point to move laterally to other side and move up and down and back to start. Finger tip then moved to within several inches of nose causing eyes to cross

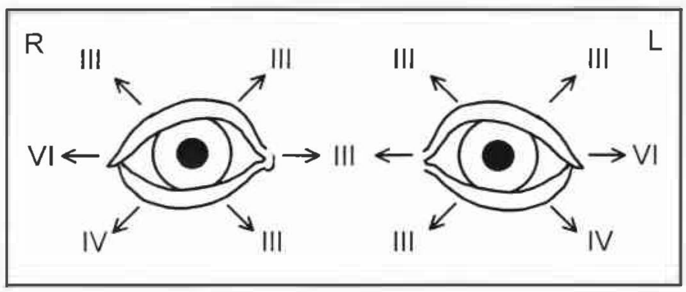


Figure 6.5. Six cardinal fields of gaze mediated by Cranial Nerves III, IV, and VI

- CN III lesion reflects as outward and slightly downward deviation of eye

Rolling the eyeball upward and medially involves using both the superior rectus (CN III) in combination with the medial rectus (CN III). Rolling the eyeball downward and medially involves using both the inferior rectus (CN III) in combination with the medial rectus (CN III).

CN IV. Trochlear: Voluntary motor function of obliquus superior muscles of eyeball. The superior obliquus mediated by CN IV rotates the eyeball on its axis directing the cornea downward and laterally.

- For eye movement, see six cardinal directions of gaze assessment under CN III
- CN IV lesion can cause upward and inward repositioning of affected eye

CN VI. Abducens: Voluntary motor function of rectus lateralis of eyeball. The lateral rectus mediated by CN VI rolls the eyeball laterally.

- For eye movement, see six cardinal directions of gaze assessment under CN III
- CN VI lesion can cause affected eye to drift medially

CN V. Trigeminal: Sensory function of face and deeper structures of head; and voluntary motor function of mastication.

- Facial sensation can be tested by touching the face for response by patient
- Muscles of mastication including the temporalis, masseter, and medial pterygoid function to close the mouth and can be collectively tested for strength as well as by a reflex test
- Lateral pterygoid functions in opening the mouth can also be tested for strength

CN VII. Facial: Voluntary motor function of muscles of expression; motor function of stapedius muscle; sensory function of taste for anterior 2/3 of tongue; autonomic function of lacrimal, submandibular, and sublingual glands. The facial muscles of expression can not be tested for strength, but can be observed for function which then can be graded as either normal (N, 5), fair (F, 3), trace (T, 1), or zero (0) .

Facial motor function:

- Have patient smile, wrinkle forehead, close eyes, pucker lips
    1. Upper motor neuron lesion, patient can wrinkle forehead and weakly close eyes
    2. Lower motor neuron lesion cannot wrinkle forehead and eye rolls upward and outward when attempting to close eye

Taste:

- Check anterior 2/3 of tongue by tasting and identifying sweet, sour, bitter, and salty substance with patient's eyes closed

Hyperacusia:

- Stapedius muscle paralysis causes failure to dampen the stapes resulting in increased acuteness of hearing
- Inquire if patient has noticed that sounds have become loud and annoying

Autonomic function:

- Check for lack of tearing or possible mouth dryness

CN VIII. Vestibulocochlear (acoustic nerve): Sensory function of hearing and balance.
Hearing:

- Can be tested by various means including a full auditory examination by a specialist
- Measured by snapping fingers or using ticking watch; also tuning fork applied to forehead to see if sound heard in each ear
    1. Tuning fork applied to mastoid and timed until vibration not detected and immediately placed next to ear for air conducted sound
    2. Tuning fork normally heard in air conducted sound twice as long as mastoid bone conduction sound

Equilibrium:

- Tested by balance and coordination tests which should be differentiated from problems associated with proprioception
- Rhomberg's test - Patient stands with feet together, arms by side, eyes open and note any problems with balance; then close eyes for 20 seconds and note differences in balance

CN IX. Glossopharyngeal: Sensory function of touch and pain for posterior tongue and pharynx; sensory function of taste for posterior tongue; voluntary motor function of pharynx muscles; autonomic function of parotid gland.

Swallowing:

- Have patient swallow
- Can be tested by the gag reflex and the ability to swallow

Voice:

- Have patient say "aaaah"

Taste:

- Apply common substances on the root of the tongue for patient to identify flavor, with patient's eyes closed

CN X. Vagus: Sensory function of touch and pain for pharynx, larynx, and bronchi; sensory function of taste for tongue and epiglottis; voluntary motor function of palate, pharynx, and larynx; autonomic motor function for thoracic and abdominal viscera.

- Vagus nerve can be tested by gag reflex using tongue depressor
- Check ability to swallow
- Have patient say "aaah."

CN XI. Accessory: Voluntary motor function of the sternocleidomastoid and trapezius muscles.

- Motor supply to the trapezius muscle can be tested by a resisted shoulder shrug test
- Motor supply to the sternocleidomastoid muscles can be tested by resisted head rotation test

CN XII. Hypoglossal: Voluntary motor function of muscles moving the tongue

- Possible lesions tested by having the patient stick out their tongue and moving it rapidly
- Measure strength by applying resistance with tongue depressor held on side of tongue
- Tremulous movement of tongue or deviation of tongue to one side might suggest a central lesion
- In this case tongue deviates to same side as lesion

### *Graded Assessment*

Several important muscles of the head and eyes are innervated by Cranial Nerves III, IV, V, VI, IX, X, XI and XII (See Table 6.1). Of these, CN V is of great importance since it supplies motor function to the muscles which move the jaw for mastication. Unlike the muscles which articulate body joints, most of the head and eye muscles cannot be graded in terms of strength. Therefore, grading is based on completion of test movements.

Table 6.1. Facial motor and sensory function by Cranial Nerves III, IV, V, VI, VIII, IX, X, XI and XII, along with assignment of muscular distributions, excluding CN VII.

| CN | Region | MD[1] | Grd.[2] | Motor or Sensory Area |
|---|---|---|---|---|
| I | Nose | Sens. | Sens. | Smell |
| II | Eye | Sens. | Sens. | Sight |
| III | Eyelid | PLF | | Levator Palpebrae Superior |
| | Eye | | | Rectus Superior, Medial, & Inferior |
| | | | | Obliquus Inferior |
| IV | Eye | | | Obliquus Superior |
| V | Face | Sens. | Sens. | Face & internal structure of head |
| | Ear | | | Tensor Tympani |
| | Palate | | | Tensor Veli Palatini |
| | Mastication | ALF | | Masseter |
| | | LF | | Temporalis |
| | | ALH | | Medial Pterygoid |
| | | ALH | | Lateral Pterygoid |
| | Suprahyoid | ALH | | Anterior Digastric |
| | | ALF | | Mylohyoid |
| VI | Eye | | | Rectus Lateralis |
| VIII | Ear | Sens. | Sens. | Hearing & Equilibrium |
| IX | Tongue | Sens. | Sens. | Taste, posterior 1/3 tongue |
| | Pharynx | | | Stylopharyngeus |
| X | Palate | | | Soft Palate: Striated Muscles |
| | Ear | Sens. | Sens. | Auricular |
| XI | Neck | PLF | | Trapezius & Sternocleidomastoid |
| | Palate | | | Levator Veli Palatini |
| XII | Tongue | PLF | | Styloglossus |
| | | LH | | Hyoglossus |
| | | LH | | Geniglossus |
| | | | | Tongue Intrinsics |

1. Chinese muscular distribution assignment.
2. Functional grade (Grd.) of either normal (N, 5), fair (F, 3), trace (T, 1) or zero (0).

The following grades can be considered: normal (N, 5) for completion of effortless and controlled movement; fair (F, 3) for difficult completion of test movements; trace (T, 1) for minimal muscle contraction; and zero (0) when no contraction can be elicited. The muscles of mastication can be tested for strength but it is not possible separate the combined effects of the temporalis, masseter and the medial pterygoid muscles. The strength of the lateral pterygoid muscles can be evaluated.

### *Graded Assessment of Facial Muscles*

Most of the face muscles are involved in facial expression and are innervated by CN VII (See Table 6.2). Facial muscles also cannot be graded in terms of strength; therefore, grading is based on completion of test movements. These are graded the same as the head and eyes muscles. Paralysis of the facial muscles can be evaluated to determine if CN VII is affected by a central or peripheral lesion.

Table 6.2. Facial muscles of expression innervated by CN VII showing relationship to superficial branches of the Facial Nerve and assignment of muscular distributions.

| CN | Region | MD[1] | Grd.[2] | Motor or Sensory Area | |
|---|---|---|---|---|---|
| VII | Tongue | Sens. | Sens. | Taste, anterior 2/3 tongue | |
| | Ear | Sens. | Sens. | External Ear | |
| | | PLH | | Stapedius | |
| | Supra Hyoid | PLH | | Posterior Digastric | |
| | | LH | | Stylohyoid | *Facial Nerve Branches* |
| | Scalp | PLF | | Occipitalis | Posterior Auricular |
| | Ear | | | Ear Intrinsics | |
| | | PLH | | Auricularis Posterior | |
| | | PLH | | Auricularis Anterior | Temporal |
| | | PLH | | Auricularis Superior | |
| | Scalp | LF | | Frontalis | |
| | Eyebrow | PLF | | Corrugator Supercilii | Temporal & Zygomatic |
| | Eyelid | PLF | | Orbicularis Occuli – Upper | |
| | | ALF | | Orbicularis Occuli – Lower | |
| | Nose | PLF | | Procerus | Buccal |
| | | ALF | | Dep. Septi & Nasi Transvr. | |
| | | ALF | | Nasalis, Alar Portion | |
| | Mouth | ALF | | Zygomaticus Major | |
| | | ALF | | Levator Labii Superior | |
| | | ALH | | Buccinator | |
| | | ALF | | Orbicularis Oris | |
| | | ALF | | Levator Anguli Oris | |
| | | ALH | | Risorius | |
| | | ALH | | Depressor Anguli Oris | Mandibular |
| | | ALF | | Depressor Labii Inferior | |
| | Chin | ALF | | Mentalis | |
| | Neck | PLF | | Platysma | Cervical |

1. Traditional muscular distribution assignment.
2. Functional grade (Grd.) of either normal (N, 5), fair (F, 3), trace (T, 1) or zero (0).

## Temporomandibular Joint (TMJ)

The joint structures involved in the movement of the jaw associated with the temporomandibular joint are note in Table 6.3. The temporomandibular joint is a critical structure since movement of the mandible is essential to the mastication and intake of food. This is perhaps why the four muscles that articulate the jaw are innervated by CN V which lies deeper in the jaw and head.

## Inspection and Observation

The jaw is inspected for possible deformities and functional abnormalities, including pain and other symptoms associated with articulating the mandible.

### *Jaw Deformities*

Typical deformities that may be present include an underdeveloped or small jaw (micrognathia), a large or protruding jaw (prognathism) or hyperplasia of condyle of the mandible.

Table 6.3. Joint structures involved in jaw movements.

| | Opening of Mouth | Closing Mouth | Protrusion | Retrusion | Lateral Deviation |
|---|---|---|---|---|---|
| Articulation | Temporomandibular (TM) | TM | TM | TM | TM |
| Plane | Sagittal | Sagittal | Horizontal | Horizontal | Horizontal |
| Axis | Frontal | Frontal | | | |
| Normal limiting factors | Tension in temporomandibular, sphenomandibular, and stylomandibular ligaments | Occlusion or contact of the teeth | | | |
| Normal end feel | Firm | Hard | | | |
| Capsular pattern | Limitation in opening mouth to (1 cm) with deviation to restricted side | | Limited: deviation to restricted side | | Limited: deviation to opposite side |
| Normal range of motion (mm)[1] | 43.5 – 52.1 | | 7.1 – 9.3 | | 8.6 – 11.5 |

1. There is wide variation in ROM values that are gender and age related where values decrease with age.

### *Occlusion of Teeth*

The function of the jaw in normal closing is observed to note possible overbite or crossbite. If overbite or crossbite/underbite is present, then anterior-posterior lateral distance is noted as well the lateral offset from centerline.

### *Other Problems*

Other problems are also noted that may be associated with temporomandibular joint dysfunction, including either missing teeth, presence of tooth pain, grinding of teeth or dizziness/tinnitus.

### *Aggravating Conditions*

Conditions or actions which aggravate temporomandibular joint problems, such as opening or closing the mouth, chewing, speaking or swallowing are also noted.

## TMJ Active Movements

Movement of the jaw is first observed by the placing the examiner's index fingers in ear of the seated patient with finger pads facing forward to feel the equality of condylar movement as the patient opens mouth. Possibly clicking and grinding of the temporomandibular joint may be observed in addition to any differences as the condyles move forward. The examiner stands in front of the patient and observes possibly lateral deviation of the jaw during opening and closing the mouth. Objective measurements are obtained during open the mouth as well as during lateral movement, protrusion and retrusion of the jaw.

### *Depression of Mandible (Opening mouth)*

Measurement of the possible deviation of the jaw, lateral to the midline, is noted at approximately at the mid-range and also at full range of mouth opening. Amount of deviation to either right of left of vertical in noted.

### *Functional ROM*

The functional range of motion can be measured by having the patient place one or more flexed fingers onto their mouth. If the mouth can only accommodate one finger, this indicates significant impairment. Normal mouth opening can accommodate two flexed fingers and normal wide-opening can accommodate three. The total vertical distance that the patient can open the mouth as measured between the upper and lower central incisors is noted.

### *Protrusion of Mandible*

With the mouth slightly opened the anterior-posterior distance that the jaw can be protruded is measured along with any possible lateral deviation to right or left.

### *Retrusion of Mandible*

With the mouth slightly opened and jaw in its normal position, the jaw is pulled back (retrusion) as far as possible. This anterior-posterior distance is noted along with any possible deviation in the lateral direction to right or left.

### *Lateral Movement of Mandible*

With the mouth slightly opened the jaw is moved laterally to the right and left extremes. The difference in the lateral deviation can be measured with a tape from the posterior aspect of temporomandibular joint to the notch of the chin, noting the distance on both the right and left sides for both right and left movement. Measurement of the offset between upper and lower central incisors can be used in place of the tape measurements.

## Auscultation

In addition to measuring the equality of movement and possible sounds of temporomandibular joint by placing the examiner's fingers in the ears, this joint can also be examined by means of a stethoscope placed anterior to the auricle. Sounds are noted during opening and closing the mouth as well as those during occlusion of the teeth. Sounds during lateral movement and protrusion of the jaw are also noted. Characteristic sounds include clicking, grating (crepitus), slipping and solid. Slipping and solid sounds are often associated with the teeth coming together and seating during occlusion.

## Passive Movements of TMJ

The active movements are next performed passively including opening and closing the mouth, lateral movement both to right and left sides, and protrusion and retraction of the jaw. Overpressure is applied at the limit of each available range and most of these tests are performed by taking a firm grip of the mandible with the examiner's thumbs inside the patient's mouth (examiner needs to wear sterile examination gloves). Overpressure at the limit of passive movement permits assessment of end feel and the mobility of the joint (graded 0 - 6) to distinguish between conditions such as muscle spasm versus joint stiffness. Any change or reproduction of presenting symptoms is also noted.

## Resisted Isometric Movement of TMJ

Resisted isometric movements of the temporomandibular joints are difficult in that it is not possible to isolate muscle strength of one particular TMJ. The jaw is held in the resting position by having the mouth opened slightly. This places the TMJ in the rotation or hinge movements region of the inferior compartment. Firm but gentle pressure is applied to the jaw or teeth and the patient is asked to only resist the movement.

- ➔ With regard to the resistive force, the examiner tells the patient, "Don't let me move you" to avoid the patient trying to move the examiner's hand by applying a greater counteracting force. This allows the examiner to control the applied force to ensure isometric movement with minimum amount of unnecessary movement.

***Depression***

Opening the mouth or depression of the jaw involves the action of the lateral pterygoid muscles. This isometric movement can be tested with the mouth slightly opened and applying an upward resistance below the chin with one hand while the other hand is placed behind the head or neck to stabilize the head.

***Occlusion***

Closing the mouth (elevation or occlusion) involves the action of the temporalis, masseter, and medical pterygoid muscles. This isometric movement can be tested with the mouth slightly open and applying downward resistance at the chin with one hand while the other hand is placed on the forehead to stabilize the head. Alternatively, the examiner can apply pressure with two fingers of one hand on the lower teeth (use of sterile examination gloves required) while the other hand is placed on the forehead to stabilize the head.

***Lateral Deviation***

Lateral deviation of the jaw individually involves the lateral pterygoid of each TMJ. The examiner places one hand above the TMJ opposite to the side being tested to stabilize the head while the other hand is placed along the patient's jaw with the mouth slightly open. Patient pushes the jaw out in lateral deviation against the resistance of the examiner's hand. Both sides are individually tested.

## Functional Assessment

Functional activities or activities of daily living (ADL) are tested after the basic movements of the TMJ have been completed. Activities examined include chewing, swallowing, talking, coughing, and blowing.

## Neurological Assessment

The main neurological assessment of the temporomandibular joint involves the jaw reflex test (graded 0 - 4). This test is performed in the seated position with the patient's mouth slightly opened. The examiner places one thumb on mandible just below the lower lip and this is struck with the reflex hammer. This test can also be performed with a tongue depressor placed in the mouth in contact with the lower teeth, and the other end held by the examiner. The tongue depressor is struck with the reflex hammer to produce a response.

- ➔ This test is best performed with the patient having their eyes closed; otherwise apprehension may result when patient sees the reflex hammer movement.

Additional neurological information, concerning the trigeminal nerve (CN V) motor fibers which innervate the muscles that articulate the temporomandibular joint, can be obtained by resisted strength testing of the jaw or functional assessment as noted above.

## Accessory Movements of TMJ

Accessory movement of the temporomandibular joint on each side of the jaw can be applied to evaluate the mobility (graded 0 - 6) in each plane by application of pressure on the mandible or teeth. This involves five possible tests, described below, that are applied independently to each side. These are performed with the mouth slightly opened for external manipulation while other movements are performed by placing the examiner's thumbs into the patient's mouth. In the latter case, sterile gloves are used.

Accessory movement of the temporomandibular joint can also be evaluated, with the patient seated, by the examiner placing both thumbs on the lower posterior teeth inside the mouth with the index fingers supporting the mandible outside the mouth. The mandible is then distracted by downward pressure of thumbs while pulling downward and forward with the index fingers while the other fingers push against the chin as a pivot point. The examiner notes the characteristic tissue stretch of the joint. Each joint can be tested individually while the other hand of the examiner is used to stabilize the head.

### *Transverse-Medial*

Transverse medial accessory movement is accomplished by applying pressure with both thumbs over the head of the mandible. With the patient in supine position, the examiner's hands are placed on the head and jaw of the tested side with the thumbs on the head of the mandible. Force is then applied in the transverse direction to determine the mobility of the temporomandibular joint in this direction.

### *Transverse-Lateral*

With the patient in supine position, transverse lateral accessory movement is produced by placing one thumb in the patient's mouth over the head of the mandible. Thumb pressure is applied in the transverse lateral direction while the examiner's other hand is placed over the head and forehead to stabilize the head position.

### *Posterior-Anterior*

Posterior anterior accessory movement is evaluated with patient in prone position with head resting on a pillow and rotated slightly to the test side. With the examiner's hands on the occiput and jaw of the tested side, pressure is applied by both thumbs over the posterior surface of the mandible head in the anterior direction.

### *Longitudinal-Caudal*

Longitudinal caudal accessory movement is produced, while the patient is in supine position, by using the downward pressure of one thumb over the molars to distract the joint. Thumb pressure is applied in the downward longitudinal direction while the examiner's other hand is placed over the head and forehead to stabilize the head position.

### *Longitudinal-Cephalad*

Longitudinal cephalad accessory movement is produced, while the patient is in supine position, by using the upward compression of the temporomandibular joint by thumb pressure over the lower mandible just anterior to the angle of the jaw. Thumb pressure is applied in the upward longitudinal direction while the examiner's other hand is placed on top of the head to stabilize the head position.

## Palpation

The temporomandibular joint is first palpated at rest to determine the relationship between the head of the mandible and the articular eminence of the temporal bone. Palpation over the joint confirms the presence of possible warmth, tissue tenderness and swelling or thickening. Possible capsular thickening or hyperplasia of the condyle is evaluated by comparison with the good side. The temporomandibular joint is also palpated on motion with the examiner's fingers in the patient's ears as previously noted, or placed anterior to the external auditory meatus. The movement, possible sounds and crepitus can be detected.

The teeth are also palpated to detect painful or missing teeth and determine if pain radiates from sensitive into the temporomandibular joint. The hyoid bone is checked for position and movement as well as for possible pain, sensitivity or spasm in the anterior and posterior digastric mm. The thyroid cartilage is also checked for freedom of motion. Muscles articulating the jaw, especially the temporalis m., are palpated for possible spasm or contraction and the existence of sensitive sites. Possible sensitive locations are also checked for in the region surrounding the mastoid process and other muscles that related to those that distribute to the jaw, such as the anterior and medial scalene mm. The cervical spine area is also palpated for possible complications affecting the jaw.

### *Diagnostic Imaging*

#### Plain Film Radiography

**Anteroposterior view.** The practitioner should note normal bone contours to detect possible bone fractures; and should also note the condylar shape and contours.

**Lateral view.** The practitioner should also note normal bone contours in this view to detect possible fractures. Position of the condylar heads with the mouth open and closed should be noted along with condylar shape and contours. Condylar movement in the open and closed positions should be noted in relationship to the TMJ and other bony structures of the skull and cervical spine.

#### Magnetic Resonance Imaging

Magnetic resonance imaging of the head and face can provide a means to detect soft tissue lesions which can than be differentiated between bone and soft tissue, including the TMJ and the disc from the bony structures.

#### Computed Tomography

Computed tomography scans can produce cross section and axial views of the head and face bones and soft tissue, providing a more precise image of fractures.

### *Dental Evaluation*

In some situations it may be helpful for the patient to have a current dental evaluation.

## Management of Head and Face Problems

Head and face problems are somewhat unique since they are mostly influenced by the effect that cranial nerves have on the muscles, vessels and sensory organs in this region of the body. Needling therapy, therefore, mostly involves selecting those nodes that have a profound affect on the cranial nerves and other structures of the head and face. The only articular joint is the temporomandibular joint and consequently mobilization and manipulation techniques only apply to this specific area. Pressure techniques, including ischemic pressure is effective in the treatment of both facial pain and temporomandibular joint problems. Cupping with long but small diameter cups is sometimes employed in treatment of facial paralysis. Remedial exercises are appropriate for both temporomandibular joint problems and facial paralysis.

### Temporomandibular Joint Mobilization

Physical techniques are typically used in treatment of pain and musculoskeletal disorders, including the application of ischemic pressure technique on sensitive locations. In some situations, needling therapy is applied prior to physical manipulations, but caution must be exercised. Hence, physical manipulations are usually not applied after EN application since electrical stimulation can produce profound analgesia.

Improving the function of the temporomandibular joint involves using the same techniques applied in performing accessory movements of the joint (See Section on Temporomandibular Joint Assessment). These techniques can involve transverse-medial, transverse-lateral, posterior-anterior, longitudinal-caudal and longitudinal-cephalad movements of the mandible.

### *Head and Face*

Use of needling therapy to treat problems of the head face and neck consist of three principal categories. The first of these involves the muscles, joints, ligaments and bones of the jaw and the treatment of temporomandibular joint problems. The second involves pathology affecting Cranial Nerve V resulting in facial pain or trigeminal neuralgia (See Table 6.1 for facial muscle innervation, except for CN VII). Facial paralysis, as result of impairment of Cranial Nerve VII is the other important problem affecting the head and face (See Table 6.2).

#### Temporomandibular Joint Dysfunction

Treatment of temporomandibular joint (TMJ) syndrome is unique in that all the muscles articulating the mandible are innervated by the trigeminal nerve. For this reason the node Xiaguan (ALF 7) is critically important to consider since it overlies the trigeminal nucleus. Four muscles involved in moving the jaw belong to either the LF, ALH or ALF distributions and therefore selection of possible distal nodes is simplified (See Table 6.4). The lateral pterygoids and the temporalis muscles mostly affect the temporomandibular joint and therefore nodes affecting these muscles are selected. The masseter muscle (ALF) also articulates the mandible but does not seem to play an important role in TMJ problems, and therefore no distal ALF vessel nodes are indicated.

However, if it is determined that the masseter muscle is involved. distal ALF vessel nodes could be considered. Pain radiation patterns associated with the temporomandibular joint can distribute either to or from the teeth, mandible, scalene muscles, temporal region or forehead. Thus under some situations additional nodes influencing these regions may be considered as well. Indications for the related muscular distribution include:

Lateral foot (LF) distribution:

- Acute cramps, spasms and pain in jaw and parietal region including TMJ syndrome
- Conditions can include clenched jaw (trismus), one-sided parietal headache, migraine, dizziness, vertigo, or retroauricular pain.

Anterior lateral foot (ALF) distribution:

- Acute cramps, spasms and pain in region of jaw and cheek.
- Conditions can include either trismus, toothache, swelling of face and cheek, tinnitus or motor impairment of the jaw.

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps under angle of jaw, possibly including toothache
- Pain, spasms and acute cramps under angle of jaw when opening or closing the mouth.

Table 6.4. Regional selection of nodes for temporomandibular joint problems.

| Temporomandibular Joint Disorder[1] | Candidate Local & Adjacent Nodes | MD* | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Shauigu (LF 8)<br>Fubai (LF 10) | LF | Fengchi (LF 20) | Zulingqi (LF 41)/<br>Diwuhui (LF 42) |
| | Qubin (LF 7)<br>Xiaguan (ALF 7)[2]<br>Jiache (ALF 6)<br>Yifeng (LH 17) | ALH | Fengchi (LF 20) | Hegu (ALH 4) |

*Muscular distribution

(1) Can consider bilateral treatment for TMJ although pain in only one side.
(2) Temporalis, lateral and medial pterygoids and masseter served by trigeminal nerve (CN V).

**Candidate Electroneedling (EN) application for:** temporomandibular joint dysfunction
Frequency/Mode/Duration: 2 Hz, continuous, 20-30 minutes

- Xiaguan (ALF 7) + lead, to Shauigu (LF 8) – lead, if problem manifests in the temporalis muscle
- Xiaguan (ALF 7) + lead, to Hegu (ALH 4) – lead, if problem manifests in the TMJ

### Facial Pain

Pain affecting the face can either involve the entire face or manifest only ipsilaterally. It may further only manifest in one particular region or face supplied by one of the branches of the trigeminal nerve (CN V) and hence pain is felt only in either the supraorbital, maxillary or mandibular regions. If pain is only reflected in a particular area, nodes are selected specifically for each region. Since sensory innervation of the face involves the trigeminal nerve, the node Xiaguan (ALF 7) which overlies this cranial nerve is selected for pain in any region of the face (See Table 6.5). Additional nodes can also be considered depending on the particular pattern of facial pain and the progress noted during the course of treatment.

Table 6.5. Regional selection of neurovascular nodes for treatment of facial pain or trigeminal neuralgia in either the supraorbital, maxillary or mandibular regions of the face.

| Facial Pain[3] | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Supraorbital Region | Yangbai (LF 14)<br>Taiyang (extra)<br>Zanzhu (PLF 2) | LF,<br>PLF | Xiaguan (ALF 7)<br>Fengchi (LF 20) | Zhongzhu (LH 3) |
| Maxillary Region | Quanliao (PLH 18)<br>Sibai (ALF 2)<br>Yingxiang (ALH 20) | ALF,<br>ALH | Xiaguan (ALF 7)<br>Fengchi (LF 20) | Hegu (ALH 4) |
| Mandibular Region | Mental Foramen Pt.<br>Daying (ALF 5)<br>Jiache (ALF 6) | ALF,<br>ALH | Xiaguan (ALF 7)<br>Yifeng (LH 17) | Hegu (ALH 4) |

(3) Facial pain and trigeminal neuralgia usually treated on same side as problem.

**Candidate Electroneedling (EN) application for:** facial pain
Frequency/Mode/Duration: 2 Hz continuous mode, 20-30 minutes

Supraorbital Region:

- Xiaguan (ALF 7) + lead, to Yangbai (LF 14) – lead

Maxillary Region:

- Xiaguan (ALF 7) + lead, to Yingxiang (ALH 20) – lead

Mandibular Region:

- Xiaguan (ALF 7) + lead, to Mental Foramen Pt. – lead

### Facial Paralysis

Facial paralysis is usually the result of external affects on the facial nerve (CN VII). Most often the condition is ipsilateral and involves the lower motor neurons. Since the facial nerve is involved, the node Yifeng (LH 17) is critical to employ even though the problem may only manifest in either the supraorbital, maxillary or mandibular regions (See Table 6.6). Additional nodes can also be considered depending on the particular pattern of paralysis and the progress noted during the course of treatment.

Facial paralysis often involves the inability to close the eyelid (ALF and PLF). When attempted to do so eye to rotates upward and outward. This condition is known as "Bell's" palsy. It is due to wind attacking vessels and collaterals and facial paralysis occurs on the side exposed to the wind. Many of people are afflicted with this problem by driving while window is open. Facial paralysis can also be induced by exposure to cold from air conditioners, sleeping with neck exposed and weather conditions. Specific dysfunction related to ALF distribution:

- Unexpected or sudden deviation of the mouth, with acute condition that the eye cannot close.

Table 6.6. Regional selection of neurovascular nodes for facial paralysis affecting either the supraorbital, maxillary or mandibular regions of the face.

| Area of Facial Paralysis[4] | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Supraorbital Region | Yangbai (LF 14)<br>Taiyang (extra)<br>Zanzhu (PLF 2) | LF,<br>PLF | Yifeng (LH 17)<br>Fengchi (LF 20) | Zhongzhu (LH 3) |
| Maxillary Region | Quanliao (PLH 18)<br>Sibai (ALF 2)<br>Yingxiang (ALH 20)<br>Xiaguan (ALF 7) | ALF,<br>ALH | Yifeng (LH 17)<br>Fengchi (LF 20) | Hegu (ALH 4) |
| Mandibular Region | Mental Foramen Pt.<br>Daying (ALF 5)<br>Jiache (ALF 6)<br>Xiaguan (ALF 7) | ALF,<br>ALH | Yifeng (LH 17)<br>Fengchi (LF 20) | Hegu (ALH 4) |

(4) Facial paralysis usually treated on same side as problem.

**Candidate Electroneedling (EN) application for:** facial paralysis
Frequency/Mode/Duration: 2 Hz - 25 Hz, mixed mode, 20-30 minutes

Supraorbital Region:

- Yifeng (LH 17) + lead, to Yangbai (LF 14) – lead

Maxillary Region:

- Yifeng (LH 17) + lead, to Yingxiang (ALH 20) – lead

Mandibular Region:

- Yifeng (LH 17) + lead, to Mental Foramen Pt. – lead

# 7

# Cervical Spine

The cervical spine is unique in the fact that it is an easily articulated flexible structure that supports the heavy mass of the head. Consequently, it is susceptible accidental damage as well as wear and tear stress. Cervical spinal nerves supply the neck, shoulders, upper back, and the arms. Pain and muscular problems can reflect in these areas making it essential that assessment determines the most likely source cervical spine disorders as opposed to problems originating in the upper body and limbs. One critical feature is the phrenic nerve which supplies the diaphragm and has roots at the C3, 4, and 5 level and upper cervical spine injuries can impair breathing. Treatment involves mobilization methods and needling therapy including possible electroneedling (EN), along with possible movement and exercise rehabilitation.

## Regional Anatomy of Cervical Spine

The cervical spine consists of 7 vertebra which form several joints. The first two of these are the atlanto-occipital joints (CO - C1) where the atlas (C1) articulates on the occipital condyle (CO) of the skull (See Figure 7.1.). These two joints are critical to nodding the head in flexion-extension (15° to 20°) and side flexion (about 10°) with negligible rotation. The remaining intervertebral joints contribute to remaining range of motions of the cervical spine (See Table 7.1).

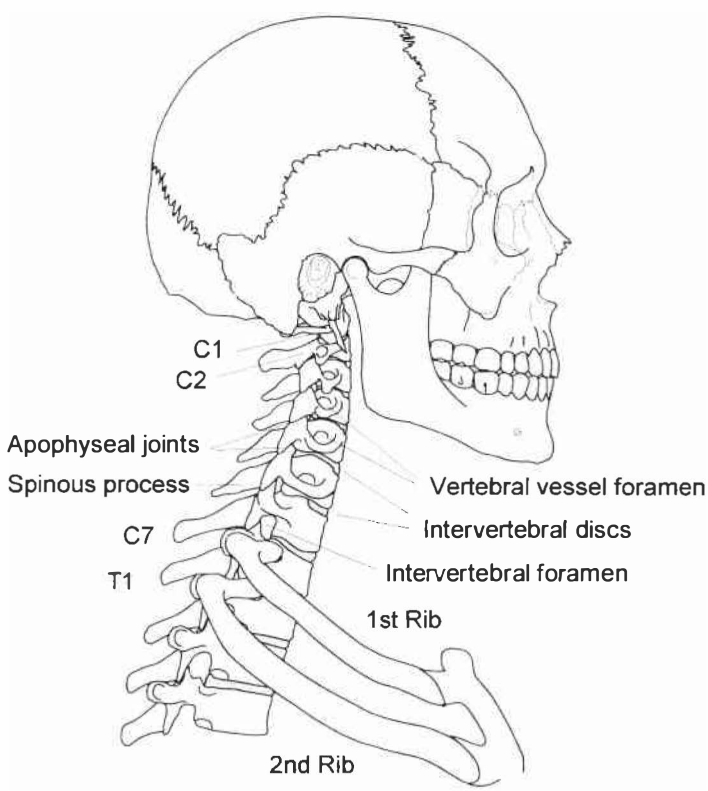


Figure 7.1. Cervical Spine, Skull, and Thoracic Area

### *Vertabra*

The atlas (C1) does not have any semblance of a vertebral body because during development it becomes the odontoid process of the axis (C2). The atlanto-axial joints, where the atlas (C1) articulates on the axis (C2) is the most mobile spinal joint. It contributes about 10° of movement in flexion and extension, approximately 5° in side flexion, and approximately 50° in rotation. The odontoid process of C2 serves as a pivot point for this rotation. Cervical vertebra C2 - C7 have transverse foramen to accommodate vertebral arteries and veins that respectively supply blood to and receive blood from the posterior brain. Rotating the cervical spine beyond 50° can result in kinking of the contralateral vertebral artery while the ipsilateral vertebral artery may be affected at 45° rotation. This can result in a condition called "vertebral artery vertigo," as well as nausea, visual disturbances, tinnitus, and falling attacks without fainting. There are intervertebral discs between each cervical vertebrae from C2 - C7 consisting of a nucleus pulposus and a tough fibrous outer ring, the annulus fibrosis.

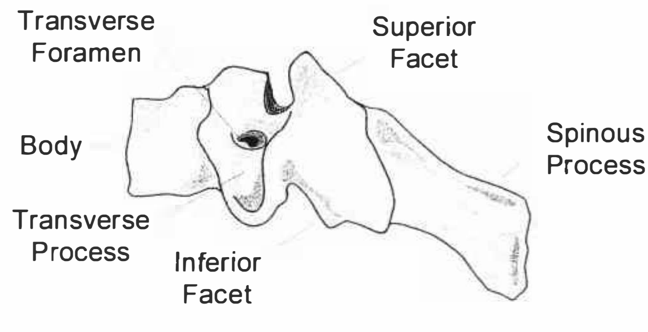


Figure 7.2 Features of cervical vertebra

Many features of cervical vertebra are common to thoracic and lumbar spine except they are generally smaller. Vertebra C2 to C7 are unique by having transverse foramen on each side to accommodate the vertebral arteries and veins. They also have a body to support the weight on the spine, an intervertebral disc, neurocentral joints, apophyseal (facet) joints, transverse processes, spinous process, and intervertebral foramen to distribute spinal nerves (See Figure 7.2).

### *Cervical Spine Ligaments*

The cervical spine is held tightly together by strong ligaments that provide a crucial function and are by necessity the normal limiting factors in movement (See Table 7.1). Cervical spine ligaments provide stability to the joints, absorb energy during trauma, and act as a joint position indicators during physiologic motions. In addition, the ligaments and paracervical muscles prevent motion between vertebrae that might injure the spinal cord or nerve roots. The major ligaments of the cervical spine include the following:

- Anterior longitudinal ligament: attaches to the anterior aspect of the body and disc of each vertebra running longitudinally up and down the spine.
- Posterior longitudinal ligament: runs longitudinally up and down posterior aspect of the spine inside the spinal canal and attaching to the vertebral body and disc. This ligament is thick in its central portion and helps prevent a disc herniation from pressing posteriorly on the spinal cord.
- Ligamentum flavum: forms a cover over the dura mater tissue that protects the spinal cord and overlies the space between the laminae of adjacent vertebrae and the neural arches. Due to its posterior location the ligamentum flavum helps to restrain hyperflexion.

- Apical ligament: single median ligament extending from the odontoid process of the axis (C 2) to the occipital bone.
- Alar ligaments: extend from the posterolateral aspect of the odontoid process of the axis (C 2) and insert on the medial surfaces of the occipital condyles. Their main function is to restrain rotation.
- Transverse ligament of atlas: functions as a restraining band by holding the odontoid process of C2 against the anterior ring of the atlas.
- Cruciate ligament: a cross shaped ligament of the atlas (C2) consisting of a transverse ligament and superior and inferior bands, the former passing upward and attaching to the margin of the foramen magnum, the latter passing downward and attaching to the body of the atlas.
- Capsular ligaments: are oriented approximately orthogonal to the articular facets to provide maximal mechanical efficiency in resisting distraction of the facets but relatively poor resistance to shear.

### *Nerve Supply*

The cervical spine accommodates the cervical plexus (C1 - C4) and most of the brachial plexus (C5 – T1). Key muscle function supplied by the cervical spine, relative motor and sensory functions, spinal segment nerve roots, and key reflexes are respectively provided in Tables 3.4, 3.5, 3.6, and 3.7. Function of prime mover (PM) and assistant mover (AM) muscles of the head and neck supplied by the cervical and brachial plexuses indicating related muscle distribution (MD) assignment and nerve root is provided in Table 7.2.

The cervical plexus is formed on both sides of the spine by the ventral rami of the first four cervical nerves (C1 - C4) with some contribution from the fifth cervical nerve (C5). This plexus supplies the skin and muscles of the head (not including facial muscles and muscles of mastication), neck, and part of the shoulders. Branches of the cervical plexus also connect with the spinal accessory nerve (CN XI) and the hypoglossal nerve (CN XII). Branches of the cervical plexus also connect with the spinal accessory nerve (CN XI) and the hypoglossal nerve (CN XII). The phrenic nerves are also a critical pair of nerves rising from the cervical plexus that supply the motor function for the diaphragm.

The brachial plexus (C5 - T1) is comprised of a network of nerves arising from both sides of the spine at the base of the neck. This plexus gives rise to the nerves supplying the arm, forearm, hand and some parts of the shoulder girdle. Anterior rami of cervical nerves C5 - C8 and first thoracic spinal nerves (T1) are the source input to the brachial plexus which runs between the spine and the upper arm just after the axilla.

## Cervical Spine Physiology

Physiological function of the muscles and tendons that articulate the cervical spine are presented below. Each specific muscle is grouped by the Chinese longitudinal muscular distributions by logical regions of the neck and shoulders. Joint structures involved in the movement of the cervical spine along with those features, including the ligaments, which contribute to restricted movement are noted in Table 7.1.

Table 7.1. Joint structures involved in movement of cervical spine.

| | Flexion | Extension | Lateral Flexion | Rotation |
|---|---|---|---|---|
| Articulation | Atlantoccipital, atlanto-axial, intervertebral | Atlantoccipital, atlanto-axial, intervertebral | Atlantoccipital, intervertebral (with rotation) | Atlantoccipital, atlanto-axial, intervertebral (with lateral flexion) |
| Plane | Sagittal | Sagittal | Frontal | Transverse |
| Axis | Frontal | Frontal | Sagittal | Vertical |
| Normal limiting factors | Tension in posterior atlantoaxial ligament, posterior longitudinal ligament, ligamentum nuchae, ligamentum flavum, tectorial membrane, posterior neck muscles | Tension in anterior longitudinal and anterior atlantoaxial ligaments, anterior neck muscles, bony contacts between spinous processes | Tension in alar ligament limits flexion to the contralateral side | Tension in alar ligament limits rotation to the ipsilateral side |
| Normal end feel | Firm/ springy | Bony | Springy | Soft/ soft springy |
| Normal active range of motion[1, 2] | 0 – (45°- 50°) | 0 – (45°- 60°) | 0 - 45° | 0 – (60°- 80°) |

1. There is wide variation in ROM values that are gender and age related where females tend to be more flexible and overall values decrease with age.
2. ROM values from the American Association of Orthopedic Surgeons (AAOS) and American Medical Association (AMA) guidelines.

## Muscles of the Head and Neck

Function of these muscles is to extend, flex and rotate head by articulation of the cervical spine. The specific function of each muscle is noted in Table 7.2 along with its particular assignment in terms of the Chinese muscular distributions. The nerve root level for each muscle is also noted. Additional information on the head and neck muscles include:

- Are involved in many musculoskeletal problems especially involving trauma or accident causing hyperextension or hyperflexion of head
- One of most common problems and can result from a simple fall or accident
- These muscles also susceptible to tension related to stress and dysfunction due to environmental exposure.
- Muscles responsible for extending head belong mostly to the PLF distribution.
- Muscles that flex head belong mostly to PMF distribution.
- Muscles in lateral aspect of neck include the scalenus anterior (LF distribution), scalenus medius (ALH) and scalenus posterior (LH).

Table 7.2. Function of prime mover (PM) and accessory/assistant mover muscles of the head and neck indicating related muscle distribution (MD) assignment and nerve root.

| | | | Acting Bilaterally | | Unilateral | | |
|---|---|---|---|---|---|---|---|
| Muscles | MD | Nerve Root | Extension | Flexion | Lateral Flexion | Rotation to Same Side | Rotation to Opposite Side |
| Rectus capitis anterior | PMF | C1, 2 | | AM | | AM | |
| Rectus capitis lateralis | PMF | C1, 2 | | | AM | | |
| Longus capitis | PMF | C1, 2, 3 | | AM | | AM | |
| Longus colli cervicis | PMF | C2 - 7 | | AM | AM | AM | |
| Scalenus anterior | LF | C3 - 8 | | AM | PM | | AM |
| Scalenus medius | ALH | C3 - 8 | | AM | PM | | AM |
| Scalenus posterior | LH | C3 - 8 | | AM | PM | | AM |
| Platysma | PLF | CN VII | | AM | | | |
| Sternocleidomastoid | PLF | CN XI; C1 - 3 | | PM | PM | | PM |
| Rectus capitis pos. maj. | PMF | C1, 2 | AM | | | AM | |
| Rectus capitis pos. min. | PMF | C1, 2 | AM | | | | |
| Obliquus capitis inf. | PMF | C1, 2 | | | | AM | |
| Obliquus capitis sup. | PMF | C1, 2 | AM | | AM | | |
| Splenius capitis | PLF | C1 - 5 | PM | | PM | PM | |
| Splenius cervicis | PLF | C6 - 8 | PM | | PM | PM | |
| Trapezius, upper | PLF | CN XI; C1 - 3 | AM | | AM | | |
| Iliocostalis cervicis | PLF | C6 - 8 | PM | | PM | | |
| Longissimus capitis | PLF | C6 - 8 | PM | | PM | PM | |
| Longissimus cervicis | PLF | C6 - 8 | PM | | | | |
| Spinalis capitis | PLF | C6 - 8 | AM | | | | |
| Spinalis cervicis | PLF | C6 - 8 | PM | | | | |
| Semispinalis capitis | PLF | C1 - 5 | PM | | PM | | |
| Semispinalis cervicis | PLF | C3 - 6 | PM | | PM | | PM |
| Rotatores, cervical | PMF | C2 - 8 | PM | | | | PM |
| Multifidi, cervical | PMF | C2 - 8 | PM | | PM | | PM |
| Interspinales, cervical | PMF | C2 - 8 | PM | | | | |
| Intertransversaii, cerv. | PMF | C2 - 8 | PM | | PM | | |

## Disorders of Muscles of the Cervical Spine

Common disorders manifested in the muscular distributions (See Chapter 2) associated with the cervical spine involves pain and stiffness of the neck with the inability to turn the neck in either direction or to flex the neck forward or backward. Any of the six muscular distribution of the neck has slight variation in either the posterior or lateral aspect of the neck.

### *Posterior Aspect*

Posterior lateral foot (PLF) distribution:

- Inability to bend the head forward.
- Inability to turn neck left or right.
- Abnormal curvature in the nape of the neck.
- Muscular spasms in the nape of the neck.

Posterior medial foot (PMF) distribution:

- Inability to bend the head backwards.

***Lateral Aspect***

Lateral foot (LF) distribution:

- Pain and spasms in the muscles and tendons in anterior lateral aspect of the neck.

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps along lateral aspect of neck.
- Inability to turn the neck left or right to look either direction.

Lateral hand (LH) distribution:

- Acute cramps and spasms along lateral aspect of neck.

Posterior lateral hand (PLH) distribution:

- Spasms in the neck muscles which can result in fistula of these muscles.
- Swelling in the neck.

## Pathology of Cervical Spine

Given the unique anatomic features of the cervical spine it is susceptible to common wear and tear disorders in present times as well as damage due slip and fall incidents and other accidental trauma. Cervical disc degeneration is perhaps most common problem followed by hypomobility lesions, cervical disc prolapse, and traumatic injuries.

### Cervical Disc Degeneration

Intervertebral disc degeneration is commonly associated with the cervical spine. The neck is a flexible structure supporting the weight of the head with an inflexible joint (fixed inferiorly) at the thorax. Because of these features, the lordotic curve of the neck tends to localize disc degeneration problems to the C5 - 6 and C6 - 7 levels.

#### *Cervical Spondylosis*

Spondylosis is much more common in the cervical spine than the lumbar spine. However, cervical disc prolapse is less common than lumbar disc prolapse. Degenerative changes noted in cervical spondylosis are associated with the discs, vertebrae, and apophyseal joints, neurocentral joints, often including osteophytic outgrowths. Common clinical manifestations include:

**Neck Pain**

Neck pain is a common complaint in cervical spondylosis and is often associated with stiffness. Manifests as a dull, aching but not severe pain, which is persistent and made worse by sudden movements or by most physical activities associated with the neck. Pain may be felt diffusely in neck, interscapular region, shoulder, or referred distally into the arms. In this latter situation, the site of the pain does not always indicate the spinal level of the disc degeneration.

### Arm Pain

Pain in the arm due to cervical spondylosis may be referred pain from the neck or be the result of nerve-root pressure. Referred neck pain often radiates into the extensor aspect of the upper arm, but may be felt at times anywhere in the extremity. It can be associated with deficits of sensation that are not segmental, or manifest with sensations of heat and cold in the arm.

Arm pain due to nerve-root pressure often follows minor trauma or overuse by activities involving excessive use of the arm or extension of the head. Mostly likely associated with synovitis of the apophyseal joints and evidence of disc prolapse is usually absent. The nerve root of C6 or C7 is commonly involved, with or without neurological signs.

### Headache

Headache is a common complaint in cervical spine disc degeneration involving spondylosis and is also caused by hypomobility lesions of the upper cervical spine. However, this does not include migraine headache which rarely is caused by cervical spine problems. Migraine headaches mostly result from problems associated with the cranial vessels and blood flow. Other causes for headache of cervical origin include: arthritis of the atlantoaxial joints; musculotendinous lesions of the attachment of the cervical muscles to the nuchal line; and, entrapment neuropathy of the occipital nerves.

#### *Atlantoaxial Arthritis*

The atlas (C1) and axis (C2) vertebrae can be affected by inflammatory and degenerative arthritis including rheumatoid arthritis, spondyloarthritis, and osteoarthritis involving the lateral atlantoaxial joints. Diagnosis of arthritis is confirmed by suitable X-rays of atlantoaxial region.

#### *Entrapment Neuropathy*

Neuropathy associated with the cervical spine can include entrapment of the occipital nerves which are medial branches of the posterior rami of C2. Entrapment may occur as the occipital nerve passes through the semispinalis capitis or trapezius muscles about 1 cm from the midline. From here it crosses the nuchal line along with the occipital artery and is distributed to the scalp and over to the frontal region.

#### *Musculotendinous Lesions*

Lesions involving musculotendinous attachments of cervical muscles to the skull at the nuchal line may result in head pain. These may be the result of: alteration in the patient's posture perhaps due to cervical spondylosis or hypomobility lesions; tension in the underlying muscles in patients complaining of head and neck pain; and, tendinitis occurring as the single clinical finding without evidence of the other associated conditions.

#### *Facial Pain*

Facial pain can occur is lesions of the cervical spine, even in the absence of headaches. Nature of the pain is often deep-seated, dull, and aching whereas pain due to the facial muscles is more superficial. The pain is often unilateral and tends to be constant at a particular location. Can occur in the supraorbital regions, behind the eyes, or infraorbital where it is sometimes mistaken for pain due to sinusitis.

#### *Vertigo*

Vertigo due to cervical spine disorders affecting the vertebral arteries and can involve cervical spondylosis, hypomobility lesions, cervical trauma, and rheumatoid arthritis. Vertigo as result of vertebral arteries is worse on moving the head or straining.

#### *Scapular Pain*

Pain referred to the scapula as result of cervical spine disorders has dull, throbbing like toothache in relation to the scapula, with or without neck pain on the same side.

#### *Anterior Chest Pain*

Pain referred to the anterior chest can be bilateral, substernal, or felt in the anterior chest wall. This arises from cervical spondylosis or hypomobility lesions. Pain is related to exertion, posturing, or breathing. This pain can mimic pain due to heart disease and lung disease.

#### *Cervical Myelopathy*

Cervical myelopathy can result from a narrowing of the spinal canal, hard bone and cartilage projecting from the posterior aspect of the vertebral body affecting the spinal cord. These conditions produce symptoms similar to spinal cord compression. The onset is insidious with weakness in the lower legs. Exhibits upper and lower motor nerve signs.

#### *Nerve Root Palsy*

Nerve root palsy is a source of atrophy involving radicular lesions involving cervical spondylosis at C5 level.

#### *Leg Pain*

Leg pain can manifest without signs of lumbar intervertebral disc changes, but can be evident in cases of marked cervical spondylosis. The leg pain manifests as being poorly localized with a dull, aching, or bursting nature. This is in contrast to signs of numbness or paresthesia characteristic of cervical spondylosis which produces cervical-cord compression. This may be a similar basis for leg pain and would help explain the common occurrence of exaggerated tendon reflexes in the lower limbs in such cases.

#### *Pressure Effects on Surrounding Tissue*

Large anterior osteophytes can cause pressure effects on surrounding tissue even causing dysphasia. These are often palpable as tender bony protuberances.

### Cervical Hypomobility Lesions

Cervical hypomobility lesions manifest with pain and stiffness of the lower cervical spine producing symptoms similar to cervical spondylosis, but without neurological signs. Clinical signs of hypomobility lesions involve the following:

### *Neck Pain*

Neck pain is usually well localized to one side. There may be painful restriction of active and passive range of motion in certain directions only. Most common restrictions are in extension, lateral flexion, and rotation toward the painful side.

### *Fibrositis*

Fibrositis affecting the cervical spine involves inflammatory hyperplasia of the muscle sheaths and fascia of the neck muscles. This results in neck pain and stiffness with palpable locations above and medial to the scapula.

### *Torticollis (Twisted Neck)*

This condition involves a contacted condition of the cervical muscles producing a twisting of the neck and an unnatural position of the head. Torticollis is prime example hypomobility syndrome. Acute torticollis involves unilateral pain radiating up and down the head and scapular regions. Neurological signs are absent except for the case of torticollis due to pressure or irritation of the accessory nerve. Head flexes away from painful side and not usually associated with head rotation.

### *Shoulder Pain*

Hypermobility lesions of the cervical spine can result in shoulder pain. In one situation, pain radiates from neck above the scapula into the shoulder where shoulder movements are painless while neck movements are painfully restrictive and may reproduce the shoulder pain. In another situation the patient may present with shoulder pain without any neck pain but shoulder pain is reproduced by neck movements. Finally, there can be a less common clinical situation where shoulder movements are painful while neck movements are slightly painful or clinically normal. Although this seems to implicate the shoulder, mobilization therapy to the C4 - 5 and C5 - 6 and traction can be beneficial to a number of these cases.

## Cervical Disc Prolapse

Prolapse of a cervical disc presents with severe pain usually felt in the neck, scapula, and down the arm initially felt along a dermatome distribution.

### *Pain Distribution*

Pain radiation patterns due to cervical disc prolapse are slightly different for specific cervical spinal nerves as follow:

C5 - pain is felt over shoulder, but may radiate down arm.

C6 - pain radiates into the scapula, shoulder, lateral aspect of arm, to thumb and index finger.

C7 - pain is felt over the upper border of the scapula, shoulder, down back of arm and forearm, and middle fingers. Sensory changes may be apparent in the middle and index fingers.

C8 - pain radiates to shoulder, medial arm, and forearm. Sensory changes may be apparent in the two medial fingers ($4^{th}$ and $5^{th}$ fingers).

#### *Neurological Manifestations*

A complete lower and upper limb neurological examination is indicated in the case of cervical disc prolapse. Neurological deficits including sensory, motor, and reflex changes are assessed in the upper limbs. Possible motor neuron involvement affecting the lower extremities is examined in terms of motor weakness or reflex changes, including alteration in the plantar responses.

### Traumatic Cervical Syndrome

The cervical spine is highly susceptible to traumatic injury given the anatomical configuration of the reasonably flexible cervical spine fixed at thorax, carrying the pendulous mass of the head. Any type of high velocity force imparted to the body, as occurs in accidents and even simple falls, can result in injuries to the head and cervical spine. Some of these incidents result in factures of the cervical vertebra. Here, C1 is often fractured if the force is applied directly downward on the head. Fractures of C1 are often fatal. Impact of the body from different directions produce hyper forward and side flexion, and hyperextension of the head, all which causes damage to the cervical spine.

#### *Hyperflexion Injuries (Head-on or Side Impact)*

Accidents involving a head-on or side impact results in hyperflexion of the head and cervical spine in the direction from which the force was received. All structures in the cervical spine can be injured, including intervertebral discs, ligaments, tendons, muscles, and vertebrae. Cervical disc prolapse can result as can vertebral fractures.

#### *Hyperextension Injuries (Rear-end)*

Hyperextension of the head and cervical spine is limited by the apophyseal or facet joints. These joints can be damaged resulting in significant pain and trauma to the cervical spine.

#### *Slip and Fall Injuries*

Slip and fall injuries can also results in hyperflexion of the head and cervical spine, especially if the individual's shoulder first impacts the ground. This put a high torque load on the neck which can result in significant damage to the cervical spine, including a broken neck.

## Assessment of Cervical Spine

### Inspection

The general impression of the patient's condition is derived during the initial intake as described in Chapter 4. Once it is determined that the cervical spine is the most likely source of the presenting symptoms special care is taken to observe finer details concerning posture and other behaviors that may confirm these suspicions. Torticollis may manifest by holding the head laterally flexed away from the affected side. Cervical nerve root pressure may be associated with the patient holding a hand under the elbow or arm of the affected side in an effort to relieve tension, or holding the head or neck to gain temporary relief of pain.

The upper, middle and lower portions of the cervical spine are somewhat unique and symptoms arising from these areas manifest in slightly different patterns basically associated with spinal nerve distribution. Problems associated with the upper division cervical segments (O/C1, C1/C2 and C2/C3) may manifest symptoms in any area of the cranium, the upper and middle cervical regions, the face, the temporomandibular joint, the anterior and lateral aspects of the neck, the sternoclavicular region and the suprascapular area. Pathology associated with the middle division segments (C3/C4 and C4/C5) may produce signs in the lower cervical regions, the supra and medial scapular areas, the shoulder, and the lateral aspect of the arm. Problems in the lower segments (C5/C6, C6/C7 and C7/T1) can produce symptoms in the lower cervical region, the supra and medial scapular areas, and any aspect of the upper limb, with the possible exception of the axilla.

## Active Movements (Range of Motion)

Before active movement assessment is performed it is essential to consider the presence of certain findings which would indicate possible caution. These include subjective findings of osteoporosis, vertebral artery symptoms, acute nerve root symptoms, bilateral limb symptoms (upper or lower), rheumatoid arthritis, and constant pain of unvarying intensity, and current use of anticoagulant medication.

In the case of upper and lower limbs, the good side is tested first to obtain a normal value to compare with the affected side. This same concept is also applied to the cervical spine, however, many of the muscles from each side insert in close proximity and therefore it is difficult to accurately assess the good side without influence from the affected side. The patient first performs active flexion, extension, lateral flexion, rotation, protraction and retraction in the <u>seated</u> position.

During these movements the examiner is noting possible limitations along with signs of pain, spasms, or stiffness. In addition, the examiner may help guide the movements to assure correct completion and also may isolate the thorax to prevent participation of the upper body in the movements. The examiner may also apply overpressure at the end of movement range to either start confirming the irritability level of the problems or to obtain a better estimate of the movement restrictions or production of symptoms. Range of motion data are recorded along with subjective symptoms noted during movement. Flexion, extension, and side flexion can be measured with a goniometer or by using inclinometers. Head rotation in the <u>seated</u> position is measured by goniometry or using a tape measure.

### *Neck Flexion*

Forward bending or flexion of the neck can be achieved to a maximum of 80° to 90°, especially when the chin is tucked in and touches the chest. Normal active range is considered from 45° to 50°. A two finger width space between the chin and chest at full forward neck flexion is considered normal. Some studies indicate a range in active neck flexion of 39° to 64° with the lower values associated with older individuals.

### *Neck Extension*

Backward bending or extension of the head is usually limited to 70° and normal range is considered 45° to 60°. There is no anatomical block to prevent movement from going beyond this position with exception of eventual bony contacts between the spinous processes and compression of the apophyseal joints. It is for these reasons that significant problems occur due to hyperextension injuries (whiplash or cervical strain). Normally, the plane of the nose and forehead is almost horizontal when the head is extended to the full position. The atlas tilts upward when the head is held if flexion resulting in posterior compression between the atlas and the occiput.

### *Lateral Flexion*

Lateral or side flexion ranges from 20° to 45° to the right and to the left. The greatest amount of side flexion is contributed between the occiput and C1 and between C1 and C2. While moving the head in side flexion the examiner needs to make certain that the patient does not move their shoulder up to meet the ear.

### *Head Rotation*

Normal head rotation is 60° to 80° in both right and left directions from the seated position. The chin does not quite reach the plane of the shoulders.

## Active Movement with Overpressure

The purpose of examining active movement as noted above is to start confirming or altering the impression of the problem's irritability and to establish a general view concerning the patterns of motion restriction or production of symptoms. Passive testing, such as discussed under accessory movements or even active tests with overpressure are conducted to attempt to better understand the nature of the presenting symptoms. Overpressure to active movements is applied at the end of the painless range of motion and is applied as controlled small amplitude oscillatory movements at the limit of range to determine end feel.

### *Cervical Rotation*

Active rotation is requested of all patients, but some conditions should only proceed to the onset of pain while others may continue to the physiological limit of motion. This latter group is patients with non-irritable cervical disorders whose rotation is mostly limited by stiffness as opposed to pain. Patient is seated while the examiner standing to side, places their hands of each side of the head applying overpressure at the temporal regions. If the patient has reached their limit of active rotation, the examiner may apply pressure to the temporal region while the elbow of the other arm is applied to the back and scapular region of the patient to passively move the head further into rotation.

### *Cervical Flexion*

At the limit of cervical flexion, overpressure may be applied to determine the end feel and pain response at the limit of physiological movement. Only the active cervical flexion is performed in patients with predominantly irritable or painful conditions. For others, passive overpressure in flexion is applied to determine the quality of end feel and pain symptoms. Standing at the seated patient's side, with one hand over the upper thoracic area to monitor that trunk movement does not occur, the examiner places the other hand on the crown of the head with the forearm aligned with the median of the sagittal plane. If the patient is able to flex the head to the limit of range the examiner then applies overpressure to determine the quality of end feel and pain symptoms.

### *Head Protraction*

Active head protraction with overpressure is used help differentiate between lower and upper cervical involvement by comparison with cervical flexion, extension and head retraction. While standing besides the seated patient, the examiner places one hand on crown of patient's head while other hand is held below the patient's chin. Both forearms are aligned in the median of the sagittal plane. The patient then shifts their head forward, keeping their face aligned vertically. Overpressure may be applied to further flex the lower division of the cervical spine while extending the upper segments.

## Passive Movements

Passive movement of cervical spine involves tissue stretch at the limit of movement in:

- Flexion
- Extension
- Right and left side flexion
- Right and left rotation

Passive movements are conducted in the situation where the patient does not have full ROM, or the end feel has not been assessed by applying overpressure at the end of active movements. Passive movements are conducted with the patient lying in the supine position.

Passive ROM values are greater in this position since residual contraction of neck muscle is not required to support the head against gravitational forces. This is why passive movements with overpressure are conducted in the supine position because overpressure at the end of active movements under full gravity does not provide an accurate impression of the true end feel.

## Resisted Isometric Movements

Muscle strength resistive tests to help differentiate between contractile and non-contractile lesions may have limited value for the cervical spine region. This occurs due to the fact that cervical muscles, which resist a given movement, are not confined to one aspect of neck motion. Thus, a particular muscle may be involved in resisting a number of movements. It therefore becomes difficult to isolate the exact source of the patient's symptoms. The other problem associated with resistive tests of the cervical spine occurs because any contractions of the neck muscles tend to produce compressive effects on the mobile segments they span. Contraction of some muscles may reproduce symptoms that are the result of compression of an intervertebral disc or facet joint. Consequently, muscular contractions which cause vertebral compression, tilt or shift or causes either increased or decreased deformation of pain-sensitive joints can mimic contractile lesions by producing or relieving symptoms. For these reasons, certain functional tests can be used in place of resisted strength testing (See Table 7.3).

### *Isometric Movements*

Isometric movements can be tested in the seated position as was done in the active movements of the cervical spine. A resistive force is applied to oppose head movement in the direction of flexion, extension, lateral flexion, and rotation.

➔ With regard to the resistive force, the examiner tells the patient, "Don't let me move you" to avoid the patient trying to move the examiner's hand by applying a greater counteracting force. This allows the examiner to control the applied force to ensure isometric movement with minimum amount of unnecessary movement.

#### Flexion

Flexion of the head is resisted by the examiner's hand on the patient's forehead while the other hand is placed between the scapulas to stabilize the thorax.

#### Extension

Extension of the head is resisted by the examiner's hand placed on the back of the head while the other hand is placed on the upper chest to stabilize the thorax.

#### Lateral Flexion

Lateral flexion of the head is resisted by the examiner's hand placed on the side of the head while the other hand is placed on the opposite shoulder. Test is repeated to test side flexion in the other direction.

#### Rotation

Head rotation is resisted by the examiner's hands placed on each side of the head. Patient resists movement in both direction of rotation.

### *Resisted Strength Tests*

Useful information on the resistive strength of the cervical muscle can still be gathered to assess possible contractile related symptoms. These tests are limited to flexion and extension of the neck and examine the muscles in a general sense.

➔ In some types of neck problems, such as vertebral artery syndrome, these tests are contraindicated.

#### Anterior Neck Flexors

Resisted movement of the neck into flexion involves the anterior neck flexor muscles including the longus capitis, longus colli, rectus capitis anterior, sternocleidomastoid and scalenus anterior muscles. Muscles which work as accessory to these include the scalenus posterior, scalenus medius, suprahyoids, infrahyoids and the rectus capitis lateralis muscles.

Patient is in the supine position with the elbows flexed and arms over the head resting on the examination table. Strong anterior abdominal muscles help stabilize the thorax; otherwise the examiners must perform this function by exerting hand pressure force on the patient's chest during resisted movement.

With the chin depressed, the patient flexes the neck through partial (grade 2) or full range (grade 3) of flexion. With the head partly flexed, resisted isometric force is applied to the forehead while the patient attempts to maintain position.

#### Anterior-Lateral Neck Flexor (Sternocleidomastoid)

By rotating the head either to the right or left, the sternocleidomastoid muscle can be tested when the neck is flexed. The patient laterally flexes the neck on the test side while rotating the head to the opposite side. The sternocleidomastoid muscle can be palpated during flexion on the test side after which an isometric resistive force can be applied by pressure on the forehead of the test side. Both sides are tested.

### Neck Extensors

The neck extensors, including the splenius capitis, splenius cervicis, longissimus capitis, spinalis cervicis, spinalis capitis, semispinalis cervicis, semispinalis capitis, rectus capitis posterior (major and minor), and obliquus capitis (inferior and superior), are tested as a group against gravity with the neck into rotation. The patient in prone position, with arms above the head and elbows flexed, extends and rotates the neck either to the right or left. Neck extensors on the side to which the head is rotated can be palpated paravertebrally as a group. For resistance testing, an isometric force is placed just proximal to the occiput on the rotated side of the head, to prevent extension and rotation. The examiner's other hand is placed on the upper back of the patient between the scapulae to stabilize the thorax.

## Functional Assessment

### *Functional Strength Tests*

As a result of possible complications of resistive strength test of the cervical muscles, some examiners apply repetitive or sustained and gentle functional tests to gather information on the condition of these muscles (See Table 6.3. These functional strength tests of the cervical spine can be graded as either normal/functional (N, 5), fair (F, 3), poor (T, 1) or non-functional (0).

### *Functional Activity Assessment*

Functional assessment can also be used to provide an overall assessment of the cervical spine function. These can be the indications for the longitudinal muscular distributions as previously discussed or it can also involve observation of normal activities including the following: swallowing; looking at the ceiling; looking down at belt buckle or shoes; checking the shoulder; retracting chin; or protruding the chin.

Table 7.3. Functional strength testing of cervical spine muscles

| Position | Action | Functional | Fair | Poor | Non-functional |
|---|---|---|---|---|---|
| Supine | Neck Flexion[1] | 6-8 Repetitions | 3-5 Repetitions | 1-2 Repetitions | 0 Repetitions |
| Prone | Neck Extension | Hold 20-25 sec. | Hold 10-19 sec. | Hold 1-9 sec. | Hold 0 sec. |
| Side | Side Lifting[2] | Hold 20-25 sec. | Hold 10-19 sec. | Hold 1-9 sec. | Hold 0 sec. |
| Supine | Rotated Flexion[3] | Hold 20-25 sec. | Hold 10-19 sec. | Hold 1-9 sec. | Hold 0 sec. |

1. Head is lifted keeping chin tucked in. 2. Head is lifted in side bending, both sides are tested.
3. Head is lifted and rotated to one side; rotation to both sides is tested.

## Neurological Assessment

The critical nature of cervical spine pathology dictates that a thorough neurological examination be performed. This involves assessment of myotomes, key reflexes, dermatome sensibility, motoric status and coordination.

### *Myotomes*

Neurological assessment with respect to the myotomes covers the whole range of cervical nerves from C1 to C8 and also including T1. Nerve roots associated with the cervical spine are evaluated by conducting resisted isometric force tests on muscles of neck and upper extremities. These tests can immediately follow the review of the peripheral joints noted above. They are conducted with the patient in the seated position, with the examiner standing in front of the patient and the joint(s) usually in neutral position. The shoulder and upper extremity muscles of both sides of the body are evaluated simultaneously to note differences in the left and right myotomes. Care is taken not to apply force or pressure directly on the joints to prevent false indications. Muscle strengths are graded 0 - 5 (Table 4.3).

#### Neck flexion (C1, C2)

For this test, the patient's head should be slightly flexed while the examiner applies pressure to the forehead while stabilizing the trunk with the other hand placed between the scapulae.

#### Neck Side Flexion (C3)

Neck side flexion is tested for both right and left movement. The examiner applies force with one hand placed above the patient's ear while stabilizing the trunk by applying pressure on the opposite shoulder.

#### Shoulder Elevation (C4)

With elbows partly flexed the patient raises the shoulder to about one half of full elevation. The examiner applies a downward pressure on both shoulders while the patient attempts to maintain position.

#### Shoulder Abduction (C5)

Patient abducts shoulders to about 70 to 80° while elbows are 90° flexed with forearms in neutral or pronated position. Examiner applies force on the humerus of each arm while the patient attempts to maintain position.

#### Elbow flexion (C6)

With the patient's elbows flexed 90° and forearms in neutral position, the examiner applies an isometric downward force on the forearms while the patient maintains arm position.

#### Wrist Extension (C6)

With the patient's elbows flexed 90° and forearms pronated, the examiner applies a downward force to the hands while patient resists extension of the wrist.

#### Elbow Extension (C7)

With the patient's elbows flexed 90° and forearms in neutral position, the examiner applies an isometric upward force on the forearms while the patient maintains arm position.

#### Wrist flexion (C7)

With the patient's elbows flexed 90° and forearms pronated, the examiner applies an upward force to the hands while patient resists flexion of the wrist.

#### Ulnar Deviation (C8)

With the patient's elbows flexed 90° and forearms pronated, the examiner applies a lateral force (radially deviated) to the hands while patient maintains hand position.

#### Thumb Extension (C8)

With the patient's elbows flexed 90° and forearms in neutral position with the thumb partly extended, an isometric downward force (into flexion) is applied by the examiner's thumb while stabilizing the patient's hand with the examiner's fingers.

#### Finger Abduction/ Hand Intrinsics (T1)

Intrinsic muscles of the hand can be tested by having the patient hold a piece of paper between the fingers while the examiner pulls the paper away or the patient may squeeze the examiner's fingers. Finger abduction can also be tested by having the patient slightly abduct the fingers while the elbows are flexed 90° and forearms pronated, and the examiner applies isometric force (into adduction) while patient maintains finger position.

### Key Reflexes

Key reflexes for the upper extremities are evaluated to provide additional information concerning C5 to C8 root levels. The jaw reflex test provides information on cranial nerve V. Key reflexes of upper extremity muscles supplied by lower cervical root nerves are checked for both sides to note possible differences. The biceps, brachioradialis and triceps reflexes are tested. In situations of possible upper motor neuron involvement, plantar reflexes may be tested as well. Reflexes are graded 0 - 4 as noted in Table 4.4.

#### Biceps (C5 - C6)

The biceps reflex is tested by placing the examiner's thumb over the patient's biceps tendon and then tapping the thumb.

#### Brachioradialis (C5 - C6)

The brachioradialis reflex is tested by tapping directly on the patient's brachioradialis tendon.

#### Triceps (C7 - C8)

The triceps reflex is tested by tapping directly on the patient's triceps tendon.

#### Jaw Jerk (CN V)

(See previous Chapter 6 on temporomandibular joint)

### *Sensibility Tests*

Sensory disturbances to light touch or pin prick are noted in relationship to cervical nerve root dermatome distributions.

### *Motoric Evaluation*

The condition and status of the muscles are noted and the location of either spastic, flaccid, rigid or clonic conditions are noted as well spasms or fasciculations. The Babinski response can be evaluated in cases where a central lesion is suspected. Wasting of muscle tissue is also noted and the girth of the affected muscle is measured and recorded to be compared to the unaffected side.

### *Coordination*

Simple index finger to nose coordination as well as reciprocal supination/pronation can be noted for degree of completing the tasks.

## Accessory Movements

Passive movements can include accessory movement, which for the cervical spine involves applying pressure over the spinous processes and the articular pillar of the cervical spine. Some passive movements are used to check the "passive range" of movement by feeling the movement between adjacent structures, spinous processes and articular pillars. One example of passive range testing is provided below in the test to check the rotation of the occiput and C1. Some of the accessory movement testing is general in nature and can be considered passive physiological testing. Specific testing of cervical spine accessory movement is performed to improve manual contact with bony prominences and may involve displacing overlying soft tissue. These tests are directed to discover if movement of specific segment levels reproduces the patient's main complaint or symptom and whether certain spinal segments are restricted in normal accessory movement.

### *General Joint Play Tests*

Many of the joint play movements performed on the cervical spine involve entire cervical spine and are not directed to any specific joint. These involve glides of the head in various directions, including traction.

#### Side Glide

With the patient lying supine and head extended over the end of table, the examiner supports patient's head and moves it from side to side. The head is maintained in normal longitudinal position and is moved in the same plane (frontal plane) as the shoulders. This movement can be compared with overall cervical side flexion. Side glide places the upper and lower cervical divisions in side flexion to opposite sides with the middle division serving as transitional zone. Pain responses reproduced in side glide can be compared with overall side flexion to help differentiate between upper and lower cervical disorders.

#### Anterior and Posterior Glide

With the patient lying supine and head extended over end of table, the examiner supports the patient's head with one hand around the occiput and the other around the chin, without choking the patient, and moves the head anteriorly and posteriorly. The head is maintained in normal longitudinal position and is moved in the sagittal plane without allowing the head to either flex or extend.

### Traction Glide

With the patient lying supine and head extended over end of table, the examiner supports the patient's head with one hand under the neck and occiput and the other around the chin, while applying a longitudinal pulling force in the vertical axis. This traction is applied in a straight longitudinal direction with the major pull being exerted on the occiput. This technique is useful evaluating symptoms affecting the distal regions of the upper extremities.

## *Specific Joint Play Tests*

Specific accessory movement tests can be used to gather information on the mobility of specific joints in the cervical. These consist of rotation test for motion between the occiput and C1. The remaining tests involve application of pressure to the vertebrae and the articular pillar. For these latter three tests the patient is prone with their head at the edge of the table, with forehead resting in the palms of their hands, without a pillow under the chest.

### Rotation of Occiput on C1

With the patient lying supine and head extended over the table the examiner supports the patient's head with a hand under the occiput and the other holding the forehead. The tip of the thumb of the hand supporting the occiput lies between the transverse process of C1 and the adjacent mastoid process. Transverse process of C1 is located anterior and inferior to the mastoid process. When the patient's head is rotated fully to the right, the tip of the examiners left thumb is positioned between the left transverse process of C1 and the left mastoid process. The patient's head is then rotated back and forth through 20° of the inner third range. As the maximum rotation is approached the transverse process is felt to draw nearer to the mastoid. Spacing between the transverse process and mastoid increases as motion of the head approaches the midline.

### Central Posterior-Anterior Pressure

This is often the first accessory movement of the cervical spine to be examined and can be used as a pain-relieving treatment when performed at grade I or II (Table 3.1) with the cervical spine in neutral or pain-relieving position. Examiner stands at the patient's head, leaning slightly forward with shoulders over the cervical spine, with thumbs placed tip to tip over the spinous processes of interest. The pads of the thumb make contact with the spinous processes while the fingers are directed toward the floor, making comfortable contact with the sides of the patient's neck. Small amplitude oscillations produced by movement of the hands is applied which is gradually increased in depth while assessing the pain, stiffness and spasm responses. The force applied to the vertebrae is imparted by the action of the arms and trunk and not by the thumbs.

### Posterior-Anterior Pressure to Articular Pillar

This accessory movement involves posterior-anterior oscillations applied to the articular pillar usually for unilateral symptoms in the neck, or conditions which cause unequal limitations between right and left sides in rotation or side flexion. The Examiner stands at the patient's head, leaning slightly forward with shoulders over the cervical spine, with thumbs placed tip to tip to one side of the spinous processes over a facet region of the articular pillar of interest. The pads of the thumb make contact with the articular pillar on the side of interest while the fingers are directed toward the floor, making comfortable contact with the sides of the patient's neck. Small amplitude oscillations produced by movement of the hands is applied in the anterior direction, which is gradually increased in depth while assessing the pain, stiffness and spasm responses. The force applied to the articular pillar is imparted by the action of the arms and trunk and not by the thumbs.

#### Transverse Pressures

The Examiner stands to the side of the patient's head with thumbs placed tip to tip along the side of the spinous processes of the cervical and thoracic spine. The pads of the thumb (tip to tip) makes contact with the spinous process on the side of interest while the fingers rest on the patient's neck and upper back on the opposite side. Small amplitude transverse springy oscillations are applied to the side of the spinous processes while assessing quality of movement. The amplitude of movement can be gradually increased in depth while assessing the pain, stiffness and spasm responses. The transverse force applied to the spinous processes is imparted by the action of the arms and trunk and not by the thumbs.

## Palpation of Cervical Spine

### *Posterior Aspect*

- Occipital protuberance
- Spinous processes and facet joints
- Mastoid process

### *Lateral Aspect*

- Transverse processes
- Lymph nodes
- Carotid arteries
- Mandible, parotid glands, TMJ

### *Anterior Aspect*

- Hyoid bone, thyroid cartilage, and first cricoid ring
- Paranasal sinuses
- Upper three ribs
- Supraclavicular fossa

## Diagnostic Imaging

Diagnostic imaging is considered when deemed necessary to complement or expand on the information derived from the clinical examination. Do to the nature and structure of the cervical spine, and its role in supporting the head, it is susceptible to common degenerative changes, anatomical variations, and congenital problems. These conditions may or may not contribute to the patient's complaint.

### Plain Film Radiography

Plain film x-rays considered for the cervical spine include an anteroposterior, open mouth (odontoid), and oblique view. Other views are considered to address specific pathologies.

**Anteroposterior view.** This orientation is used to examine the shape of the vertebrae, the disc space, presence of lateral wedging or osteophytes, or cervical rib. Frontal alignment of cervical spine is also evaluated.

**Open mouth or odontoid view.** This is an anteroposterior view through the mouth observe the odontoid process of C2 in relation to C1.

**Lateral view.** This view provides significant information about the cervical spine including: variations in curvature; subluxations, kinking, displacements, or forward shifting (C1 on C2) of vertebrae; horizontal displacement; abnormal shape of the vertebrae; disc space; and lipping at vertebral edge or osteophytes.

**Oblique view.** This orientation provides a view of the intervertebral neural foramen and the posterior elements of the cervical spine. Practitioner should note the presence of: facet joint overriding; and lipping or osteophytes.

### Magnetic Resonance Imaging (MRI)

MRI used to differentiate between various soft tissues and bone, including differentiating between the disc annulus fibrosus and nucleus pulposus. May also reveal: disc lesions and protrusions; visualization of spinal cord, nerve roots, thecal sac, bone, and bone marrow. MRI angiography is useful in determining the condition of the vertebral artery.

### Computed Tomography

Computed tomography (CT) helps delineate bone and soft tissue anatomy of the cervical spine in cross section, including axial views, and show disc prolapse. CT scans can also reveal: true size and extent of osteophytes; bone fragments in spinal canal after a fracture; and bony defects in vertebral bodies and neural arches.

## Management of Cervical Spine Disorders

Findings derived from the preceding process are considered in a logical process to differentiate the presenting symptoms. From this, the most likely cause of the problem is determined from which a treatment a management plan is devised. A logical approach to treatment planning is based on the practical application of muscular distribution theory in the selection of critical nodes to be used. Also, assessment and use of sensitive locations, application physical modalities, and application of mobilization techniques are considered. Needling therapy is then based on application local and adjacent nodes associated with the affected region as well as use of both distal and proximal nodes related to specific muscular distributions.

Typical treatment modalities include needling therapy, electroneedling (EN), mobilization, and manipulation. Other modes of care are employed as needed and can include cupping, moxibustion (in cold disorders), heat application, manual pressure, tuina, and massage, articulation of joints, plasters and liniments. Traction and stretching techniques may be appropriate as well. In situations of muscle weakness as result of cervical spine pathology, a remedial exercise program may be indicated.

## Cervical Spine Mobilization

Physical techniques are typically used in treatment of pain and musculoskeletal disorders, including the application of ischemic pressure technique on sensitive locations. In some situations, needling is applied prior to physical manipulations, but caution must be exercised. Hence, physical manipulations are usually not applied after electroneedling since this technique can produce profound analgesia.

A wide range of mobilization procedures can be applied, each to address specific problem areas or manifestation of specific clinical signs. These can be applied to affect either the upper or lower portion of the cervical spine and can involve movement in different directions. The techniques listed below provide one set of possible approaches to address the most common problems encountered in the cervical spine.

### *Mobilization - Upper Cervical Spine*

The following three mobilization techniques for the upper cervical spine are used to address unilateral cervical pain or pain in the head arising from pathology at C1- C2.

#### Longitudinal Movement

This procedure is basically the same as "traction glide" except an oscillatory motion is induced by gentle longitudinal pulling to elongate the intervertebral joints and then releasing the force and repeating the process. The procedure is concentrated on the upper cervical region. Care is exercised not to relieve irritable nerve root type symptoms completely so as not to induce patient apprehension when the procedure is completed and some of the symptoms return.

#### Posterior-Anterior Central Vertebral Pressure

This procedure is basically the same as "central posterior-anterior" pressures. The only difference is that oscillations of applying therapeutic force are deeper than that which used to evaluate accessory movement. The other difference is this technique is concentrated on the upper cervical spine.

#### Posterior-Anterior Unilateral Vertebral Pressure

This procedure is basically the same as "posterior-anterior pressure to articular pillar." The main difference involves the amplitude of the oscillatory pressures, which in the case of mobilization, is deeper and stronger. This procedure is concentrated on the upper cervical spine.

### *Mobilization - Lower Cervical Spine*

Mobilization techniques applied to the lower cervical spine include problems from C2 - C7 and can also be considered applicable for the cervical spine in general.

#### Longitudinal Movement

This technique is basically identical to the procedure of the same name applied to the upper cervical spine. The only difference in this case it is applied to concentrate on the lower cervical spine region. This is often the first maneuver to consider and is used to treat most cervical pain problems and also torticollis. Use of this technique gains the confidence of the patient and also serves as a prognostic indicator if the patient improves.

#### Posterior-Anterior Central Vertebral Pressure

Same as the same mentioned procedure noted above for the upper cervical spine. This is used in situations of pain distributed down the midline or unilaterally down the cervical spine. It is also applied for severe muscle spasms and cervical spondylosis.

#### Posterior-Anterior Unilateral Vertebral Pressure

This is basically the same as the procedure noted above for the upper cervical spine. It is applied for unilateral neck pain and cervical spondylosis.

#### Lateral Flexion

Used for unilateral pain in the neck, head, scapula or arm, and also used in case of painfully restricted cervical rotation.

#### Transverse Vertebral Pressure

This technique is applied for cervical spondylosis and in situations of cervical pain, especially if it is well localized or unilateral.

#### Rotation

This valuable technique is the first to be applied for unilateral neck pain.

#### Anterior-Posterior Unilateral Vertebral Pressure

This technique is used when pain is felt in the anterior or lateral aspect of the neck which is reproduced by posterior-anterior pressure.

### *Cervical Traction*

Manual traction can be used to address lesions affecting the upper and lower cervical spine. Traction in flexion is useful to treat conditions of arm pain where there is restriction of lateral flexion and rotation of the neck toward the painful side. Intermittent variable traction can be used for cervical spondylosis. The rate of improvement in signs and symptoms may be slower with device aided traction than is experienced with mobilization techniques. Manual traction techniques are very similar to longitudinal movement as described above. The difference being that longitudinal movement is applied in the form of gentle oscillations while traction is applied as a steady force.

Sometimes traction can immediately relieve symptoms characteristic of acute nerve root disorder, such as pain, numbness, tingling running down the upper arm, and deep seated pain in the neck or shoulder. These symptoms can return after release of traction forces. Therefore, the practitioner is careful to only apply manual traction to the point that symptoms decrease but not necessarily disappear. This is necessary so not to cause the patient distress when the symptoms return to full amplitude when the longitudinal force is released. Relief of symptoms by manual traction would indicate that this technique should be considered as a treatment choice, perhaps along with other manipulations.

#### Manual Traction - Neutral Position

Manual traction in position of neutral rotation is used both as an examination and treatment approach, especially where upper limb distal symptoms predominate. This technique is basically the same as "traction glide" or "longitudinal movement" previously mentioned.

**Manual Traction - Rotation**

This procedure is the same as manual traction noted above, except the head is rotated to the position of least pain before the traction is applied.

## Needling Therapy for Cervical Spine Disorders

Problems related to the cervical spine frequently manifest in the posterior or lateral aspect of the neck with possible radiation patterns to the upper extremities and sometimes the lower extremities. Often the situation involves both the posterior and lateral aspect of the neck. Use of needling to treat problems of the neck involves the muscles, joints, ligaments and bones of the cervical spine as viewed in terms of the posterior and lateral aspects of the neck (See Tables 7.4 and 7.5).

### *Posterior Aspect of Neck*

Pain resulting from problems affecting the posterior aspect of the neck can also radiate down into the upper back, the scapular and shoulder regions, as well as over the head to cause headache. Local and adjacent neurovascular nodes are selected based on known good nodes that influence the local affected area. Selected proximal and distal nodes are associated with the three (PLF, PMF, PLH) muscular distributions, which are usually the source of the pathology (See Table 7.4). The PLH distribution (levator scapula muscle) is frequently involved in both the posterior and lateral aspect of neck related problems. Additional nodes may be selected as well, depending on either the specific nature of the problem or the unique musculoskeletal dysfunction and pain radiation patterns. Indications for related muscular distributions include:

Posterior lateral foot (PLF) distribution:

- Inability to bend the head forward.
- Inability to turn neck left or right.
- Abnormal curvature in the nape of the neck.
- Muscular spasms in the nape of the neck.

Posterior medial foot (PMF) distribution:

- Inability to bend the head backwards.

Table 7.4. Regional selection of nodes for treatment of pain and musculoskeletal dysfunction of the posterior aspect of the head and neck.

| Head and Neck Regions | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Posterior Aspect | Fengchi (LF 20)<br>Jianjing (LF 21)<br>Jianzhongshu (PLH 15) | PLF | Tianzhu (PLF 10)<br>Dazhu (PLF 11) | Feiyang (PLF 58)/<br>Kunlun (PLF 60) |
| | | PMF | Tianzhu (PLF 10)<br>Dazhu (PLF 11) | Zhubin (PMF 9)/<br>Taixi (PMF 3) |
| | | PLH | Tianzhu (PLF 10)<br>Dazhu (PLF 11) | Houxi (PLH 3) |

**Candidate EN application for:** posterior aspect of the head and neck
Frequency: 2 Hz; Mode: continuous; Duration: 20 - 30 minutes (consider bilateral treatment); Candidate Nodes:

- Tianzhu (PLF 10) + lead, to Dazhu (PLF 11) – lead, if problem manifest posterior neck muscles
- Fengchi (LF 20) + lead, to Jianzhongshu (PLH 15) – lead, if problem manifests in the trapezius or levator scapula muscles

### *Lateral Aspect of Neck*

Problems related to the lateral aspect of the cervical spine frequently manifest with possible radiation patterns to the upper extremities and sometimes the lower extremities. Radiation patterns can also distribute to the shoulders, jaw, teeth, anterior neck and the forehead. Local and adjacent nodes are selected based on known good nodes that influence the local affected area. Selected proximal and distal nodes are associated with the four (LF, ALH, LH, PLH) specific muscular distributions related to the lateral aspect of the neck. These structures are typically the source of the noted pathology (See Table 7.5). Additional nodes may be selected as well, depending on either the specific nature of the problem or the unique musculoskeletal dysfunction and pain radiation patterns. Possible indications and related muscular distribution include:

Lateral foot (LF) distribution:

- Pain and spasms in the muscles and tendons in anterior lateral aspect of the neck.

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps along lateral aspect of neck.
- Inability to turn the neck left or right to look either direction.

Lateral hand (LH) distribution:

- Acute cramps and spasms along lateral aspect of neck.

Lateral posterior hand (LPH) distribution:

- Spasms in the neck muscles which can result in fistula of these muscles.
- Swelling in the neck.

Table 7.5. Regional selection of nodes for treatment of pain and musculoskeletal dysfunction of the lateral aspect of the head and neck.

| Head and Neck Region | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Lateral Aspect | Fengchi (LF 20)<br>Tianyou (LH 16)<br>Tianchuang (PLH 16)<br>Jianjing (LF 21) | LF | Fengchi (LF 20) | Zulingqi (LF 41)/ Diwuhui (LF 42) |
| | | APH | Dazhu (PLF 11) Feishu (PLF 13) | Hegu (LI 4) |
| | | LH | Fengchi (LF 20) | Zhongzhu (LH 3) |
| | | PLH | Jianzhongshu (PLH 15) | Houxi (PLH 3) |

**Candidate EN application for:** lateral aspect of the head and neck
Frequency: 2 Hz ; Mode: continuous; Duration: 20-30 minutes (consider bilateral treatment); Candidate Nodes:

- Fengchi (LF 20) + lead, to Jianjing (LF 21) – lead, if problem manifest in posterior neck muscles
- Fengchi (LF 20) + lead, to Jianzhongshu (PLH 15) – lead, if problem manifests in the trapezius or levator scapula muscles

## Remedial Exercises for Head and Neck

Exercises of the head and neck include flexion, lateral flexion, extension, and rotation of the neck to strengthen the prime movers and assistant muscles (See Table 7.2). In some types of neck problems, such as vertebral artery syndrome, some of these exercises may be contraindicated. In addition, in cases of traumatic neck injuries involving significant movement of the head, the patient may be susceptible to benign paroxysmal positional vertigo (BPPV). In this situation the neck exercises need to be performed in the seated or standing position so as to not to provoke a BPPV episode.

### *Anterior Neck Flexors*

Exercise of the neck in flexion involves the anterior neck flexor muscles including the longus capitis, longus colli, rectus capitis anterior, sternocleidomastoid and scalenus anterior mm. Muscles exercised as assistant to these include the scalenus posterior, scalenus medius, suprahyoids, infrahyoids and the rectus capitis lateralis mm.

Subject is in the supine position with elbows flexed and arms over the head resting on the floor. With chin depressed, the subject flexes the neck through full range of flexion and holds the position for 2 - 3 seconds and then slowly lowers head to start point. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets as conditions improve. As strength permits, shoulder and neck muscles can be contracted to provide antagonistic internal dynamic resistance (IDR) (See Chapter 5) to head flexion. Initial use of IDR for head flexion and other movements may require supervised practice to assure that patient is able to effectively provide adequate internal resistive force for any given exercise.

### *Anterior-Lateral Neck Flexor (Sternocleidomastoid)*

The sternocleidomastoid muscle is exercised by forward flexing the neck with the head rotated to the opposite side of the problem side. The exercise is first conducted on the unaffected side with the head rotated to the affected side. While supine with the elbows flexed and arms over the head resting on the floor, the subject forward flexes the neck through full range of flexion with the head rotated to the contralateral side and holds the end-position for 2 - 3 seconds and then slowly lowers head to start point. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets as conditions improve. Repeat other side. As strength permits, shoulder and neck muscles can be contracted to provide antagonistic IDR to anterior-lateral neck flexion.

### Lateral Flexion

Prime movers: scalenus anterior, medius and posterior, sternocleidomastoid, splenius capitis and cervicis, semispinalis capitis and semispinalis cervicis.

Subject is side lying with head on a pillow or on the floor. Head is slowly lifted off the floor and laterally flexed to the full range possible. The end-position is held for 2 - 3 seconds and the head slowly lowered to start point. This exercise is repeated up to 8 repetitions and eventually performed for 5 sets as conditions improve. As strength permits, shoulder and neck muscles can be contracted to provide antagonistic IDR to head side flexion.

### Neck Extensors

Exercising the neck extensors, includes the splenius capitis, splenius cervicis, longissimus capitis, spinalis cervicis, spinalis capitis, semispinalis cervicis, semispinalis capitis, rectus capitis posterior (major and minor), and obliquus capitis (inferior and superior), muscles moved as a group with the neck into rotation. Neck extension is performed with the head laterally rotated to one side to isolate extensor muscles on each side of the neck. Neck problems often manifest one side.

With the subject in prone position, and arms above the head and elbows flexed, the laterally rotated head is slowly lifted off the floor to extend to the full range possible. The end-position is held for 2 - 3 seconds and the head slowly lowered to start point. Care is taken to avoid moving the thoracic spine or shoulders during head extension. This exercise is repeated up to 8 repetitions and eventually performed for 5 sets as conditions improve. As strength permits, shoulder and neck muscles can be contracted to provide antagonistic IDR to head extension. Repeat other side.

### Neck Rotation

The function of neck rotation is unique in that muscles on both sides of the neck have prime and assistant roles in moving the neck in the one direction. Those on the same side include the splenius capitis and cervicis, and the erector spinae of the neck as prime movers with the suboccipital group as assistants. At the same time, muscles on the opposite side of the neck have prime mover role in simultaneously rotating the neck in conjunction with the preceding muscles include the sternocleidomastoid, semispinalis cervicis, cervical rotatores, and cervical multifidi, with the upper fibers of the trapezius as assistant mover.

Subject is seated and gravitational forces are cancelled so externally directed resistance (EDR) (See Chapter 5) needs to be employed to challenge muscles providing neck rotation. Patient needs to be instructed in how to apply EDR for any particular exercise. The same caution also applies to the use of IDR to efficiently provide significant internal resistive force to neck rotation.

While seated and facing forward, the subject places one palm on the lateral aspect of their forehead to provide EDR to resist head rotation as the head is moved to the same side. Basically the force provided by the muscles to rotate the head is only resisted by hand on the forehead to the level that the head is allowed to rotate when applying EDR. If head rotation is fully resisted, then this is applying an isometric force. Initially, it is desirable to move the head with the external force.

The head is rotated to one side using EDR with the palm on the side of the forehead from the neutral position to full rotation to one side and back to start point. The EDR is applied in both directions. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets as conditions improve. Rotation exercises first performed on the good side and then on the affected side.

# 8.

## Scapula

The scapula (omo or shoulder blade) in humans is a large but thin flat bone that is basically triangular in shape and placed on a posterolateral aspect of the thoracic cage. The scapula forms the posterior part of the shoulder girdle. Its main main purpose is to provide the articualation surface of the glenoid fossa for the humerus and is the origin site for several muscles that move the humerus. The scapula is held in its position by the clavicle which articulates with the sternum and scapular acromium. There is a large spine on the posterior upper aspect of the scapula that is easily noted externally and by palpation.

Borders of the scapula are identified as the superior angle at the top, the medial border close to the spine, the inferior angle at the lower aspect of the scapula, and the lateral border. There are three main fossa that provide origins for key muscles that move the humerus including the infraspinatus located on the posterior aspect below the scapular spine, the supraspinatus on the upper aspect of the scapula above the spine, and the subscapular fossa on the front of the scapula for the subscapularis muscle (See Figure 8.1). Other muscles that have their origins on the scapula include the (See Table 9.3):

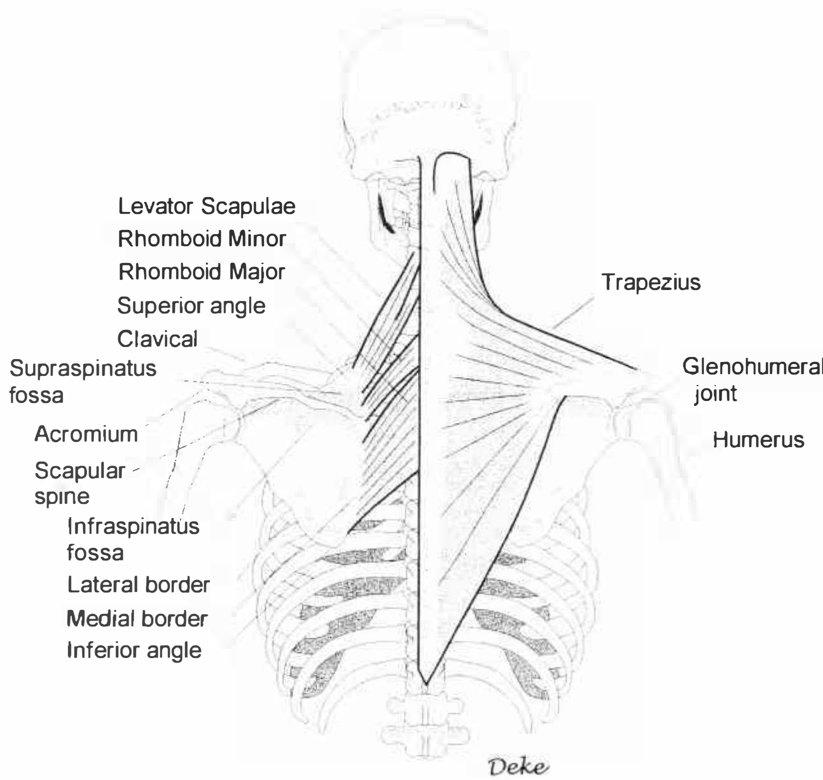


Figure 8.1. Posterior muscles moving scapula

(Serratus anterior, first serratus anterior, pectoralis minor, and subclavius not shown)

- Coracobrachialis on the coracoid process
- Biceps brachii (short head) on the coracoid process
- Biceps brachii (long head) on the supra-glenoid tubercle
- Triceps brachii (long head) on the infra-glenoid tubercle

- Deltoid on the spine of scapula
- Teres major and minor on the lateral border
- Latissimus Dorsi (a few fibers) on the inferior angle
- Omohyoid on the superior border

The several muscles that function to move the scapula (along with the shoulder) necessarily have their insertion sites on the scapula itself. Scapular movements are in elevation, depression, protraction, retraction, lateral rotation, medial rotation, upward rotation, downward rotation, anterior tipping, and posterior tipping (See Table 8.2). Two fundamental joint are involved in moving the scapula with articulation between the scapula, clavicle and sternum to form the acromioclavicular and sternoclavicular joints. These joints are held together by ligaments which normally restrict movement of the scapula (See Tables 8.1a and 8.1b). The scapula also provides the glenoid fossa for the articualation surface of the humerus to form the important glenohumeral joint for movement of the humerus (See Chapter 9).

## Scapulothoracic Joint

The clavicle is anchored to the manubrium of the sternum to support and hold the acromion of the scapula out from the rib cage to allow free movement of the arm. The main body of the scapula is held in place on the upper posterior thorax by virtue of musculotendinous structures and this is often referred to as the scapulothoracic joint. This allows the scapula to be moved upward (elevation), downward (depression), outward from the vertebral column (abduction) and inwardly toward the vertebral column (adduction), as well as being rotated either medially or laterally. Two specific joints of the scapula include the acromioclavicular and sternoclavicular joints.

### *Acromioclavicular Joint*

The acromioclavicular (AC) joint is the junction between the acromion and the clavicle and provides the ability to raise the arm above the head. This is gliding synovial joint and functions as a pivot point; acting like a strut to provide a greater degree of arm rotation. The acromioclavicular joint is stabilized by following ligaments:

- Superior acromioclavicular ligament: consists of a quadrilateral band, covering the superior part of the articulation, and extending between the upper part of the lateral end of the clavicle and the adjoining part of the upper surface of the acromion.
- Inferior acromioclavicular ligament: is somewhat thinner than the superior portion; it covers the under part of the articulation, and is attached to the adjoining surfaces of the both bones.
- Coracoacromial ligament: consists of a strong triangular band extending between the coracoid process and the acromion attached to the top of the acromion just in front of the articular surface for the clavicle; and by its broad base covering the whole length of the lateral border of the coracoid process.
- Coracoclavicular ligament: connects the clavicle with the coracoid process of the scapula providing an efficient means of retaining the clavicle in contact with the acromion and consists of two fasciculi called the:

- Trapezoid ligament, and
- Conoid ligament

### *Sternoclavicular Joint*

The sternoclavicular (SC) joint is the junction between the clavicle and sternal manubrium to provide a fixed reference on the thorax. It permits rotary movement of the clavicle as well as elevating the arm in abduction above 110 degrees. There several essential ligaments involved along with an articular disc, including the:

- Anterior sternoclavicular ligament: is a broad band of fibers covering the anterior surface of the articulation and attached to the upper and front part of the sternal end of the clavicle. This ligament is covered by the sternal portion of the sternocleidomastoid and the integument.
- Posterior sternoclavicular ligament: is a band of fibers, covering the posterior surface of the sternoclavicular joint and attached to the upper and back part of the sternal end of the clavicle. It passes obliquely downward and medially, and fixed below to the back of the upper part of the sternal manubrium.
- Interclavicular ligament: is a flattened band which passes in a curved direction from the upper part of the sternal end of one clavicle to that of the other, and is also attached to the upper margin of the sternum.
- Costoclavicular ligament: is short, flat, strong, and rhomboid in form attached below to the upper and medial part of the cartilage of the first rib, it ascends obliquely backward and laterally, and is fixed above to the costal tuberosity on the under surface of the clavicle.

### Neurology

Muscles moving the scapula are supplied by nerves that originate from spinal nerves C2 - T1 and the Accessory Nerve XI, C2 - 4 (See Table 8.2) as follow:

- Spinal accessory nerve: trapezius, upper, middle, and lower fibers
- Dorsal scapular and 3$^{rd}$ and 4$^{th}$ cervical nerves: levator scapulae
- Dorsal scapular nerve: rhomboid minor, rhomboid major
- Long thoracic nerve: serratus anterior
- Anterior thoracic nerve: pectoralis minor
- Nerve to Subclavius: subclavius
- Thoracodorsal nerve: Latissimus dorsi

## Scapular Physiology

The main function of the shoulder girdle is to hold the arm out from the body, by means of the scapula and clavicle to allow full movement of the arm, hand and fingers. The scapula must be elevated and rotated to accommodate either full flexion or abduction of the arm, in order to maintain proper function of the glenohumeral joint. The planes and axes of articulation of the scapular joints, normal limiting factors to movement, normal end feels and active range of motion for shoulder girdle movements involving elevation by either full flexion or full abduction of the arm, are noted in Table 8.1a and 8.1b.

Table 8.1a. Joint structures involved in movement of the scapula.

| | Elevation | Depression | Abduction | Adduction |
|---|---|---|---|---|
| Articulation | Scapulothoracic, Acromioclavicular, Sternoclavicular | Scapulothoracic, Acromioclavicular, Sternoclavicular | Scapulothoracic, Acromioclavicular, Sternoclavicular | Scapulothoracic, Acromioclavicular, Sternoclavicular |
| Plane | Frontal | Frontal | Horizontal | Horizontal |
| Axis | Sagittal | Sagittal | Vertical | Vertical |
| Normal limiting factors | Tension in costoclavicular ligament, inferior stemoclavicular joint capsule, lower fibers of trapezius, pectoralis minor, and subclavius | Tension in interclavicular ligament, sternoclavicular ligament, articular disk, upper fibers of trapezius and levator scapulae; bony contact between the clavicle and the superior aspect of the first rib | Tension in trapezoid ligament, anterior sternoclavicular ligament, posterior lamina of the costoclavicular ligament, trapezius, and rhomboids | Tension in the conoid ligament, anterior lamina of the costoclavicular ligament, pectoralis minor, and serratus anterior |
| Normal end feel | Firm | Firm/ hard | Firm | Firm |
| Normal active range of motion | 10 - 12 cm (total range for elevation-depression) | 10 - 12 cm (total range for elevation-depression) | 15 cm (total range for abduction-adduction) | 15 cm (total range for abduction-adduction) |

Table 8.1b. Joint structures involved in movement of the scapula.

| | Medial (Downward) Rotation | Lateral (Upward) Rotation |
|---|---|---|
| Articulation | Scapulothoracic, Acromioclavicular, Sternoclavicular | Scapulothoracic, Acromioclavicular, Sternoclavicular |
| Plane | Frontal | Frontal |
| Axis | Sagittal | Sagittal |
| Normal limiting factors | Tension in the conoid ligament and serratus anterior | Tension in trapezoid ligament, anterior sternoclavicular ligament, the rhomboids and the levator scapulae |
| Normal end feel | Firm | Firm/ hard |
| Normal active range of motion | 60° displacement of inferior angle is 10 - 12 cm (total range for medial-lateral rotation) | 60° displacement of inferior angle is 10 - 12 cm (total range for medial-lateral rotation) |

## Muscles Moving the Shoulder Girdle

Only a small area of the head of the humerus makes contact with the glenoid fossa of the scapula. Consequently, when the arm is raised in flexion or abduction beyond a certain limit, the shoulder must also rise and laterally rotate the scapula to maintain contact between the glenoid fossa and the head of the humerus. Of the many muscles involved in the complex movement of the shoulder girdle, the interplay between the trapezius (PLF), rhomboids (ALH) and levator scapulae (PLH) muscles have strong influence on problems affecting the shoulders. The muscles moving the scapula along with their functions, nerve root innervation and muscular distribution assignments are noted in Table 8.2. The lower (sternal) part of the pectoralis major muscle (PMH) also functions as a prime depressor and accessory/assistant medial (downward) rotator of the scapula although it inserts on the humerus.

Table 8.2. Function, nerve root, and muscle distribution (MD) of prime mover (PM) and accessory/ assistant mover (AM) muscles articulating the scapula and shoulder girdle

| Muscle | MD | Nerve Root | Elevation | Depress. | Medial[1] Rotation | Lateral[2] Rotation | Abduc.[3] | Adduc.[4] |
|---|---|---|---|---|---|---|---|---|
| Trapezius upper fibers | PLF | XI; C2 - 4 | PM | | | | | |
| Trapezius middle fibers | PLF | XI; C2 - 4 | PM | | | PM | | PM |
| Trapezius lower fibers | PLF | XI; C2 - 4 | | PM | | | | |
| Levator scapulae | PLH | C3 - 5 | PM | | PM | | | |
| Rhomboid minor | ALH | C4, 5 | PM | | PM | | | |
| Rhomboid major | ALH | C4, 5 | PM | | PM | | | |
| Pectoralis minor | AMH | C7, 8, T1 | | AM | PM | | | |
| Subclavius | LF | C5, 6 | | AM | AM | | | |
| First serratus anterior | LF | C5, 6 | AM | | | | AM | |
| Serratus anterior, upper | MH | C5, 6, 7 | | | | | PM | |
| Serratus anterior, lower | MH | C5, 6, 7, 8 | | AM | | PM | PM | |
| Latissimus dorsi | PLF | C6, 7, 8 | | PM | AM | | | |

1. Downward rotation; 2. Upward rotation; 3. Protraction; 4. Retraction

# Disorders of Affecting Scapula

## Problems of Muscles Moving the Scapula

There is a dynamic interplay between muscles that articulate the shoulder girdle, especially between the trapezius and the rhomboids. Inability to raise the shoulders, for example can be the result of problems in the trapezius, however, contraction or spasm of the rhomboids can prevent the scapula from rotating and hence causes inability to raise the shoulders as well. Therefore this particular problem can involve both the posterior lateral foot (PLF) and posterior lateral hand (PLH) muscle distribution groups. Specific disorders associated with the longitudinal muscle distributions related to the shoulder girdle include:

Posterior lateral foot (PLF) distribution:

- Inability to raise the shoulders due to pain in the trapezius and neck.

Posterior lateral hand (PLH) distribution:

- Pain wrapping around the scapula and leading up to the neck.

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps from region of the rhomboids traveling up along the neck.
- Inability to raise the shoulders due to pain in the region of the rhomboids.

Anterior medial hand (AMH) distribution:

- Spasms in the sides of the upper ribs associated with the pectoralis minor muscle.

Medial hand (MH) distribution:

- Acute cramps and spasms along the serratus anterior muscles.

Lateral foot (LF) distribution:

- Pain and spasms along top of shoulder.

## Pathology of the Shoulder Girdle

Injuries of shoulder affecting the scapula are common in athletics, bicycle incidents, automobile accidents, and simple slip and fall accidents where the shoulder impacts the ground or floor. Ligaments of the acromioclavicular (AC) and sternoclavicular (SC) joints can be ruptured and joints can also be separated or dislocated. The joints are also affected by arthritis. Ends of the clavicle can also be fractured requiring medical assistance. Separated shoulders often occur in people who participate in sports such as football, soccer, horseback riding, hockey, biking, rowing, rugby, snowboarding, and wrestling. Joint separation are classified into 6 types, with 1 through 3 increasing in severity, and 4 through 6 being the most severe.

### *AC Joint Sprains and Separations*

Separation of the AC joint usually results from a fall or blunt force injury to the corner of the shoulder. Referring to the AC joint as "separated" is understood to mean that the ligaments are torn and the clavicle no longer lines up with the acromion. The injury occurs at a point between the clavicle and acromion and felt as a prominence on the top outside edge of the shoulder. This type of injury is common in sports such as hockey, football, lacrosse, rugby, horseback riding, hockey, biking, and rowing. It also can occur as the result of any fall or blow to the shoulder. The injury causes pain and difficulty moving the arm, and depending upon severity may produce a bump or "step-off" which is seen to increase by a downward pull on the arm, or when holding a weight by the side. Examination may reveal signs of tenderness and swelling at the end of the clavicle with potential instability at this site. This indicates that scapula may display excessive motion in relation to the distal end of the clavicle. X-rays may used in the evaluation to exclude a fracture of the scapula and grade the severity of the injury, especially if a weight is placed in the hand and an X-ray is taken for comparison to the uninjured side.

#### Type I

A Type I AC separation involves trauma to the ligaments that form the AC joint without no severe tearing or fracture. This would also be referred to as a First degree (1°) ligament sprain where only a few ligament fibers are torn (See Chapter 3). This results in pain without any evidence of an AC joint separation.

#### Type II

A Type II AC separation involves a Second degree (2°) sprain or partial tear of the coracoclavicular ligaments along with a complete tearing or Third degree (3°) sprain of the acromioclavicular ligament. When these injuries occur, the lateral clavicle becomes a little more prominent appearing as causing a noticeable bump on the shoulder. Severe pain and loss of movement are common.

**Type III**

In a Type III AC separation both acromioclavicular and coracoclavicular ligaments are torn typical of a Third degree (3°) ligament causing a complete separation of the clavicle along with a significant permanent bump formed by the lateral end of the clavicle.

**Type IV**

This is a type III injury with avulsion of the coracoclavicular ligament from the clavicle, with the distal clavicle displaced posteriorly into or through the trapezius. This is a serious injury and generally known to require surgery.

**Type V**

This is type III but with exaggeration of the vertical displacement of the clavicle from the scapula, and generally requiring surgery.

**Type VI**

This is type III with inferior dislocation of the lateral end of the clavicle below the coracoid. It is extremely rare and generally the result of motor vehicle collisions. This problem also requires surgery.

***AC Intraarticular Meniscus Injury***

The AC joint contains 2 types of fibro cartilaginous discs which vary considerably in size and shape. They are classed as either complete or partial (meniscoid). This intraarticular meniscus undergoes rapid degeneration with time until it is basically no longer functional beyond the age of fifty.

***AC Arthritis***

Arthritis of the AC joints is a wear and tear condition affecting the cartilage needed to allow the bones to move smoothly with each other. It is characterized by pain and swelling, especially aggravated by activity. Eventually, the joint can continue to wear down causing the joint get larger and with the development of spurs. Arthritis of the AC joint can be aggravated by certain motions of the arm, such as reaching across the body toward the other arm. Weight lifters are susceptible to AC joint wear and tear especially with the bench press and to a lesser extent military press. Arthritis at the AC joint in weight lifters is also referred to as "osteolysis" (an active resorption or dissolution of bone).

***Sternoclavicular Joint***

The SC joint is one of the least commonly dislocated joints in the body. Motor vehicle accidents cause nearly half of all SC dislocations. Sports injuries cause about 20 percent and the remaining due to falls and other types of accidents. Indirect force by something hitting the shoulder very hard causes most injuries to the SC joint. This causes the shoulder to be pushed in and rolled either forward or backward, affecting the SC joint. When the SC joint is dislocated by pushing the clavicle forward to be in front of the sternum, is called an anterior dislocation. Dislocating in the opposite direction is less common because the ligaments on the back side of the joint are so strong. This is called a posterior dislocation.

### SC Joint Dislocations

Dislocation of the SC joint causes severe pain that is aggravated by any movements of the arm. The medial end of the clavicle juts out near the sternum in anterior dislocation. This causes a hard bump in the middle of the chest while in posterior dislocation a bump is usually not obvious. Severe pain and tenderness are present over the SC joint in an anterior dislocation. Any movement of the shoulder causes increased pain. Pain is also increased when the patient is supine, and the individual usually prefers a sitting position, supporting the arm on the injured side.

Posterior dislocation of the SC joint is caused by both direct and indirect trauma resulting in the backward displacement of the clavicle medial. Posterior dislocations are extremely hazardous to the mediastinal structures, causing pressure against the trachea and heart and its great vessels. This is very serious and can cause difficulty breathing, shortness of breath, or a feeling of choking. Some patients have trouble swallowing or have a tight feeling in their throats. This situation requires immediate medical help to get the SC joint back into position.

### Sprains

Sometimes excessive force may only sprain the SC joint. Mild sprains cause pain, but the joint is still stable. However, the joint becomes unstable in moderate sprains.

### Ligament Injury

In rare cases, patients have a stable joint but a painful clicking, grating, or popping feeling. This indicates an injury to the intra-articular disc ligament. This type of injury causes pain and problems moving the SC joint.

### Arthritis

Injury to the SC joint can result in the development of osteoarthritis which eventually causes pain and stiffness.

## Examination of the Scapula

The shoulder is inspected with respect to clavicle, sternum, and acromion for possible dislocation, separation, or obvious signs of arthritis affecting the acromioclavicular (AC) and sternoclavicular (SC) joints. A preliminary functional assessment can be performed by having the patient to elevate, depress, protract, or retract the scapula. Patient is asked to report any clicking or grinding sounds from the AC or SC joints. If possible, the patient is asked to elevate the arm in abduction above 110 degrees to check for scapular rotation.

### Active Movements of Scapula

Active and passive movement of the scapula is usually evaluated on the basis of visual observations because of the nature of the scapulothoracic structures that are sometimes considered as a joint. The range of motion (ROM) is estimated as either "full" or "restricted" although some objective measurements can be obtained. Measurements of individual scapular movements are usually relative over a given range between the limits of opposing motions, such as between the limits of elevation and depression, abduction and adduction, and medial rotation and lateral rotation (see Table 8.1a and b). Active movements of the scapula are observed with the patient seated, initially in a relaxed anatomical position.

### *Elevation*

The normal active range of motion (ROM) between elevation and depression of the scapula is 10 - 12 cm. In active elevation of the scapula the patient moves the shoulders up toward the ears in a cranial direction.

### *Depression*

The normal active range of motion (ROM) between elevation and depression of the scapula is 10 - 12 cm. In active depression of the scapula the patient moves the shoulders downward toward the waist in a caudal direction.

### *Abduction*

The normal active range of motion (ROM) between abduction and adduction of the scapula is approximately 15 cm. From the start position, the patient flexes the arms to 90° and scapular abduction is observed as the patient reaches forward. The vertebral border of the scapula moves away from the vertebral column.

### *Adduction*

The normal active range of motion (ROM) between abduction and adduction of the scapula is approximately 15 cm. In active adduction the patient moves the scapulae horizontally toward the vertebral column.

### *Medial Rotation*

The normal active range of motion (ROM) between medial and lateral rotation of the scapula is approximately 60° or 10 - 12 cm displacement of the inferior angle of the scapula. In active medial rotation of the scapula the patient adducts and extends the arm as if to place the dorsum of the hand on the small of the back. The inferior angle of the scapula moves in a medial direction during this movement.

### *Lateral Rotation*

The normal active range of motion (ROM) between medial and lateral rotation of the scapula is approximately 60° or 10 - 12 cm displacement of the inferior angle of the scapula. In active lateral rotation of the scapula, the patient elevates the arm either in flexion or abduction. The inferior angle of the scapula moves in a lateral direction away from the vertebral column.

## Passive Movements of Scapula

Passive movements of the scapula are employed to further evaluate presenting symptoms and to assess end play characteristics at least for scapular elevation, depression, abduction and adduction. In these four passive tests the patient is lying on the side with the test side up and with the head relaxed and supported on pillows.

### *Elevation*

The normal end feel at the limit of scapula elevation is firm. This is assessed with examiner's right or left hand cupping the inferior angle of the scapula and elevating the scapula by pressure applied in the cephalad direction. The examiner's other hand assists in controlling the direction of movement.

***Depression***

Normal end feel at the limit of scapula depression is firm/hard. In passive depression of the scapula the examiner's right or left hand is placed on top of the shoulder and depresses the scapula. The examiner's other hand cups the inferior angle of the scapula to assist in controlling the direction of movement.

***Abduction***

Normal end feel at the limit of scapula abduction is firm. In passive abduction of the scapula, the examiner grasps the vertebral border and inferior angle of the scapula and abducts scapula by pulling laterally upward. The examiner's other hand is placed on top of the shoulder to assist in scapular abduction.

***Adduction***

Normal end feel at the limit of scapula adduction is firm. In passive adduction of the scapula, the examiner grasps the vertebral border and inferior angle of the scapula and adducts scapula by pushing medial toward the vertebral column. The examiner's other hand is placed on top of the shoulder to assist in scapular adduction.

## Resisted Movements of the Scapula

Isometric muscle strength testing of the scapula is conducted for scapular elevation, depression, adduction, abduction and rotation. These movements are necessary in order to evaluate the principal muscles that move the scapula. Against-gravity isometric tests and gravity-eliminated tests are considered for each movement to measure the full range of strength for all the muscles involved. Resisted movements against-gravity are used for measuring muscle strength grades from 3+ to 5, while unresisted movement just against the force of gravity result in grades from 2+ to 3 (see Table 4.3). The unresisted against-gravity tests are conducted first through the full range of motion (ROM) as an initial screening. Successful completion of this test then directs the examiner to perform against-gravity isometric tests to evaluate muscle strengths in the range of 3+ to 5, and the gravity-eliminated test is not required to be conducted.

Failure of the against-gravity screening test then indicates that examiner go directly to performance of gravity-eliminated tests. Gravity-eliminated tests are necessary to evaluate muscle strength grades from 0 to 2.

- ➔ With regard to the resistive force, the examiner tells the patient, "Don't let me move you" to avoid the patient trying to move the examiner's hand by applying a greater counteracting force. This allows the examiner to control the applied force to ensure isometric movement with minimum amount of unnecessary movement.

***Trapezius Muscle Screening Test***

A convenient screening test can be performed before a detailed assessment is performed on scapular elevation. This involves simultaneous contraction of the upper, middle, and lower fibers of the trapezius muscles on both sides. The patient stands with hands raised above their head with the back facing the examiner. The hands are held together with palms facing forward and one palm placed on the back of the other. The patient maintains their standing position while the examiner pushes on both elbows. Contraction, or lack thereof, can be observed for upper, middle, and lower fibers of the trapezius muscles.

### *Scapular Elevation*

Elevation of the scapula is accomplished by the upper fibers of the trapezius (PLF) and the levator scapulae (PLH) muscles pulling up on the scapula. The rhomboid major and minor muscles (ALH) are accessory muscles to scapular elevation.

#### Against-Gravity: Upper Fibers of Trapezius and Levator Scapulae

Elevation of the scapula is tested with the patient seated, the shoulder abducted slightly, and the elbow flexed 90°. The patient elevates the shoulder to bring the acromion closer to the ear while the examiner palpates the upper fibers of the trapezius about midway between the inion and the acromion process. The levator scapula lies deeper a may not be palpable. This test can be conducted unilaterally by elevating only one shoulder while the examiner stabilizes the origins of the muscles in question by placing one hand on the lateral aspect of the head. When successfully completed, resisted strength grades are then determined.

➔ During the unilateral shoulder elevation screening test the patient may attempt to substitute lowering the ear to the shoulder and contralateral trunk side flexion.

Isometric strength tests are performed starting with the shoulder partially elevated with resistance applied over the top of the shoulder downward in the direction of scapular depression. If tested unilaterally, the examiner stabilizes the head by placing one hand on the lateral side of the head while resisting elevation by pressure applied over the shoulder with the other hand.

#### Gravity-Eliminated: Upper Fibers of Trapezius and Levator Scapulae

This test is conducted with the patient lying prone, with arms at the side and the shoulder in neutral position and the head stabilized on the examination table. The examiner supports the weight of the upper extremity on the tested side to reduce friction between the shoulder and the table. The patient then elevates the scapula through the full range of motion while the examiner palpates the upper fibers of the trapezius.

➔ During the unilateral scapular elevation the patient may attempt to substitute contralateral trunk side flexion.

### *Depression and Adduction of Scapula*

The lower fibers of the trapezius (PLF) have a principal role in depressing and adducting the scapula and the middle fibers of the trapezius work as an accessory muscle to this movement.

#### Against-Gravity: Lower Fibers of Trapezius

This initial screening test is conducted with the patient lying prone, with head rotated to the opposite side, and the shoulder abducted to about 130° with forearm in neutral position. The patient then raises the test arm to produce depression and adduction in the scapula while the examiner palpates the lower fibers of the trapezius medial to the inferior angle of the scapula along a line between the spinous process of T12 and the root of the scapular spine. When this screening test is successfully completed, resisted strength grades are then determined.

➔ Patient may attempt to substitute contraction of the middle fibers of the trapezius and trunk extension.

If the patient is unable to abduct the arm into the screening test position or the posterior shoulder joint muscles are weak, the arm can be placed at the side or allowed to hang down over the edge of the table. With a hand placed on the scapula the examiner moves it into depression and adduction and the patient then attempts to hold the scapula in this position.

For the resisted isometric strength test, the patient lies prone in the screening test position noted above with the shoulder abducted to about 130° and forearm in neutral position. Resistive force is applied over the scapula in the direction of scapular elevation and abduction to fully resist movement when the patient raises the arm. In all tests where the examiner stabilizes the scapula care is taken not to actual move the scapula. An alternate to this test involves applying resistive force against the patient's forearm in a downward direction. Use of the arm as a resistive lever assumes that the posterior shoulder joint muscles (deltoids) are strong.

**Gravity Eliminated: Lower Fibers of Trapezius**

Gravity-eliminated testing of scapular depression and adduction is conducted with the patient lying prone with arms relaxed at the sides. The examiner supports the upper extremity to react out the force of gravity and to reduce friction between the patient's shoulder and the examination table. The patient then depresses and adducts the scapula through full range of motion.

➔ Patient may attempt to substitute contraction of the middle fibers of the trapezius and ipsilateral trunk side flexion.

***Scapular Adduction***

Scapular adduction is primarily accomplished by the middle fibers of the trapezius (PLF), with accessory participation of the trapezius upper and lower fibers.

**Against Gravity: Middle Fibers of Trapezius**

The initial screening test is conducted with the patient prone, shoulder flexed to 90° and in neutral rotation, with the arm hanging vertically over the examination table. The patient then adducts the scapula toward the midline of the back while the examiner palpates the middle fibers of the trapezius between the medial (vertebral) border of the scapula and the vertebrae, above the spine of the scapula. When this screening test is successfully completed, resisted strength grades are then determined.

➔ During scapular adduction the patient may attempt to substitute contraction of the rhomboid major and minor muscles, and ipsilateral trunk rotation.

The isometric test is performed with the patient in the same position noted above for the screening test. The examiner applies the resistive force in the direction of scapular abduction by placing the hand flat on the scapula to resist the patient's attempt to move the scapula into adduction. For good results, care should be exercised to prevent any resistance forces being applied over the humerus.

### Gravity Eliminated: Middle Fibers of Trapezius

The gravity-eliminated scapular adduction test is performed with the patient seated with the shoulder flexed 90°, with slight horizontal abduction and internal rotation. Examiner supports the patient's upper limb and the patient is advised to avoid trunk rotation while adducting the scapula through full range of motion. The examiner palpates the middle fibers of the trapezius.

➔ During scapular adduction the patient may attempt to substitute shoulder horizontal abduction, and ipsilateral trunk rotation.

## *Medial Rotation and Adduction of Scapula*

The rhomboid major (ALH) m. is mainly responsible for medial rotation of the scapula which also involves some movement in adduction as well. The rhomboid minor (ALH) m. also participates in this movement. Accessory muscle participation includes the middle fibers of the trapezius.

### Against Gravity: Rhomboid Major and Minor

The initial screening test is performed with the patient prone with the shoulders relaxed and the arm lying at the side with the palmar surface of the hand facing upward. The arm is moved to where the dorsum of the hand on the tested side is placed over the buttock of the non-test side. The patient then raises the arm up away from the back maintaining the position over the buttocks, while the examiner palpates the rhomboids along an oblique line between the vertebral border of the scapula and C7 to T5. The rhomboid major can further be palpated medial to the vertebral border of the scapula near the inferior angle, lateral to the lower fibers of the trapezius. When this screening test is successfully completed, resisted strength grades are then determined for the rhomboids.

➔ During scapular medial rotation and adduction the patient may attempt to substitute tipping the scapula forward by contraction of the pectoralis minor.

Isometric resistance is applied over the scapula in the direction of scapular abduction and lateral rotation, with care not be apply pressure over the humerus. The patient lifts the arm on the test side as noted above to medially rotate the scapula which is fully resisted by the isometric force.

### Gravity Eliminated: Rhomboid Major and Minor

Medial rotation and adduction in the gravity-eliminated case is performed with the patient seated with relaxed shoulders and the dorsum of the hand positioned over the buttocks of the non-test side. The patient is advised to avoid ipsilateral trunk rotation and/or forward flexion of the trunk. The scapula is rotated and adducted when the patient moves the test hand away from the back, while maintaining the same position over the buttock of the non-test side.

➔ During scapular medial rotation and adduction the patient may attempt to substitute ipsilateral trunk rotation and/or forward flexion of the trunk, and tipping the scapula forward by contraction of the pectoralis minor.

## *Abduction and Lateral Rotation of Scapula*

Abduction of the scapula mainly involves the serratus anterior (MH) muscles, with lateral rotation involves the lower serratus anterior muscles. Muscles acting accessory to these movements include the upper fibers of the trapezius (lateral rotation) and the pectoralis minor (abduction).

**Against Gravity: Serratus Anterior**

The initial screening test is conducted with patient supine and the shoulder of the test side flexed to 90° with slight horizontal abduction, and elbow extended with forearm in neutral position. The patient then lifts the shoulder and arm straight up (shoulder protraction) by abducting the scapula, while the examiner palpates the serratus anterior muscles along the midaxillary line over the thorax. When this screening test is successfully completed, resisted strength grades are then determined for the serratus anterior mm.

Caution must be considered in the situation where the shoulder joint is unstable. The test position can still be configured but the examiner must fully support the upper extremity and resistive forces cannot be applied. In this instance it is only possible to assess a strength grade of 3.

➔ Patient may attempt to substitute contraction of the pectoralis major muscle to protract the shoulder.

Isometric strength testing of the serratus anterior muscles is conducted in the same test position noted above with the arm flexed to 90° with slight horizontal abduction, and elbow extended with forearm in neutral position, and with the scapula abducted about half way. The examiner grasps the upper arm proximal to the elbow to apply a downward force with one hand while steadying the arm with the other hand against the inner side of the patient's forearm. The examiner fully resists the patient's attempt to move the scapula into further abduction and lateral rotation.

**Gravity Eliminated: Serratus Anterior**

The gravity-eliminated test is conducted with the patient seated with the shoulder flexed to 90° with slight horizontal abduction, and the elbow extended. The examiner supports the weight of the upper extremity and the patient is instructed to avoid trunk rotation during scapular abduction. The patient then abducts the scapula (shoulder protraction) through the full range of motion while the examiner palpates the serratus anterior muscles.

➔ Patient may attempt to substitute contraction of the pectoralis major and minor, and contraction of the upper and lower fibers of the trapezius, and contralateral trunk rotation, in place of scapular abduction.

An alternate to this position can be utilized if the patient is unable to assume a seated position. The serratus anterior mm. can be tested in the against-gravity supine configuration where the examiner holds the arm into scapular abduction while the patient attempts to maintain this position. The examiner palpates the serratus anterior mm. to evaluate quality of the contractions.

**Serratus Anterior: Clinical Test**

A simple and effective clinical test can be quickly performed to observe weakness or strength in the serratus anterior muscles, although a specific grade cannot be assigned. While standing, the patient's hands, at shoulder level with the shoulders in slight horizontal abduction and elbows extended, are placed against a wall. Initially the patient leans into the wall while allowing the thorax to sag toward the wall resulting in adduction of the scapulae. The patient then pushes the thorax away from the wall causing abduction of the scapulae.

Weakness is demonstrated by "winging" of the scapula. Here the medial border and inferior angle become more prominent, with the scapula remaining in an adducted and medially rotated position.

## Accessory Movements

Two accessory or joint play movements can be applied to the acromioclavicular and sternoclavicular joints. Accessory joint movement graded 0 - 6 as noted in Table 4.5.

### *Acromioclavicular Joint*

Accessory movement of the acromioclavicular joint is determined by applying dorsal and ventral movement (glides) to the clavicle.

#### Dorsal Glide

Patient is seated with arm resting at side. While facing the patient from the side, the examiner places one hand on the scapular spine to fixate the acromion while the other hand moves the lateral end of the clavicle posteriorly. The examiner's forearms are held parallel to the direction of force and its resistance.

#### Ventral Glide

Patient is prone while the examiner is seated on the table facing patient's head. One hand of the examiner grasps the shoulder and fixates the scapula by pressure on the coracoid process while the thumb of the other hand is placed on the dorsal surface of the clavicle. Thumb pressure is applied to move the clavicle in the ventral direction (anteriorly).

### *Sternoclavicular Joint*

Accessory movement of the sternoclavicular joint is determined by applying craniodorsal and caudoventral movement (glides) to the clavicle.

#### Craniodorsal Glide

Patient is supine with arm resting on abdomen with trunk stabilized by pressure on table. While standing at patient's side, examiner places both thumbs on the medial inferior side of the clavicle being tested. Thumb pressure is applied to move the clavicle in the dorsal-cranial direction to accommodate the obliquity of the join axis. Adjust thumb pressure for comfort and avoid applying pressure to the supraclavicular nerve.

#### Caudoventral Glide

Patient is supine with arm resting on abdomen and trunk is stabilized by pressure on the table. While standing at patient's the examiner places fingers behind the medial clavicle, parallel to the clavicle. The clavicle is moved in the ventral-caudal direction to accommodate the obliquity of the joint by pulling forward and downward.

## Diagnostic Imaging

See Chapter 9, Shoulder

# Management of Scapular Problems

Scapular problems are addressed by mobilization of the shoulder girdle joints where is signs of hypomobility. Needling therapy is the primary treatment approach using local and adjacent, distal, and proximal nodes related to the muscular distributions. Electroneedling (EN) stimulation may be employed to enhance therapeutic effect of needling if manual needling doesn't achieve desired therapeutic results after several treatments. Exercise therapy may be appropriate if weakness is apparent in the trapezius muscles. Pressure techniques can be applied to address sensitive nodes, tight muscle bands, or muscle spasms.

## Scapular Mobilization

### *Sternoclavicular and Acromioclavicular Joints*

If accessory movement of the sternoclavicular or acromioclavicular joints has a grade of 0 - 2, small amplitude mobilization movements can be applied identical to the movements used to measure their accessory movements or joint play as previously described. Movement is made only to the amplitude that does not result in pain.

### *Scapulothoracic Joint*

Hypomobility problems of the scapula can be addressed with small amplitude motion of the scapulothoracic joint as described below. Caution is advised to not move the scapula into the region that causes pain.

#### Dorsal Tilt of Scapula

Patient is prone with arm resting at their side. Practitioner stands at side of patient and cups the scapula inferior angle with one hand while other hand grasps the shoulder. Opposite parallel and opposite forces are applied through the practitioner's forearms to lift the scapula away from the thorax. Patient must be completely relaxed to facilitate this mobilization effort.

#### Scapulothoracic Mobilization

With patient lying on their side facing the practitioner, the patient's arm is supported by the therapist's arm. Practitioner grasps the medial and lateral scapular borders in the web spaces of both hands and glides the scapula in various directions. This includes elevation, depression, abduction, adduction, and rotation. Procedure used to enhance relaxation and mobility of all shoulder girdle joints.

## Needling Therapy for Scapular Problems

Regional selection of nodes to treat pain and dysfunction that mainly manifests in the scapular region or involves impaired function in moving the shoulder girdle needs to consider nodes that have great influence on this region (see Table 8.3). As noted in treating problems of the cervical spine, a general group of local and adjacent nodes are selected for scapular problems regardless of the specific muscular distribution that is involved. However, proximal and distal nodes are selected based on the specific muscular distribution involved.

Table 8.3. Candidate regional, proximal and distal nodes for pain and disorders of the scapula.

| Pain or Disorder of the Scapula | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Jianzhen (PLH 9)<br>Naoshu (PLH 10) | ALH* | Dazhu (PLF 11)<br>Feishu (PLF 13) | Hegu (ALH 4) |
| | Tianzong (PLH 11) | LH | Fengchi (LF 20) | Zhongzhu (LH 3) |
| | Bingfeng (PLH 12)<br>Jianwaishu (PLH 14)<br>Gaohuangshu (PLF 43) | PLH | Tianzhu (PLF 10)<br>Jianzhongshu (PLH 15) | Houxi (PLH 3) |

* Can consider Huatuojiaji nodes at T1 and T3 level.

**Candidate EN application for:** scapular problems
Frequency/Mode/Duration: 2 Hz, continuous, 20-30 minutes

Anterior lateral hand (ALH) distribution

- Dazhu (PLF 11) + lead, to Naoshu (PLH 10) – lead
- Feishu (PLF 13) + lead, to Jianzhen (PLH 9) – lead

Lateral hand (LH) distribution

- Fengchi (LF 20) + lead, to Bingfeng (PLH 12) – lead

Posterior lateral hand (PLH)

- Jianzhongshu (PLH 15) + lead, to Tianzong (PLH 11) – lead

## Remedial Exercises for Muscles Moving Shoulder Girdle

Exercise of muscles moving the scapula and shoulder girdle are considered for scapular elevation, depression, adduction, abduction and rotation (See Table 8.2).

### *Scapular Elevation*

Exercise in scapular elevation involves the upper fibers of the trapezius and the levator scapulae mm. with the rhomboid major and minor mm. participating as assistant muscles. Exercise is conducted with the subject seated, shoulder abducted slightly, and the elbow flexed 90°. The shoulder is then slowly elevated to bring the acromion closer to the ear. The end-position is held for 2 - 3 seconds and the shoulder slowly lowered to start point. Exercise can be performed simultaneously on each side if strength is the same on each side. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets.

As strength permits, shoulder and back muscles should be contracted to provide internal dynamic resistance (IDR) to scapular elevation. As strength increases a light-weight dumbbell can be held with the arm extended straight down to increase exercise load and further the strengthening process.

### *Depression and Adduction of Scapula*

The lower fibers of the trapezius have a principal role in depressing and adducting the scapula and the middle fibers of the trapezius work as an assistant muscle to this movement. The subject is prone, with head rotated to the opposite side, and the shoulder abducted to about 130° with forearm in neutral position. The arm is then slowly raised to produce depression and adduction in the scapula. The end-position is held for 2 - 3 seconds and the arm slowly lowered to start point.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder and back muscles should be contracted to provide IDR antagonistic resistance to scapular depression and adduction. As strength increases a light-weight dumbbell can be held in the hand to increase exercise load and further the strengthening process.

### *Scapular Adduction*

Scapular adduction is primarily accomplished by the middle fibers of the trapezius, with assistant participation of the trapezius upper and lower fibers. The subject is prone, with arms to the side. The shoulder in then slowly lifted off the floor (shoulder retraction). The end-position is held for 2 - 3 seconds and the shoulder slowly lowered to the floor. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, chest and back muscles should be contracted to provide IDR antagonistic resistance to shoulder retraction.

As strength recovers, the arm can be extended from the side, abducted 90° with forearm in neutral position and palms on floor. The shoulder is slowly retracted and arm lifted off the floor. The end-position is held for 2 - 3 seconds and the shoulder and arm slowly lowered to the floor. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength increases light-weight dumbbell can be held in the hand to increase exercise load and further the strengthening process.

### *Medial Rotation and Adduction of Scapula*

The rhomboid major m. is mainly responsible for medial rotation of the scapula which also involves some movement in adduction as well. The rhomboid minor m. also participates in this movement. Assistant muscle participation includes the middle fibers of the trapezius. The subject is prone with the shoulders relaxed and one arm lying at the side while the other, with the palmar surface of the hand facing upward, and dorsum of the hand of the target side placed over the buttock of the non-exercise side. The arm is slowly raised away from the back maintaining the position over the buttocks. The end-position is held for 2 - 3 seconds and the hand slowly lowered to the buttock.

This exercise is repeated up to 8 repetitions and eventually performed for 5 sets. As strength permits, shoulder and back muscles should be contracted to provide IDR antagonistic resistance to the rhomboids. As strength increases light-weight dumbbell can be introduced to increase exercise load and further the strengthening process.

### *Abduction and Lateral Rotation of Scapula*

Abduction of the scapula mainly involves the serratus anterior muscles, with lateral rotation involving the lower serratus anterior muscles. Muscles acting assistant to these movements include the upper fibers of the trapezius (lateral rotation) and the pectoralis minor (abduction). The subject is supine and the shoulder of the exercise side flexed to 90° with slight horizontal abduction, and elbow extended with forearm in neutral position. The subject then slowly lifts the shoulder and arm straight up (shoulder protraction) by abducting the scapula. The end-position is held for 2 - 3 seconds and the shoulder slowly lowered to the floor.

This exercise is repeated up to 8 repetitions while keeping the arms held straight up, and eventually performed for 4 - 5 sets. As strength permits, shoulder and back muscles should be contracted to provide IDR antagonistic resistance to the serratus anterior muscles. As strength increases light-weight dumbbell is grasped in the hand to increase exercise load and further the strengthening process.

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# 9

# Shoulder

Three actual joints are involved in moving the shoulder by articulation between the humerus, scapula, clavicle and sternum to form the glenohumeral, acromioclavicular and sternoclavicular joints. The clavicle is anchored to the manubrium of the sternum to support and hold the acromion of the scapula out from the rib cage. The main body of the scapula is held in place on the upper posterior thorax by virtue of musculotendinous structures often referred to as the scapulothoracic joint (See Chapter 8). The scapula must be elevated and rotated to accommodate either full flexion or abduction of the arm, in order to maintain proper function of the glenohumeral joint. The planes and axes of articulation, normal limiting factors to these scapular movements, normal end feels and active range of motions are noted in Tables 8.1a and 8.1b.

## Glenohumeral Joint

The glenohumeral joint permits extension, flexion, rotation, abduction and abduction of the arm. The arm can be abducted and adducted in the frontal plane as well in the horizontal plane. When flexion exceeds 60° or abduction in the frontal plane exceeds 30° the scapulothoracic movement comes into play. The planes and axes of articulation, normal limiting factors to movement of the humerus, normal end feels and active range of motion for arm movements are noted in Table 9.1. Arm flexion and frontal plane abduction are noted in Table 9.2.

Table 9.1. Joint structures involved in movement of the glenohumeral joint.

| | Extension | Internal Rotation | External Rotation | Horizontal Abduction | Horizontal Adduction |
|---|---|---|---|---|---|
| Articulation | Glenohumeral | Glenohumeral | Glenohumeral | Glenohumeral | Glenohumeral |
| Plane | Sagittal | Horizontal | Horizontal | Horizontal | Horizontal |
| Axis | Frontal | Longitudinal | Longitudinal | Vertical | Vertical |
| Normal limiting factors | Tension in anterior band of coracohumeral ligament, anterior joint capsule, & pectoralis major clavicular fibers | Tension in posterior joint capsule, infraspinatus & teres minor | Tension in all bands of glenohumeral ligament, coracohumeral ligament, anterior joint capsule, subscapularis, pectoralis major, teres major and latissimus dorsi | Tension in anterior joint capsule, glenohumeral ligament, and pectoralis major | Tension in posterior joint capsule; Soft tissue apposition |
| Normal end feel | Firm | Firm | Firm | Firm | Firm/ soft |
| Normal active range of motion | 0 - 60° | 0 - 70° | 0 - 90° | 0 - 45° | 0 - 135° |

Table 9.2. Joint structures involved in elevation movement of the shoulder

| | Elevation Through Flexion | Elevation Through Abduction |
|---|---|---|
| Articulation | Glenohumeral, Scapulothoracic, Acromioclavicular, Sternoclavicular | Glenohumeral, Scapulothoracic, Acromioclavicular, Sternoclavicular |
| Plane | Sagittal | Frontal |
| Axis | Frontal | Sagittal |
| Normal limiting factors | Tension in posterior band of coracohumeral ligament, posterior joint capsule, shoulder extensors, and external rotators; scapular movement limited by tension in rhomboids, levator scapula, and trapezoid ligament | Tension in middle and inferior bands of glenohumeral ligament, inferior joint capsule, shoulder adductors; greater tuberosity of humerus contacting upper portion of glenoid and glenoid labrum or lateral surface of acromion; scapular movement limited by tension in rhomboids, levator scapula, and trapezoid ligament |
| Normal end feel | Firm | Firm/ hard |
| Normal active range of motion | 0 - 180°<br>0 - 60°, glenohumeral<br>60 - 180°, glenohumeral, scapular movement and trunk movement | 0 - 180°<br>0 - 30°, glenohumeral<br>30 - 180°, glenohumeral, scapular movement and trunk movement |
| Capsular Pattern | Glenohumeral: External rotation, abduction (only through 90-120° range), internal rotation<br>Sternoclavicular/Acromioclavicular: Pain at extreme range of motion | |

## Shoulder Physiology

Movement of the head of the humerus on the glenoid fossa does not represent a true ball and socket joint because this structure is held together by tendons and muscles involved in moving the humerus itself. The glenoid fossa of the scapula has a fibrocartilage labrum which increases the glenohumeral cavity by 50%. Articulation of the humerus is perhaps one of the more complex mechanical functions in the body. These unique features result in the shoulder being susceptible to many problem involving tendon lesions of muscles holding the glenohumeral joint together.

### Muscles Moving Upper Arm

Most of the muscles moving upper arm have insertions on the proximal end of the humerus bone with their origins on the scapula, clavicle, chest and back. Other major muscles include the long head of the biceps brachii (ALH) which originates at the supraglenoid tubercle and inserts on the radial tuberosity and forearm and the long head of the triceps (PLH) muscles that originate on the axillary border of the scapula and inserts on the olecranon of the ulna. The biceps brachii, short head (AMH) and the coracobrachialis (MH) muscles originate at the coracoid process of the scapula and respectively insert at the radial tuberosity and medial surface of the humerus. These muscles all function to extend, flex, abduct, adduct or rotate the humerus. Muscles moving the humerus along with their function, nerve root innervation and Chinese muscular distribution assignments are noted in Table 9.3. Many of these muscles work in conjunction with those that move the shoulder girdle (See Table 8.2).

Table 9.3. Function, nerve root, and muscle distribution (MD) assignment of primary mover (PM) and accessory/assistant mover (AM) muscles articulating the humerus

| Muscle | MD | Nerve Root | Ext. | Flex. | Abd. | Add. | Intr. Rot. | Extr. Rot. | Hor. Abd. | Hor. Add. |
|---|---|---|---|---|---|---|---|---|---|---|
| Supraspinatus | LH | C4, 5, 6 | | | PM | | | | | |
| Infraspinatus | PLH | C5, 6 | | | | | | PM | PM | |
| Teres minor | PLH | C5, 6 | | | | | | PM | PM | |
| Teres major | PLH | C5, 6, 7 | PM | | | PM | PM | | | |
| Anterior deltoid | AMH | C5, 6 | | PM | AM | | AM | | | PM |
| Middle deltoid | ALH | C5, 6 | | | PM | | | | PM | |
| Posterior deltoid | LH | C5, 6 | AM | | AM | | | AM | PM | |
| Subscapularis | ALH | C5, 6, 7 | | AM[1] | AM[1] | AM[2] | PM | | | AM[1] |
| Latissimus dorsi | PLF | C6, 7, 8 | PM | | | PM | AM | | AM | |
| Pectoralis major, upper | MH | C5, 6, 7 | | PM | AM[2] | | AM | | | PM |
| Pectoralis major, lower | PMH | C7, 8, T1 | | | | PM | | | | PM |
| Triceps, long head | PLH | C6, 7, 8, T1 | AM | | | AM | | | | |
| Biceps brachii. long head | ALH | C5, 6 | | AM | AM | | | | | |
| Biceps brachii short head | AMH | C5, 6 | | AM | | AM | AM | | | |
| Coracobrachialis | MH | C5, 6, 7 | | AM | | AM[2] | AM[2] | AM[3] | | PM |

1. Varies with joint position and activity of synergic muscles; 2. Only when arm is above the horizontal; 3. Only from a position of rotation to the neutral point

### Neurology

All muscles moving the humerus receives innervation from the brachial plexus except for the supraspinatus and infraspinatus which are supplied by nerve roots C4, 5, and 6 (See Table 9.3). Specific nerves supplying these specific muscles include:

- Suprascapular nerve: supraspinatus, infraspinatus
- Axillary (circumflex) nerve: teres minor, anterior deltoid, middle deltoid, posterior deltoid
- Subscapular nerve: teres major, subscapularis
- Thoracodorsal nerve: latissimus dorsi
- Lateral and medial pectoral nerves: pectoralis major upper and lower
- Radial nerve: triceps, long head
- Musculocutaneous nerve: biceps brachii (long head and short head), coracobrachialis

## Disorders Affecting Shoulder

Disorders affecting muscles moving the humerus result in dysfunction of the shoulder joint, inability to fully use the upper arm and pain in the region of particular muscles involved, including pain in the chest area. The most common disorders include shoulder pain, tendon lesions, capsulitis, pain referred from cervical spine problems, and possible visceral referred pain reflecting in the shoulder and upper arm area.

Muscles with their origin on the chest that insert on the humerus (MH and PMH longitudinal muscular distributions) can experience pain and disorder as result of muscular type problems. They can also reflect cardiac referred pain due to conditions that produce angina pectoris. Chest pain that radiates down left arm that is worse on exertion, accompanied with shortness of breath and facial pallor, should be carefully examined in light of possible heart disease.

### Problems in Muscles Moving Upper Arm

Specific disorders related to the longitudinal muscular distributions associated with moving the humerus include the following conditions:

Posterior lateral hand (PLH) distribution:

- Pain in posterior aspect of arm, shoulder and axilla
- Pain wrapping around scapula

Lateral hand (LH) distribution:

- Acute cramps and spasms along posterior deltoid muscle and upper scapular region

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps along medial deltoid muscle and subscapular regions
- Inability to raise shoulders due to pain in medial deltoid muscle and subscapular regions

Anterior medial hand (AMH) distribution:

- Acute cramps and spasms along anterior deltoid muscle

Medial hand (MH) distribution:

- Acute cramps and spasms along clavicle and upper sternal pectoralis muscle
- Pain in anterior region of chest with dypsnea related to region of the cardia (indicates possible angina pectoris)

Posterior medial hand (PMH) distribution:

- Acute cramps and muscular pain in lower sternal, costal and abdominal pectoralis muscles
- Pain and pressure in chest and heart radiating down arm and elbow (indicates possible angina pectoris)

Posterior lateral foot (PLF) distribution:

- Cramp like pain in axilla, involving latissimus dorsi muscle, extending to supraclavicular region

### Pathology of the Shoulder

Pain is obviously the most common complaint in problems affecting the shoulder. This may arise from intrinsic disorders of the glenohumeral joint or may be referred from extrinsic causes outside the shoulder area due to cervical spine or visceral problems. Elbow pain can also reflect into the shoulder on the same side. Shoulder pain can manifest as a painful arc on abduction of the arm or be due to tendon lesions involving the principal muscles moving the arm, or due to capsulitis of the glenohumeral capsule. Shoulder can also be affected by glenohumeral joint instability and thoracic outlet syndrome.

### *Shoulder Pain*

Pain in the shoulder is a very common symptom principally because of the glenohumeral joint structure and function, and because this joint normally enjoys considerable mobility and stability. However, the shoulder experiences degenerative changes that develop in its surrounding soft tissue structures. Hence, shoulder pain may arise from intrinsic disorders of the glenohumeral joint. Shoulder pain may also be the result of extrinsic source such as cervical spine disorders or visceral referred pain. In both of these cases there may be neck pain alone, neck and arm pain, or arm pain alone. But shoulder pain due cervical spine disorders involves nerve root compression and pain is felt down the arm along with neurological signs and possible muscular weakness.

#### Pain Quality

Quality and characteristics of shoulder pain provide clues to its source. Patients describe pain arising from intrinsic shoulder lesions as having a deep aching quality, which is made worse by movement. Night pain sufficient to disturb the patient's sleep is commonly found with glenohumeral joint lesions and reflects the degree of the underlying inflammation. Sleep-disturbing shoulder pain is a common symptom for inflammation of the joint capsule (capsulitis) or arthritis of the glenohumeral joint. It is also a common sign in patients with supraspinatus tendinitis, especially when patient rolls over on their affected shoulder.

#### Pain Location

The location of pain often provides possible clues to its source. In acromioclavicular joint pain, the patient often places fingers over upper part of the affected joint. Pain due to intrinsic disorders of the glenohumeral joint may be felt deep inside the joint and patient clasps hand over lateral aspect of the joint and sometimes over the tip of the shoulder. Patients with pain referred from the neck often clasps opposite hand over the trapezius area. Referred pain from the viscera may be localized diffusely in scapular region.

Some patients with intrinsic problems of the glenohumeral joint report pain in the area of the deltoid insertion, and it may be difficult to convince them that the source of pain is from the shoulder. Pain felt in the deltoid insertion region is typically referred further distally as the degree of inflammation in the involved structures is greater.

#### Cervical Spine

Pain referred to one shoulder due to cervical spine disorders can manifest with neck pain alone which radiates to the shoulder which is reproduced by neck movements but not by shoulder movements. Another situation involves shoulder pain alone without neck pain where neck movements reproduce the pain while shoulder movements do not. This latter situation often associated with hypomobility lesions at C4 - 5, C5 - 6 where movement of these joints reveal pain and restriction.

Another, but uncommon, variation manifests with shoulder pain alone in absence of neck pain. Shoulder movements cause pain at the limit of movement range while active neck movements may be normal or may result in slight degree of pain or restriction of neck movement. However, passive intervertebral movements of C4 - 5 or C5 - 6 produce pain and reveal restricted joint movement on same side as shoulder pain.

### Visceral Referred Pain

Shoulder pain referred from visceral sources is important but uncommon, and can be confusing. Visceral referred pain arises from intra-thoracic or intra-abdominal diseases that can be differentiated through associated symptoms, such as cough, chest pain, heart signs, or abdominal symptoms. A full physical examination may be required, including X-ray or other diagnostic imaging studies.

Shoulder pain referred from the gallbladder or right lung reflects in the right shoulder and the right upper back. Pain referred from the diaphragm reflects on the left upper shoulder, while pain from the left lung, spleen, and heart reflect into the left shoulder. Heart referred pain also radiates down the left arm, following the pathway of the radial artery.

## *Tendon Lesions*

Common tendon lesions are mainly associated the supraspinatus muscle but can also involve tendons of the infraspinatus, bicep, and subscapularis muscles. Tendon lesions include tendinitis, tendon rupture, subluxation concerning the bicep tendon, and calcification.

### Supraspinatus Tendon

Lesions of the supraspinatus tendon are a common source of shoulder pain. This lesion basically involves degeneration of the tendon. This condition may remain asymptomatic for a considerable period of time before clinical manifestations appear. Clinical signs that arise include: supraspinatus tendinitis; subacromial bursitis, incomplete rupture of the tendon; complete rupture of the tendon; and calcification.

#### *Tendinitis*

Supraspinatus tendinitis usually follows overuse or trauma involving tendon degeneration or damage. Patient complains of pain usually over outer aspect of shoulder which may radiate down to the deltoid insertion region, or only be felt there. The deltoid and the supraspinatus work as a single unit. If pain is sufficiently severe to radiate down to the elbow, it is likely to disturb patient's sleep. Natural history is often one of exacerbations and remissions over several years.

Major clinical signs include pain being reproduced on active and/or passive abduction of the shoulder. Often felt as a painful arc in the midrange of abduction (60° - 120°) as further discussed below. When returning arm from full abduction, patient may feel pain again, and arm may suddenly drop. Pain may be reproduced on isometric resistance testing.

Confirming signs include a disturbance of the scapulohumeral rhythm during abduction and returning arm to neutral position. Supraspinatus tendon can also be palpated. Plain film X-rays of shoulder are usually normal. However, there may be degenerative changes in the tendon resulting in sclerosis, roughening, and possible pitting on the greater tuberosity of the humerus.

#### *Tendon Rupture*

Degeneration of the supraspinatus tendon makes it susceptible to partial rupture involving the superior or inferior surface of the tendon. Clinical presentation is essentially the same as supraspinatus tendinitis. This condition occurs in younger people through overuse in athletics or work, but most commonly occurs in the elderly population.

Complete rupture of the supraspinatus tendon usually occurs in a region just proximal to its insertion into humeral greater tuberosity called the "critical zone." The tendon can occasionally be avulsed from its insertion into the greater tuberosity and patient may report having felt or heard a painful snap in the shoulder. This is a serious condition that can occur in the elderly with a long standing history of tendinitis. It can also occur in athletes with no history of supraspinatus tendinitis. Onset can follow a sudden movement or injury of the shoulder.

***Calcification***

Calcification of the supraspinatus tendon is present in a low percentage of routine shoulder X-rays. It develops in the degenerated portion of the tendon proximal to its insertion. This condition may be asymptomatic or be associated with supraspinatus tendinitis. Clinical signs for calcific tendinitis are essentially the same as uncomplicated supraspinatus tendinitis. Calcific deposit can be of sufficient size to catch beneath the acromion to produce a mechanical impedance of full shoulder abduction. Acute calcific bursitis can result in an intense painful situation in the shoulder. It can be common in the younger and more active age group. Pain may start rapidly, radiate down upper arm, and become worse especially by any shoulder movement, and can disturb sleep. Patient reports painful limitation in movement of any direction making it difficult to properly assess these movements. Plain film X-rays used to confirm presence of calcific deposits. After problem is resolved, X-rays may show that calcific deposits have disappeared.

### Infraspinatus Tendinitis

This condition is not as common as supraspinatus tendinitis but is related to degenerative changes in the infraspinatus tendon. Infraspinatus tendinitis is more common in individuals involved in sports like swimming or tennis, and also in laborers. Area of the lesion may be at the musculotendinous juncture or over the insertion site of the tendon posterior to the greater tuberosity of the humerus. Clinical signs initially manifest with pain in the posterior aspect of the shoulder which is made worse by most shoulder movements. Pain may radiate down posterior aspect of upper arm when this condition is severe. Pain can be reproduced by stretching or contracting the infraspinatus tendon. Patient may report a painful arc in the midrange of shoulder abduction where the tendon may catch on the acromion. A tender location of swelling or thickening may be palpable over the tendon insertion site or at the musculotendinous junction.

### Biceps Tendon

The bicep participates in all shoulder movement which involves the groove sliding along the tendon. This action makes the bicep tendon susceptible to wear and tear degeneration including the following:

***Tendinitis***

Bicep tendon is second most common source of shoulder tendinitis usually involving the bicipital groove of the humerus. Overuse and trauma to the shoulder can result in degeneration of the tendon leading to tendinitis. Problems with the bicep tendon can also be associated with tenosynovitis of the synovial sheath covering the bicep tendon, producing similar symptoms as tendinitis.

Patients complain of chronic and recurring pain in the anterior shoulder which may radiate down anterior aspect of the upper arm. Pain may be reproduced on some shoulder movements and by contracting or stretching the bicep tendon.

***Tendon Rupture***

Rupture of the long head bicep tendon within the bicipital groove is not uncommon. It often occurs in middle-aged or older males with a history of bicep tendinitis. Rupture may occur by lifting activities or extreme overuse, or by a fall on an outstretched hand, or may spontaneously occur. Patient may have been conscious of a tearing or snapping sensation in shoulder. Shoulder becomes painful and difficult to move with evidence of bruising appearing over the upper shoulder a few days later. One of the most obvious signs is the long head bicep muscle is displaced to the lower aspect of the upper arm and bulge appears when the bicep is contracted.

***Subluxation of Biceps Tendon***

The long head bicep tendon is retained in the bicipital groove by the strong transverse humeral ligament which also prevents bowstringing in when the muscle is contracted. The transverse ligament may be ruptured during injury where the shoulder is abruptly forced into extension while the shoulder is in abduction. The ligament can also be ruptured by bending down and lifting heavy weights from the ground level. Other factors include an individual having a shallow bicipital groove. When the transverse ligament ruptures the bicep tendon is free to sublux out of the bicipital groove. Examiner can reproduce patient's symptoms by holding arm in 90° abduction with the elbow flexed. Bicep tendon is palpated and can be felt to slip in an out of its groove when the arm is rotated medially and laterally.

**Subscapularis Tendinitis**

Tendinitis of the subscapularis tendon is not a common condition. Patient may present with pain in the anterior shoulder usually after overuse trauma due to excessive internal rotation of the shoulder. Examiner should be able to reproduce patient's pain by resisted isometric contraction of the subscapularis muscle. Shoulder abduction and lateral rotation may produce a painful arc. Tenderness may be palpated localized medial to the lessor humeral tuberosity where the subscapularis muscle inserts.

***Painful Arc***

Painful arc refers to the situation where pain is felt in the middle range of arm abduction (60° - 120°). There is no pain with arms at the side, but as the arm is moved into abduction (45° - 60°) in the frontal or coronal plane, pain is felt as the greater tuberosity approaches the acromion process. Painful and inflamed structures between these two bony prominences are impinged and cause pain. Inflammation possibly caused by: subacromial bursitis; calcium deposits; or tendinitis of rotator cuff muscles. As the shoulder is further abducted (120°), the painful structure slides under the coracoacromial ligament and the pain ceases.

Pain may be felt on active and passive movement in abduction, or as the arm is raised or lowered. Also, painful arc condition often shows a disturbance of the scapulohumeral rhythm, with jerky type of movement usually demonstrated on lowering through the painful region. A sudden hitch may be apparent. Possible substitution or trick movements may include moving the arm forward from the frontal plane.

Soft tissue lesions associated with painful arc include: posteriorly the infraspinatus tendon; superiorly the supraspinatus tendon; and anteriorly the subscapularis tendon. Degenerative changes can be apparent in the inferior acromioclavicular joint, acromion, and the greater humeral tuberosity.

### *Bursitis*

A bursa is a special sac or saclike structure or cavity filled with a viscid fluid situated in various locations in the musculoskeletal system where friction between two moving tissue surfaces may develop. A bursa can become inflamed producing an intensely painful condition called bursitis.

#### Subacromial Bursitis

The subacromial bursa consists of serous sac that is in intimate contact with the supraspinatus tendon which forms the major part of the floor of the bursa. The tendon and the bursa form a functional unit in the subacromial space. Hence, chronic subacromial bursitis is often coupled with supraspinatus tendinitis. Subacromial bursitis is usually secondary to lesions in the rotator cuff and not associated with capsulitis. Patient may experience a painful arc in mid range of passive or active shoulder abduction. However, the patient's pain is not reproduced by resisted shoulder abduction which distinguishes it from supraspinatus tendinitis.

#### Subcoracoid Bursitis

This condition occurs infrequently and may follow overuse, especially with repetitive shoulder rotation which may occur in people driving heavy vehicles or in playing table tennis. Pain usually localized over the anterior aspect of the shoulder just distal to coracoid process of the scapula. Patient's pain can be reproduced at the end by lateral shoulder rotation movement and by passive horizontal adduction of the arm across the chest. Resisted movements are usually pain free.

### *Capsulitis of Shoulder Joint*

This condition represents an inflammatory lesion of the glenohumeral joint capsule which leads to thickening and contraction of the capsule resulting in joint volume loss. Clinical signs include painful stiffness affecting the active and passive range of all shoulder movements. Capsulitis occurs most commonly in middle aged females but almost never arises as a complication of existing intrinsic lesions such as supraspinatus or bicipital tendinitis.

Pathology associated with capsulitis indicates that shoulder capsule is thickened and retracted causing marked restriction in the glenohumeral joint. However, joint surfaces and surrounding tissue, such as the subacromial bursa and tendons are normal. Plain film X-ray findings may be essentially normal or may show disuse osteoporosis or small cystic inclusions along the capsule insertion line into the humeral head. X-rays are essential to differentiate between capsulitis and arthritis of the shoulder joint which may have similar clinical findings. Clinical findings of capsulitis may be confirmed by arthrography demonstrating loss in joint volume and joint recesses. Only 5 - 10 ml of contrast medium can be injected instead of the 20 - 30 ml for a normal joint.

Onset of capsulitis is usually gradual, but can be sudden at times. Condition may occur in one shoulder and then after some variable time, occur in the other shoulder.

Once an attack is resolved, second attacks in the same shoulder are rare. Typical findings indicate four stages of progressive restriction as follow:

**Stage 1**

Pain usually experienced in and around glenohumeral joint which is made worse by movement, but stiffness is not usually noticed by patient.

**Stage 2**

Pain becomes more intense and is present at night distributing patient's sleep especially if they roll onto affected shoulder. Most shoulder movements produce pain and sudden movements or jarring, produce intense pain. Pain commonly felt deep in the shoulder or in region of deltoid insertion, and may radiate further into the elbow. Shoulder becomes increasingly stiffer with severe functional limitations. At this time there is great difficulty in dressing, working, driving car, hanging clothes on line or in closet.

**Stage 3**

At this stage there is little spontaneous pain at rest, although pain is produced on sudden stretching the joint. Stiffness is now more pronounced due to adhesion formation and contracture of the thickened joint capsule. The supraspinatus and infraspinatus muscles can become atrophic and wasted. Unfortunately, the term "frozen shoulder" is applied to this situation causing confusion in treatment of this problem.

**Stage 4**

This stage involves a gradual resolution of stiffness and gradual return of shoulder mobility. However, degeneration and weakness of the shoulder is apparent. Course of a protracted case can be 9 - 18 months, or even longer.

***Instability of Shoulder Joint***

Shoulder joint instability or recurrent subluxation can result from a capsular tear as found in recurrent dislocations. This condition often related to a previous injury resulting in dislocation of the shoulder. Recurrent subluxation can occur if the glenohumeral joint capsule has been torn, even in absence of a previous dislocation. Patient has a history of recurrent attacks of shoulder pain in response to movement. Pain may be so severe that patient is unable to move arm. Attacks may only last for short period of time and patient may aware of clicking sensation in shoulder or that shoulder slips out.

Examiner may demonstrate abnormal shoulder movements by positioning patient's arm in abduction and lateral rotation while applying pressure to the back of the humeral head. This may reproduce patient's pain and the shoulder joint may be felt to begin to sublux.

***Entrapment Neuropathy***

**Thoracic Outlet Syndrome**

Peripheral nerves of the brachial plexus and the subclavian artery form a neurovascular bundle that passes through the thoracic outlet of the neck and passing under the clavicle. Any compression affecting this area due to trauma or other causes can produce various neurological and vascular symptoms including pain affecting the shoulder and arm. Resulting pain and paresthesia commonly manifest along the ulnar side of the arm. Onset of symptoms can be spontaneous but may follow injury to the neck or arm, and especially due to crushing type trauma to the upper thorax. Patient's symptoms may be reproduced by sustained traction of the shoulder by pulling on down and backward on the patient's wrist (costoclavicular syndrome or military brace test), while passive elevation of the shoulder girdle may relieve symptoms (shoulder girdle passive elevation test). (Also see Adson's maneuver for thoracic outlet syndrome)

**Suprascapular Nerve Entrapment**

The suprascapular nerve derived from C5 and C6 provides motor function to supraspinatus and infraspinatus muscles along with sensory function to posterior shoulder capsule and the acromioclavicular joints. This nerve runs through the suprascapular notch on the upper anterior border of the scapula before entering the supraspinatus fossa. Compression of this nerve occurs in the suprascapular notch which is enclosed by a transverse ligament. Entrapment can be the result of overuse, such as painting a house or trimming trees, or trauma especially in traction.

Pain may be severe or vaguely localized in the posterolateral aspect of the shoulder, and may radiate down the arm. If entrapment is prolonged there may be wasting of the supraspinatus and infraspinatus muscles. Pain can be reproduced by passively adducting the arm fully across the chest and applying overpressure at end of range to compress the nerve. Pain may also be reproduced by elevating the arm above the head and then depressing the shoulder girdle. In addition, pressure over the nerve can reproduce the pain.

## Examination of Shoulder

### Active Shoulder Movements (ROM)

Movement assessment of the shoulder starts by the patient articulating upper arm and shoulder through full range of motion possible in all axes to include extension, internal rotation, external rotation, horizontal abduction, horizontal adduction and elevation of the shoulder through flexion and abduction. Range of motion (ROM) is measured in degrees and any symptoms occurring during movement, along with their qualities are noted.

➔ Possible movements that already present with pain and dysfunction are tested after all other tests so as not to increase patient discomfort and apprehension which can affect the other tests

***Extension***

Normal active ROM for shoulder extension is 0 - 60° and can be measured with patient either seated or lying prone starting with arm at side with palm facing medially. In the prone position, goniometer axis is placed over axis of glenohumeral joint lateral aspect at the center of humeral head, about 2.5 cm inferior to lateral aspect of acromion process. The stationary arm of the goniometer is maintained parallel to the lateral midline of the trunk and the moveable arm parallel to longitudinal axis of humerus, pointing toward the lateral epicondyle. Humerus is then moved posteriorly to extend upper arm to full limit of extension. Elbow is allowed to simultaneously flex so the hand remains near surface of the examination table. Arm extension can also be measured with a bubble inclinometer held against lateral aspect of the humerus at about the mid point, adjusted to indicate zero before moving arm.

In seated position, arm is at the side with palm facing medially. Goniometer positions are same as measuring in extension as noted above with the fixed arm of the goniometer held vertically. Patient's arm is moved posteriorly from the neutral position until full range of pain free extension is obtained.

➔ Patient may attempt to substitute scapular anterior tilting and elevation, and shoulder abduction. In the seated position the patient may flex the trunk

***Internal Rotation***

Normal active ROM for internal rotation of shoulder is 0 - 70° and can be measured in the prone, supine, or seated position. Shoulder is abducted 90° in prone test configuration with elbow flexed 90° and forearm held down from side of table in neutral position. A small pillow or towel can be placed under humerus to maintain the abducted position.

➔ This position is contraindicated if patient has a history of posterior dislocation of the glenohumeral joint (conduct measurement from supine position)

Axis of the goniometer is placed on the olecranon process of the ulna with the stationary arm pointing perpendicular to the floor. The movable arm is aligned parallel with the longitudinal axis of the ulna, pointing toward ulnar styloid process. A gravity sensitive bubble inclinometer can be held on ulna with start position adjusted to zero. Palm of hand is moved posteriorly and up toward to ceiling to limit of internal rotation.

➔ Patient may attempt to substitute elbow extension and scapular elevation and abduction

The seated position can be used, especially if the patient cannot achieve 90° of shoulder abduction. With the patient seated, the shoulder is abducted about 15° with the elbow flexed 90° and the forearm in neutral position. Goniometer axis is placed under the olecranon process of the ulna with the fixed arm perpendicular to the trunk while the movable arm is held parallel to the axis of the ulna. The palm of the hand is moved toward the abdomen to the full limit of internal rotation.

➔ In seated position, patient may attempt to substitute scapular elevation and abduction

***External Rotation***

Normal active ROM for external rotation of the shoulder is 0 - 90° and can be measured in the supine, prone, or seated position. In the supine test configuration, the shoulder is abducted 90° with the elbowed flexed 90° and forearm held upright and pronated. A small pillow or towel is placed under the humerus to achieve the abducted position.

➔ This start position is contraindicated if the patient has a history of anterior dislocation of the glenohumeral joint (do test from prone position)

Goniometer axis is placed on olecranon process of the ulna with the stationary arm pointing upward and perpendicular to the floor. The movable arm is aligned parallel with the longitudinal axis of the ulna, pointing toward the ulnar styloid process. A gravity sensitive bubble inclinometer can be used and held on the ulna and adjusted to zero at start position. Dorsum of the hand is moved posteriorly and downward toward the examination table to the limit of external rotation.

➔ Patient may attempt to substitute elbow extension and scapular depression and adduction

Seated position can be used, especially if patient cannot achieve 90° of shoulder abduction. With patient seated, shoulder is abducted about 15° with the elbow flexed 90° and forearm in neutral position. Goniometer axis is placed under the olecranon process of ulna with fixed arm perpendicular to trunk while the movable arm is held parallel to axis of the ulna. Dorsum of the hand is moved laterally away from the body to the full limit of external rotation.

➔ In seated position, patient may attempt to substitute scapular depression and adduction

***Horizontal Abduction (Horizontal Extension)***

Normal active ROM for shoulder horizontal abduction is 0 - 45° and is normally measured with patient seated. Shoulder is placed in 90° of abduction and neutral rotation, with elbow flexed 90° and forearm in neural position, with examiner supporting arm in abduction. The axis of the goniometer is placed over the acromion process with the fixed arm perpendicular to the trunk of the body. The moveable arm is parallel to the longitudinal axis of the humerus. The humerus is then moved posteriorly to the limit of motion in horizontal abduction.

➔ Patient may substitute ipsilateral trunk rotation or scapular retraction

***Horizontal Adduction (Horizontal Flexion)***

Normal active ROM for shoulder horizontal adduction is 0 - 135° and normally measured with the patient seated. The shoulder is placed in 90° of abduction and neutral rotation, with elbow flexed 90° and forearm in neural position, with the examiner supporting the arm in abduction. The axis of the goniometer is placed over the acromion process with the fixed arm perpendicular to the trunk of the body. The moveable arm is parallel to the longitudinal axis of the humerus. The humerus is then moved anteriorly with the hand approaching the opposite side of the chest, to the limit of motion in horizontal adduction.

➔ Patient may substitute ipsilateral trunk rotation or scapular protraction

***Elevation through Flexion***

Normal active ROM for shoulder elevation through flexion is 0 - 180° with the glenohumeral joint providing the initial 0 - 60° range of movement with participation of scapular and trunk movement required in the range of 60 - 180°. This test can be performed with patient lying supine or standing. In supine position, patient with arm to side, the goniometer axis is placed at lateral aspect of the head of the humerus, about 2.5 cm inferior to the lateral aspect of the acromion process. The stationary goniometer arm is aligned parallel to the lateral midline of trunk while the movable arm is parallel to the axis of the humerus, pointing toward lateral epicondyle of the humerus. The humerus is then actively moved anteriorly into full flexion.

In seated position, patient's arm hangs down at the side, with palm facing medially, with examiner stabilizing the scapula. The goniometer is placed at the center of the head of the humerus with the fixed arm aligned vertically parallel to the trunk and the moveable arm is aligned with the humerus. The patient raises their arm anteriorly up over the head to the limit in flexion. Measurement with a gravity sensitive bubble inclinometer can be performed by holding it against the humerus adjusted to zero before start of movement. This position is held throughout the range of movement in flexion.

In seated position, goniometer can also be placed on medial border of the scapula to measure lateral rotation of scapula during elevation through flexion.

➔ In seated position patient may attempt to substitute trunk extension and shoulder abduction.

### *Elevation through Abduction*

Normal active ROM for shoulder elevation through abduction is 0 - 180° with the glenohumeral joint providing the initial 0 - 30° range of movement with participation of scapular and trunk movement required in the range of 30 - 180°. Elevation though abduction can be conducted with the patient supine, seated, or prone position. In the supine patient, the arm is at the side and held in the position of adduction and external rotation with palm facing upward to allow more clearance for the greater tuberosity of the humerus to clear the acromion process. Before abducting the arm, it is necessary to confirm that the patient is capable of full external rotation.

The goniometer is placed so that its axis coincides with the midpoint of the anterior or posterior aspect of the glenohumeral joint (about 1.3 cm inferior and lateral to the coracoid process) with the fixed arm parallel to the sternum and the moveable arm parallel to the longitudinal axis of the humerus. The patient then moves the humerus laterally, in abduction, to the full limit of motion in elevation.

In the seated configuration, the arm is held at the side, externally rotated so the palm of the hand is facing forward. The goniometer is positioned over the posterior axis of the glenohumeral joint, just lateral to scapula and about 2.5 cm inferior to the posterior aspect of the acromion process. With a bubble inclinometer, it is placed on the shaft of the humerus and adjusted to zero before movement starts. The shoulder is then abducted to the full limit of elevation.

➔ Patient may attempt to substitute contralateral trunk side flexion, scapular elevation, and shoulder flexion.

In seated or posterior position of this test, the goniometer can also be placed on medial border of scapula to measure lateral rotation of scapula during elevation through abduction.

## Passive Shoulder Movement

Shoulder passive movements are accomplished by examiner for the same configurations and test positions noted above in: Active Movements of Shoulder (ROM). All the same motion directions are evaluated to assess symptoms and to measure joint end feel in those directions.

### *Extension*

Normal end feel for shoulder extension is firm.

### *Internal Rotation*

Normal end feel for shoulder internal rotation is firm.

### *External Rotation*

Normal end feel for shoulder external rotation is firm.

***Horizontal Abduction***

Normal end feel for shoulder horizontal abduction is firm.

***Horizontal Adduction***

Normal end feel for shoulder horizontal adduction is firm/soft.

***Elevation through Flexion***

Normal end feel for shoulder elevation through flexion is firm.

***Elevation through Abduction***

Normal end feel for shoulder elevation through abduction is firm/hard.

## Resisted Movements of Shoulder

The major tendon lesions affecting the shoulder usually involve the supraspinatus, infraspinatus, biceps, and subscapularis muscles. These muscles and tendons are evaluated by resisted isometric movement in abduction, lateral rotation, forward flexion, and medial rotation of the shoulder. Resisted strength measurements are also obtained to evaluate the condition of the other muscles involved in the remaining movements of the shoulder. Resisted strength measurements graded 0 - 5 (See Table 4.3).

***Shoulder Abduction to 90°***

Resisted abduction is used principally to test the supraspinatus tendon (LH) although the middle fibers of the deltoids m. (ALH) have a significant role in abducting the arm. Isometric resistance testing is performed with patient seated with elbow flexed 90° and glenohumeral joint abducted to 30°. Examiner stands behind patient with one hand on lateral aspect of elbow while patient's resists only to the point of preventing examiner in moving the arm downward. Simultaneously, the practitioner palpates supraspinatus tendon over its insertion into the greater tuberosity. This is often difficult to accomplish because the tendon lies deep to the deltoids.

➔ Patient may substitute shoulder elevation (upper fibers of trapezius), shoulder external rotation (biceps brachii, long head), and contralateral or ipsilateral side flexion of the trunk to compensate for failure to perform this test

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. This can be conducted with the patient lying supine and test arm is at the side with elbow extended. The examiner supports the patients arm with one hand and arm while stabilizing the scapula with other hand. The patient then abducts the shoulder to 90°.

➔ Patient may substitute contralateral trunk side flexion, shoulder elevation (upper fibers of the trapezius) and shoulder external rotation (long head of biceps) to compensate for extreme weakness in supraspinatus and middle deltoid or rupture of supraspinatus tendon.

***Lateral (External) Rotation***

Resisted lateral rotation is used to principally test the infraspinatus tendon (PLH) although accessory muscles including the teres minor (PLH) and posterior deltoid (LH) mm. have a role as well in external rotation. Resisted strength test in normal prone configuration involves externally rotating shoulder approximately 30° from start position before application of resistive force. Isometric resistance is applied proximal to wrist joint on posterior aspect of the forearm in direction of shoulder internal rotation.

Application of resistive force stresses the elbow and shoulder joints and must be applied with caution, especially if there is possible pathology in those structures.

➔ Patient may substitute elbow extension (triceps) and scapular depression (lower fibers of trapezius) if unable to contract the infraspinatus muscle

If patient is unable to lie prone or is not able to abduct the shoulder 90°, resisted lateral rotation can then be considered depending whether patient is not able to lie prone or abduct the shoulder (1), or if patient is unable to lie prone (2) as follow:

1) Examiner stands in front of patient who is either seated or standing with elbow flexed 90° and arm held firmly against side with palm facing inward. Examiner applies force on dorsal surface of patient's wrist while the patient prevents examiner moving their arm into medial rotation.
2) Examiner stands behind patient who is either seated or standing with elbow flexed 90° and arm abducted 90° which is then fully rotated medially with palm of hand facing backward. With one hand the examiner stabilizes the patient's arm proximal to the elbow while other hand is placed over dorsal surface of patient's hand to resist forward movement and prevent lateral rotation.

If the isometric strength is less then Grade 2+, a gravity eliminated may be indicated. This can be conducted with the examiner standing to side of patient who is either seated or standing with elbow flexed 90° and arm held firmly against the side with palm facing inward. Examiner then supports forearm with one hand while stabilizing humerus with the other while patient externally rotates shoulder by swinging hand away from body.

➔ Patient may attempt to substitute elbow extension (triceps), scapular depression (lower fibers of the trapezius), and forearm supination if failing to normally complete this test.

***Medial (Internal) Rotation***

Resisted medial rotation is principally used to test the subscapularis tendon (ALH) although accessory muscles including latissimus dorsi (PLF), teres major (PLH), upper pectoralis major (MH) and anterior deltoid (AMH) muscles are involved in this movement. Resisted strength test in normal prone configuration involves internally rotating shoulder approximately 30° from start position before application of resistive force. Isometric resistance is applied proximal to wrist joint on anterior aspect of forearm in direction of shoulder external rotation. Application of resistive force stresses the elbow and shoulder joints and must be applied with caution, especially if there is possible pathology in those structures.

➔ Patient may attempt to substitute elbow extension (triceps) and scapular protraction (pectoralis minor) if unable to internally rotate the shoulder.

If patient is unable to lie prone or is not able to abduct shoulder 90°, the gravity-eliminated seated or standing position is used to conduct shoulder internal rotation screening test. An alternate resisted internal rotation can also be considered where examiner stands in front of patient who is either seated or standing with elbow flexed to 90° and held firmly by side with palm facing inward. Examiner places palm over palmar surface of patient's wrist to fully resist medial movement while simultaneously palpating the subscapularis tendon over its insertion into the lessor tuberosity.

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. This can be conducted with examiner standing to side of patient who is either seated or standing with elbow flexed 90° and arm held firmly against the side with palm facing inward. Examiner then supports forearm with one hand while stabilizing the humerus with other while patient internally rotates shoulder by swinging palm of hand in toward the abdomen.

➔ Patient may attempt to substitute elbow extension (triceps), shoulder abduction, and pronation of the forearm if unable to internally rotate the shoulder.

***Forward Flexion***

Resisted forward flexion is used primarily to test the biceps, long head tendon (ALH) although the biceps, short head (AMH), anterior deltoid (AMH), upper pectoralis major (MH) and coracobrachialis (MH) muscles are involved in flexion of the upper arm. Isometric resistance testing is performed by first placing biceps tendon in a stretch while patient is standing with shoulder extended (approximately 50 - 60°) and elbow fully extended with forearm pronated causing palm to face backward. Standing behind patient, the examiner places hand over dorsal aspect of the patient's wrist to fully resist any forward movement to flex the arm while simultaneously palpating long head biceps tendon in the bicipital groove.

Additional isometric tests of the biceps can be performed to address the role of the biceps in flexing the elbow and supinating the forearm (See Chapter 9 on Elbow).

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. This can be conducted with the patient in a side-lying position with test side up, with the arm supported at the side and shoulder held in full extension (approximately 50 – 60°) with slight abduction and neutral rotation. With examiner supporting arm, the patient flexes shoulder to 90°.

➔ Patient may attempt to substitute scapular elevation and trunk extension when failing to perform shoulder flexion.

***Shoulder Flexion to 90°***

Shoulder flexion to 90° is used to test anterior fibers of the deltoid (AMH) although this movement involves accessory muscles, including the biceps brachii, coracobrachialis, and middle fibers of the deltoid, clavicular fibers of the pectoralis major, upper and lower fibers of the trapezius and the serratus anterior. Isometric strength grades for anterior deltoid are obtained with the patient seated or lying supine. Patient holds shoulder in flexion to approximately 80 – 90° while isometric resistance is applied on the anteromedial aspect of the arm just proximal to elbow joint while. Resistive force is applied in direction of shoulder extension, slight abduction and external rotation.

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. This can be conducted with the patient in a side-lying position with test side up, with arm supported at the side and shoulder held in slight abduction and neutral rotation. With examiner supporting the arm, patient flexes shoulder to 90°, while simultaneously adducting and slightly internal rotating the shoulder.

➔ Patient may attempt to substitute scapular elevation and trunk extension when failing to perform shoulder flexion

### *Shoulder Flexion and Adduction*

Shoulder flexion with shoulder adduction is used to test the coracobrachialis (MH), with accessory muscles including the anterior fibers of the deltoid, clavicular fibers of the pectoralis major, and the short head of the biceps brachii muscles. With the patient lying supine and shoulder flexed approximately 80°, isometric resistance is applied to the anteromedial aspect of the distal humerus applying the force in the direction shoulder abduction and extension.

➔ Patient may substitute scapular elevation to assist this movement

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. The patient is placed in a side-lying position with the test side up, with the arm supported at the side and the shoulder held in slight abduction and external rotation, with the elbow fully flexed with forearm supinated. With the examiner supporting the arm, the patient flexes the shoulder through full range of motion, while simultaneously adducting and externally rotating the shoulder slightly.

➔ Patient may substitute scapular elevation to assist this movement

### *Shoulder Extension*

Shoulder extension is primarily performed by the latissimus dorsi (PLF) and teres major (PLH) muscles, although accessory muscles to this movement include the teres minor, posterior fibers of the deltoid, and the triceps muscles. Resisted isometric testing is performed with patient lying prone with the test arm to the side and slightly extended with the shoulder in internal rotation and palms facing upward. Force is applied proximal to the elbow on the posteromedial aspect of the arm in the direction of flexion and slight abduction to fully resist patient's attempt to extend arm.

➔ Patient may attempt to substitute contraction of the pectoralis minor

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. The patient is placed in a side-lying position with the test side up, with the arm supported at the side with forearm supinated and the shoulder in internal rotation. The patient's hips and knees are flexed and the examiner supports the arm as the patient extends the shoulder while maintaining shoulder adduction.

➔ Patient may attempt to substitute contraction of the pectoralis minor

### *Shoulder Horizontal Abduction*

Horizontal abduction of the shoulder provides a test for the posterior fibers of the deltoid (LH) although accessory muscles include the infraspinatus and teres minor muscles. Isometric test performed with patient lying prone with shoulder in slight abduction, elbow flexed 90° and the forearm pronated and hanging vertically over edge of table, with portion of arm just distal to the shoulder resting on the examination table. The resistive isometric force is applied on the posterolateral aspect of the arm proximal to the elbow joint in direction of shoulder horizontal adduction and slight internal rotation, to fully resist further abduction of the shoulder. Examiner stabilizes shoulder by applying pressure over the scapula.

➔ Patient may attempt to substitute contraction of the rhomboids, middle fibers of the trapezius, and ipsilateral trunk rotation

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. This test is conducted with the patient seated and shoulder abducted to about 75°, with the elbow flexed 90°, and the forearm pronated. The examiner supports the patient's full arm with one hand and arm while stabilizing the scapula with the other hand. The patient horizontal abducts and slightly externally rotates the shoulder.

➔ Patient may attempt to substitute contraction of the rhomboids, middle fibers of the trapezius, and ipsilateral trunk rotation

***Shoulder Horizontal Adduction***

Muscles used in horizontal adduction of the shoulder primarily involve the clavicular (MH) and sternal (PMH) heads of the pectoralis major muscle. Muscles providing accessory movement include the anterior fibers of the deltoid (AMH) and to a lessor degree, the latissimus dorsi and teres major muscles that extend the shoulder. These muscles are all tested as a group with prime emphasis on the pectoralis major. If weakness is detected in the pectoralis muscle, the individual clavicular and sternal heads can be tested separately, since each head has a separate innervation. In this situation the humerus is positioned so that its direction of resistive force is aligned directly opposite to pull of the fibers in each portion of the pectoralis major.

**Pectoralis Major (clavicular and sternal heads)**

This test performed with patient supine, shoulder abducted to 90°, elbow flexed 90° with forearm pronated, and shoulder horizontally adducted 90°. Isometric force is applied on anterior aspect of the arm proximal to elbow joint, in the direction of shoulder horizontal abduction, while examiner's other hand is placed on the patient's opposite shoulder for stabilization.

➔ Patient may attempt to substitute trunk rotation or scapular protraction

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. This test is conducted with the patient sitting with the shoulder abducted to 90°, and the elbow flexed 90°, and the arm supported by the examiner, while the patient adducts the shoulder. The scapula and trunk are stabilized by examiner's other hand placed on top of the shoulder.

➔ Patient may attempt to substitute contralateral trunk rotation to simulate horizontal adduction of the shoulder

**Pectoralis Major (Clavicular Head)**

With the patient lying supine, the shoulder is abducted to 70 - 75°, with elbow flexed 90° and forearm pronated. Resistive isometric force is applied on anteromedial aspect of the arm just proximal to elbow in the direction of abduction, extension, and slight external rotation of the shoulder.

➔ Patient may attempt to substitute contralateral trunk rotation, and contraction of the coracobrachialis and short head of biceps brachii in place of pectoralis clavicular head contractions

**Pectoralis Major (Sternal Head)**

With the patient lying supine, the shoulder is abducted to approximately 125 - 135°, with elbow flexed 90° with forearm pronated. Resistive isometric force is applied on anteromedial aspect of arm just proximal to elbow in the direction of abduction, flexion, and slight external rotation of the shoulder.

➔ Patient may attempt to substitute contralateral trunk rotation and contraction of the latissimus dorsi and teres major in place of pectoralis sternal head contractions.

## Functional Assessment

The shoulder plays an obvious and important role in activities of daily living (ADL) that require movement in flexion, abduction, adduction, extension, lateral and medial rotation, horizontal abduction and horizontal adduction. Common activities including eating, dressing, combing hair, reaching for something on a shelf, washing opposite shoulder, and other functions. Simply motions can demonstrate proper or abnormal movement of the shoulder include:

- Arm elevation
- Opposite shoulder touch
- Scapula superior angle touch
- Scapula inferior angle touch
- Shoulder protraction and retraction
- Painful arc

## Special Tests

A significant number of special tests have been developed over the years to assess possible conditions of the shoulder including instability of the glenohumeral joint, impingement disorders, tendon lesion of the muscles moving the arm, labral tears.

***Shoulder Instability***

### Apprehension Test

Purpose of this test is to detect anterior shoulder subluxation or dislocation involving the inferior glenohumeral ligament. Patient is supine in a relaxed position on the examination table. Patient's arm is supported with the shoulder abducted 90° and the elbow flexed 90°. While supporting the humerus at the elbow with one hand, grasp patient's forearm with other hand. Gently and gradually externally rotate shoulder. If patient has had a recent anterior dislocation or subluxation of the glenohumeral joint, apprehension or discomfort will occur as the shoulder approaches 90° of external rotation. Be careful not to cause an actual anterior dislocation when externally rotating the arm. Test may be modified to detect more subtle cases of anterior instability by placing the patient prone on examination table. Place one hand on the forearm and the palm of other hand on the posterior aspect of the proximal humerus. Abduct and externally rotate the shoulder 90° while pushing the humeral head anteriorly. When anterior instability is present, this position accentuates the anterior subluxation and elicits further apprehension and patient discomfort.

### Relocation Test

Purpose of test is to detect chronic anterior dislocation of the glenohumeral joint and is a companion to the apprehension test. Patient is patient supine with the shoulder in 90° abduction and zero degrees internal rotation, with the elbow flexed 90°. Examiner places one hand on patient's mid-forearm and other hand on the anterior aspect of the proximal humerus. The shoulder is carefully rotated externally while applying a posteriorly directed force to the anterior proximal humerus. Application of posteriorly directed force should prevent anterior subluxation and reduce the patient's pain and apprehension. If anterior instability is present, removing the posteriorly directed force will cause the patient's apprehension and pain to return.

**Anterior Instability Test**

This test is used to detect anterior instability in the glenohumeral joint. Patient is supine with the glenohumeral joint slightly over edge of table. Shoulder is abducted 90° and externally rotated 60 to 80° with elbow flexed 90°. Examiner grasps the patient's distal humerus at the elbow and supports the arm. Thumb of examiner's other hand is placed in the axilla on the anterior inferior humeral head with fingers on the posterior aspect of the humeral head. While maintaining elbow flexion and neutral shoulder rotation, examiner applies a posterior force to the humerus as the fingers of the other hand push the humeral head anteriorly. Examiner's thumb used to detect amount of anterior translation. Test is repeated as amount of glenohumeral abduction is increased. As the humerus is abducted, varying amounts of anterior translation and laxity may be felt. If the capsular structures are intact a firm end point is noted at the end of each anterior levering maneuver. Also, compare bilaterally. Lack of a firm end point, patient apprehension and pain, and excessive anterior levering may indicate capsular structure injury.

**Anterior/ Posterior Translation Test**

This test used to assess anterior or posterior glenohumeral laxity. Patient is seated with arms relaxed at side. Examiner places one hand on the scapula superior aspect, stabilizing it against the thorax while the humeral head is grasped with the other hand. Examiner's fingers and thumb used to push the humeral head anteriorly and then posteriorly. Note the amount of translation in both directions as compared to test application on uninvolved shoulder.

**Posterior Glenohumeral Instability Test**

This test used to assess humeral head posterior subluxation. Patient is supine and relaxed while examiner holds the patient's arm in 90° of abduction and 30 to 45° of horizontal adduction. Thumb of the other hand is placed on the anterior humeral head, using the fingers to locate the posterior glenohumeral joint. Apply a posteriorly directed force on the anterior humeral head while palpating posteriorly for any subluxation. Maintain the posterior displacement with thumb, while slowly abducting arm horizontally to neutral. If the humeral head is actually subluxed, a sudden reduction may be felt as the arm is horizontally abducted. To fully ascertain the amount of posterior subluxation, this maneuver may be repeated a few times.

**Inferior Shoulder Instability (Sulcus Sign)**

Purpose of test is to assess inferior glenohumeral laxity. Patient is standing with the involved arm hanging relaxed at the side. Examiner grasps the patient's forearm below the elbow and pulls the arm distally. Alternatively, the patient can be instructed to use their unaffected hand to grasp the wrist of the involved arm. While patient applies a downward directed, distractive force on the involved arm, examiner palpates the space between the humeral head and the undersurface of the acromion. An indention or sulcus may be noticed on the top of the middle deltoid as the humeral head subluxes inferiorly indicating inferior glenohumeral instability. Examiner also performs this test on the uninvolved shoulder, comparing bilaterally.

### Inferior Drawer Test or Feagin Test

Purpose of test is to assess humeral head inferior subluxation involving the inferior glenohumeral ligament and is a modification of the sulcus sign test. Patient is standing with shoulder abducted 90°, elbow in full extension and arm resting on examiner's shoulder. Examiner places both hands along the proximal humerus over the deltoid and with fingers interlocked. An inferiorly directed force is applied to the humerus and examiner palpates for inferior movement, which is indicative of glenohumeral joint inferior instability. Also, must watch for apprehension or discomfort displayed in the patient's face which indicates a positive result. Test should also be performed on the uninvolved shoulder, comparing bilaterally.

Test can also be performed with patient seated on examination table with shoulder abducted 90° while examiner holds patient's extended (straight elbow) arm at the elbow and holding arm against examiner's body. The other hand is used to apply a downward and forward force on the head of the humerus. A sulcus may be observed above the coracoid process.

## *Impingement Syndromes*

### Hawkins Impingement Sign

Patient is sitting or standing while examiner places patient's arm in 90° of forward flexion and forcefully internally rotates the arm, bringing the greater tuberosity in contact with the lateral acromion. A positive result is indicated if pain is reproduced during the forced internal rotation. These results suggest that pain is in the supraspinatus tendon.

### Neer Impingement Sign

With the patient seated or standing the examiner places one hand on the posterior aspect of the scapula to stabilize the shoulder girdle. The other hand used to take the patient's internally rotated arm by the wrist and place it in full forward flexion. If there is impingement, the patient will report pain in the range of 70° to 120° of forward flexion as the rotator cuff comes into contact with the rigid coracoacromial arch.

## *Muscle and Tendon Lesions*

### Drop Arm (Codman's) Test (Supraspinatus)

This test used to evaluate supraspinatus tendon problems. Patient can be standing or seated. Examiner passively abducts the patient's arm to full range of pain free motion and then observes as patient slowly lowers arm. Frequently, the arm will drop to the side if patient has a rotator tear or supraspinatus dysfunction. Patient may be able to lower arm to 90° (since abduction range above 90° mostly due to deltoid function) but will not be to continue maneuver as far as the waist. Positive test indicates supraspinatus tear.

### Yergason Test

This test is used to evaluate condition of the bicep tendon. Patient is seated while the elbow is flexed 90° with the thumb up and forearm in neutral position. Examiner grasps the wrist resisting attempts by patient to actively supinate the forearm and flex the elbow. Suggests bicep tendonitis if pain is provoked.

**Ludington's Test**

This is a test of the biceps long head tendon. While seated the patient's clasps both hands on top of the head or back of neck, allowing the interlocking fingers to support the weight of the upper limbs. This allows maximum relaxation of biceps tendon. Patient then alternately contracts and relaxes the biceps muscles. Examiner palpates the biceps tendon. If positive, tendon will not be felt and this indicates a rupture.

**Speed's Test (Bicep or Straight Arm Test)**

Biceps tendon is tested while patient's arm is extended behind and the forearm supinated with elbow slightly flexed. Examiner resists shoulder forward flexion by the patient while patient's arm is supinated and the elbow is completely extended. Positive test elicits increased tenderness in the bicipital groove and indicates bicipital tendinitis.

**Bicep Subluxation (Transverse Humeral Ligament Test)**

Test for rupture of the transverse humeral ligament. Patient is seated with the shoulder abducted and medially rotated. Examiner's fingers are then placed along the bicipital groove and the patient's shoulder is laterally rotated. Feel for the bicep tendon popping out of its groove. This indicates a positive test.

**Drop Sign (Infraspinatus)**

This test is concerned with the infraspinatus muscle and possible dysfunction of the posterosuperior cuff. Patient is seated on examination table with back to the examiner. Examiner holds affected arm at 90 degrees of abduction (in the scapular plane) and at almost full external rotation, with the elbow flexed at 90 degrees, by the patient's wrist while supporting the elbow. Maintenance of this position of external rotation of the shoulder is a function mainly of the infraspinatus. Patient then asked to actively maintain this position as the examiner releases the wrist while supporting the elbow. The sign is positive if a lag or "drop" occurs. Magnitude of the lag is recorded to the nearest 5°.

**Hornblower's Sign (Teres Minor)**

Patient is sitting or standing with shoulder externally rotated at 90° of abduction. Examiner supports the arm in the scapular plane. Elbow is flexed to 90° and the patient is asked to rotate the arm externally against the resistance. Positive sign is the inability to maintain the externally rotated position and the arm drops back to neutral position. Positive result suggests possible tear or dysfunction of infraspinatus and teres minor.

**Gerber Lift-Off Test (Subscapularis)**

Patient can be sitting or standing with hand of affected side placed on the small of the back, causing the arm to be extended and internally rotated. Examiner then passively lifts the hand off the small of the back, placing the arm in maximal internal rotation, after which the examiner releases the hand. If the hand falls onto the back because the subscapularis is unable to maintain internal rotation, the test result is positive. Patients with subscapularis tears have an increase in passive external rotation and a weakened ability to resist internal rotation. Positive results indicate possible rupture of the subscapularis.

### *Labral Tears*

#### Glenoid Labrum Clunk Test (Internal Derangement)

Purpose of test is to assess the glenoid labrum's integrity and stability. Patient is supine with the glenohumeral joint slightly over the edge of table. Examiner places one hand on the elbow supporting patient's arm with the shoulder maximally flexed and the elbow relaxed in approximately 60° of flexion. Place examiners fingers of other hand on the posterior aspect of the humeral head. Rotate the humerus and maneuver it between the end ranges of glenohumeral abduction and flexion. As the humerus is moved through these extreme ranges of motion, a glenoid labrum tear, if present, may be trapped or caught. This trapping of the torn labrum will often cause a grinding or "clunking" sensation to be felt or heard. Examiner should also perform this test on the uninvolved shoulder and compare bilaterally.

#### O'Brien Test

This test used to examine superior labral pathology. Patient is sitting or standing and attempts to elevate the extended, pronated arm from a starting position of 90° forward flexion and 20° to 30° of adduction against resistance. Resisted flexion, adduction, and internal rotation will cause more pronounced symptoms. The result is considered positive if symptoms are relieved with resisted forward flexion when the test is repeated with the arm supinated.

### *Thoracic Outlet Syndrome*

#### Addison Maneuver

Involves test for thoracic outlet syndrome with patient seated and arm hanging relaxed. Patient rotates head to face tested shoulder. Patient then extends head while examiner lateral rotates and extends patient's shoulder while locating the patient's radial pulse. Patient then instructed to take a deep breath and hold it. Disappearance of radial pulse indicates positive result showing compression of neurovascular structures to arm.

#### Costoclavicular Syndrome (Military Brace)

This test is one of several that are similar to the Adson maneuver. Patient is seated or standing with arms hanging relaxed. Symptoms of possible thoracic outlet syndrome may be reproduced by sustained traction of the shoulder. Examiner first palpates the radial artery pulse and pulls patient's wrist downward and backward into extension. Examiner feels radial pulse. Positive result indicated if radial pulse disappears. Test effective for patients complaining of symptoms from wearing a heavy coat or back pack.

#### Elevated Arm Stress Test (EAST) (Roos Test)

Patient is seated or standing with both arms abducted to 90° with elbows flexed 90° and laterally rotated with palms facing forward. The forearm muscles are exercised by slowly closing and opening the fingers for three minutes. Test is positive if patient cannot keep arms in starting position for three minutes; suffers ischemic pain, heaviness, or weakness in arm; or numbness and tingling occur in hand before three minutes. Any of these responses indicate neurological impingement within the thoracic outlet.

#### Shoulder Girdle Passive Elevation

This test used to verify thoracic outlet syndrome by relieving existing symptoms. Patient is seated with both arms crossed over the chest. Examiner is positioned behind patient and passively elevates the shoulder girdle by applying an upward force toward the shoulder by placing hands below both elbows of the patient (passive bilateral shoulder shrug). The shoulder girdle elevated position is held for 30 seconds. Improved arterial flow is noted by a stronger pulse, hand temperature increase, and improved skin color changes. Restored venous flow is noted by decreased venous engorgement and cyanosis. Possible changes in neurological signs include reduced pain as neural ischemia is released, as well as the feeling of numbness changing to pins and needles or tingling.

### *Neurological Functional Tests*

#### Upper Limb Tension Test (Brachial Plexus Tension or Elvey Test)

This test is thought of as the upper limb equivalent of the straight leg raising test for the leg. It is considered when patient presents with upper limb radicular signs or peripheral nerve involvement. With the patient supine, the joints of the upper arm are placed into certain positions to stress each of the neurological structures differently. Upper arm symptoms are more readily aggravated than those of the lower arm. Side flexion of the contralateral cervical spine can further sensitize the test.

➔ If patient's neurological signs are in an acute phase or are becoming worse, or if there are cauda equina or spinal cord lesions, these stress tests are contraindicated

It is important that the shoulder is positioned and held in constant depression during the test even with abduction. There are four upper limb tension tests as follow:

***ULTT 1***

This test provides stress or bias on the median nerve, anterior interosseous nerve, and nerve root levels C5, C6, and C7. With the contralateral cervical spine in side flexion, the shoulder on the affected side is held in depression while abducted at 110° with the elbow extended, forearm supinated, with wrist extended, and fingers thumb held in extension.

***ULTT 2***

This test provides stress or bias on the median nerve, musculocutaneous nerve, and axillary nerve. With the contralateral cervical spine in side flexion, the shoulder on the affected side is laterally rotated and held in depression while abducted at 10° with the elbow extended, forearm supinated, with wrist and fingers held in extension.

***ULTT 3***

This test provides stress or bias on the radial nerve, musculocutaneous nerve, and axillary nerve. With the contralateral cervical spine in side flexion, the shoulder on the affected side is medially rotated and held in depression while abducted at 10° with the elbow extended, forearm pronated, wrist extended in ulnar deviation, and fingers and thumb held in flexion.

***ULTT 4***

This test provides stress or bias on the ulnar nerve and nerve root levels C8 and T1. With the contralateral cervical spine in side flexion, the shoulder on the affected side is laterally rotated and held in depression while abducted at 10° to 90° until hand touches ear with the elbow flexed, forearm supinated, wrist extended in radial deviation, and fingers and thumb held in extension.

### Tinel's Sign (at Shoulder)

This test involves tapping an area of the brachial plexus above the clavicle located in the scalene triangle. Stimulating a tingling sensation in one or more nerve roots is considered a positive sign.

## Neurological Evaluation of Shoulder

***Myotomes-Key muscle strength (graded 0-5)***

Trapezius muscle (XI, C4)

Deltoid muscle (C5)

***Key Reflexes:***

None at shoulder

## Accessory Movements: Glenohumeral Joint

Five accessory movements are evaluated for the shoulder joint, conducted with the patient supine with the upper arm in neutral position. In some situations it may be useful to repeat these tests with the arm abducted or flexed 90°.

***Caudal Humeral Glide***

Longitudinal caudal movement is produced by application of pressure over the head of the humerus directed downward toward the humeral shaft.

***Cephalad Humeral Glide***

Longitudinal cephalad movement is produced by grasping the upper arm and applying a compressive force along the humeral shaft.

***Ventral Humeral Glide***

Posteroanterior movement is produced by applying pressure under the posterior surface of the humeral head with the patient supine, which is directed to the front. This test can also be performed with the patient lying prone with the coracoid process stabilized on a firm table or sandbag.

***Dorsal Humeral Glide***

Anteroposterior movement is produced by applying pressure on the anterior surface of the humeral head which is directed downward toward the back.

***Lateral Traction***

Lateral movement is produced by grasping proximal region of upper arm and pulling the humeral head away from the glenoid cavity.

## Diagnostic Imaging

***Plain Film Radiography***

**Anteroposterior View.** May consist of a true anteroposterior view or a tilt view.

**Axillary Lateral View.** This view shows the relationship of the humeral head to the glenoid fossa and useful in diagnosing anterior and posterior shoulder dislocations, and avulsion fractures of the glenoid. Patient must be able to abduct the arm 70° to 90°.

**Transscapular (Y) View.** This is the true lateral view of the scapula and shows the position of the humerus relative to the glenoid, acromion, and coracoid process.

**Stryker Notch View.** This view centers on the coracoid process with the patient lying supine with the arm flexed and hand on top of head.

**West Point View.** The patient is prone in this view which is used to delineate possible glenoid fractures.

**Arch View.** This a lateral view to determine the width and height of the subacromial arch.

#### *Magnetic Resonance Imaging (MRI)*

MRI is useful in diagnosing soft-tissue injuries to the shoulder and is the imaging method of choice for demonstrating shoulder soft-tissue abnormalities. This allows differentiation of bursitis, tendonitis, muscles strains, impingement, labral tears, glenoid irregularities, and state of bone marrow.

#### *Computed Tomography*

Computed tomography is effective in diagnosing bone and soft tissue injuries and abnormalities of the shoulder, especially when used in conjunction a radiopaque dye (computed tomoarthrogram). Main advantage is to view cross sections including axial or perpendicular views.

## Management of Shoulder Disorders

Management of shoulder disorders involves physical modalities to improve mobility, needling therapy, possible electroneedling EN application, and remedial exercises or rehabilitation.

### Shoulder Mobilization

Any of the physiological or accessory movements previously described can be applied to the shoulder to improve mobility and reduce pain in affected joints. Passive movement treatments are graded from I-V and consist of either small or larges amplitude oscillations that do not move into the restricted or painful area, except for grade V which involves a sharp thrust beyond the pathological limit of movement (See Table 5.1). Grade V mobilization techniques are not usually applied to the shoulder. Mobilization application usually starts with small amplitude oscillatory movements at the end of range (Grade IV) to improve joint mobility. When pain is present, Grade I and II movements are used by just moving to the area where pain manifests. The following movements are considered:

- Glenohumeral joint
- Caudal humeral glide
- Ventral humeral glide
- Dorsal-ventral humeral oscillation
- Dorsal humeral glide
- Dorsal humeral glide (flexion exceeding 70°)
- Graded lateral rotation
- Lateral traction

### Needling Therapy for Shoulder Problems

Treatment of problems affecting the shoulder and upper arm usually involves using most of the nodes local to the shoulder, as well as appropriate distal and proximal nodes. Local shoulder nodes include ALH, PLH, and LH distribution nodes. Distal sites on the hand and arm and proximal locations on the upper back and neck are selected depending upon the most likely muscular pathways to be involved.

Appropriate local and adjacent, distal and proximal nodes for treatment of shoulder problems are noted in Table 9.4 which concerns pain and dysfunction related to the shoulder. Additional nodes are considered that have a direct influence on the muscle moving the arm mainly located on the scapula. Selection of nodes is considered in terms of the problems affecting either the anterior-lateral or lateral-posterior aspect of the shoulder. Treatment only applied to the affected side.

Table 9.4. Candidate regional, proximal and distal nodes for pain and disorders of the shoulder.

| Pain or Disorder of the Shoulder | Candidate Local & Adjacent Nodes | MD* | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Anterior Lateral | Yunmen (AMH 2)<br>Jugu (ALH 16)<br>Jianyu (ALH 15)<br>Jianliao (LH 14) | AMH<br>ALH | Fengchi (LF 20)<br><br>Dazhu (PLF 11)**<br>Feishu (PLF 13) | Hegu (ALH 4) |
| Lateral Posterior | Jugu (ALH 16)<br>Jianliao (LH 14) | ALH | Dazhu (PLF 11)<br>Feishu (PLF 13) | Hegu (ALH 4) |
| | Jianzhen (PLH 9) | LH | Fengchi (LF 20) | Zhongzhu (LH 3) |
| | Naoshu (PLH 10) | PLH | Tianzhu (PLF 10)<br>Jianzhongshu (PLH 15) | Houxi (PLH 3) |

* Muscular distribution
** Add if signs of subscapularis tendonitis or pain

### *Node Selection*

#### Anterior Lateral Shoulder

Candidate node selection for anterior lateral shoulder problems (Table 9.4) address shoulder pain and dysfunction reflecting in this area. This includes glenohumeral joint problems, including capsulitis, as well as pain in the anterior and lateral deltoids, subacromial or subcoracoid bursitis, involvement of the teres major muscle, bicepital tendonitis, and latissimus dorsi involvement. Additional nodes can be considered depending on the extent and nature of the patient's problems:

- In case of capsulitis, subacromial bursitis, or swelling of shoulder, Naoshu (PLH 10) may also be added
- If shoulder pain is reflected to deltoid insertion, Binao (ALH 14) can be considered as well
- If the pain is more anterior with suspected involvement of the subscapularis muscle (ALH), nodes Dazhu (PLF 11) and Feishu (PLF 13) (related to the rhomboid muscles-ALH) can be added as additional proximal locations
- Proximal nodes Dazhu (PLF 11) and Feishu (PLF 13) or Jianzhongshu (PLH 15) may also be considered for capsulitis

#### Lateral Posterior Shoulder

Node selection for lateral posterior shoulder (Table 9.4 for the PLH, LH, and ALH muscular distributions) problems includes shoulder pain and dysfunction reflecting in this area. This involves glenohumeral joint problems, including capsulitis, as well as pain in the lateral and posterior deltoids, subacromial bursitis, supraspinatus tendonitis, infraspinatus tendonitis, and teres minor involvement. Additional nodes may be added to the treatment protocol that addresses the extent and nature of the patient's problems:

- In case of capsulitis, subacromial bursitis, or swelling of shoulder, Yunmen (AMH 2) may also be added
- Bingfeng (PLH 12) added for supraspinatus muscle belonging to the lateral hand (internal membrane) distribution
- If shoulder pain is reflected to deltoid insertion, Naohui (LH 13) can be considered as well
- In case of infraspinatus, teres major, or teres minor involvement, Tianzong (PLH 11) may be added.

### *Candidate Electroneedling (EN) Application*

Electroneedling (EN) may be considered for uncomplicated cases of shoulder problems if they fail to respond to standard needling therapy after three to five treatments. Electroacupuncture might be introduced from the time of the first treatment for complicated cases. These cases have a long history and may have involved surgery as well. They typically have a well documented record of previous treatments and diagnostic imaging studies. Nodes selected for standard treatment are based on Table 9.4 as modified according to the preceding discussion. These same nodes are still used and EN will be applied only to some selected nodes, or one or two additional nodes are to be added. Candidate EN to be added to the standard needing treatment is discussed below for the anterior lateral and lateral posterior shoulder. Frequency, mode, duration, and lead placement for EN are noted as follows:

#### Anterior Lateral Shoulder

**Frequency:** 2 Hz
**Operating Mode:** continuous
**Duration:** 20-30 minutes

Anterior Lateral Shoulder (two circuits)

Fengchi (LF 20) + lead*, to Jianyu (ALH 15) – lead

Jianzhongshu (PLH 15) + lead, to Jianliao (LH 14) – lead

* Plus (+) lead refers to the positive while the minus (–) lead refers to the negative

#### Lateral Posterior Shoulder

**Frequency:** 2 Hz
**Operating Mode:** continuous
**Duration:** 20-30 minutes

1. Lateral Posterior Shoulder (two circuits for ALH distribution)

Dazhu (PLF 11) + lead, to Jianliao (LH 14) – lead

Feishu (PLF 13) + lead, to Naoshu (PLH 10) – lead

2. Lateral Posterior Shoulder (two circuits for PLH and LH distributions)

Fengchi (LF 20) + lead, to Jianliao (LH 14) – lead, for LH (internal membrane)

Jianzhongshu (PLH 15) + lead, to Naoshu (PLH 10) – lead, for PLH

## Remedial Exercises for Muscles Moving the Shoulder Joint

Muscular and tendon problems affecting the shoulder often involve the so-called "rotator cuff" which includes the supraspinatus, infraspinatus, teres minor and subscapularis muscles. The muscles and tendons biceps brachii are also prominent in shoulder dysfunction. These and other muscles moving the shoulder joint are exercised using movements of the arm and shoulders in abduction, lateral rotation, forward flexion, and lateral rotation (See Table 9.3).

## Rotator Cuff

The rotator cuff is comprised of ligaments and tendons of the supraspinatus, subscapularis, infraspinatus, and teres minor muscles. The first of these muscles is involved in shoulder abduction up to about 90° while the other three are essential to internal and external rotation of the shoulder. External rotation exercises, involving the infraspinatus and teres minor mm. are more important is restoring strength since these muscles are not strongly helped by other muscles working assistant to the prime movers. Internal rotation is assisted by strong muscles such as the latissimus dorsi and teres major. Thus special care should be taken to assure that subscapularis m. is participating strongly during internal rotation of the shoulder.

### *Shoulder Abduction to 90°*

This exercise involves abducting the shoulder to 90° while in the seated position to strengthen the supraspinatus m (prime mover), although the middle fibers of the deltoids m. participate. Initially subject is seated with arm at side, with the elbow flexed 90°, forearm in neutral position and shoulder in neutral rotation. This exercise can also be performed side-lying. The subject slowly abducts the arm to 90° and holds the position for 2 - 3 seconds and then slowly lowers arm to start point.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder and back should be contracted to provide antagonistic resistance to shoulder abduction.

When subject is fully capable of completing the above routine it is modified to fully extend the elbow in order to increase to resistive gravity load. With arm by the side and elbow extended in neutral position, the arm is slowly abducted to 90° and held in position for 2 - 3 seconds and then slowly lowers arm to start point. This exercise is repeated up to 8 repetitions and eventually performed for 4-5 sets. As strength permits, shoulder and back muscles should be contracted to provide IDR antagonistic resistance to shoulder abduction. As strength increases light-weight dumbbell can be introduced to increase exercise load and further the strengthening process.

### *Medial (Internal) Rotation*

Medial rotation is used to exercise the prime movers consisting of the subscapularis and teres major muscles, although assistant muscles including the latissimus dorsi, upper pectoralis major and anterior deltoid muscles participate in this movement.

The subject is supine with the shoulder externally rotated and slightly adducted by holding elbow next to body with the elbow flexed 90°, and the forearm in neutral position. The subject slowly internally rotates the shoulder by moving the palmar side of the hand up arcing over toward the lower chest. The arm in then slowly moved by external rotation to the start point.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder and back muscles should be contracted to provide IDR antagonistic resistance to shoulder internal rotation. As strength increases light-weight dumbbell can be introduced to increase exercise load and further the strengthening process.

#### *Lateral (External) Rotation*

Lateral rotation is used to exercise the prime movers involving the infraspinatus and teres minor mm. although the posterior deltoid participates as assistant mover in external rotation. The subject is side lying with the upper arm resting on the side and the shoulder internally rotated and elbow flexed 90°, and the forearm in neutral with palm resting on lower chest. While making a fist the arm is slowly raised in an arc to the full extent of external rotation. The end position is held for 2 - 3 seconds and the arm slowly moved back so fist is resting on lower chest.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder and back muscles should be contracted to provide IDR antagonistic resistance to shoulder external rotation. As strength increases light-weight dumbbell can be introduced to increase exercise load and further the strengthening process.

#### *Combined Lateral (External) and Medial (Internal) Rotation*

This exercise is conducted while lying supine with the shoulder abducted to 90° and elbow flexed to 90° and forearm held in pronation. The arm is externally rotated by moving the dorsum of the hand toward the direction that the head is pointed until the back of the hand touches the floor. The direction is reversed by moving the palmar surface of the hand up toward the ceiling (internal rotation) and then toward the feet, making a 180° arch, until the palm touches the floor. The rotator cuff muscles should be tightened (IDR) to increase the contractile force and alternatively stretch one set of rotator cuff muscles while contracting the other set. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength increases a light weight dumbbell may be introduced to further improve strength.

### Shoulder Forward Flexion

Forward flexion is used exercise the anterior deltoid and upper pectoralis major muscles as prime movers with the biceps long head and short head, and coracobrachialis as assistant muscles participating in flexion of the upper arm.

#### *Biceps Brachii (long head)*

Subject is supine with elbow extended and forearm supinated and resting on floor. The arm is slowly lifted, with elbow extended, to flex the shoulder to 90°. End position is held 2 - 3 seconds and then arm is slowly lowered to start point.

This exercise is repeated up to 8 repetitions and eventually performed for 4-5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder forward flexion. As strength increases light-weight dumbbell can be introduced, grasped with palm facing upward, to increase exercise load and further the strengthening process.

### *Anterior Fibers of Deltoid: Shoulder Flexion to 90°*

Shoulder flexion exercise to 90° is used to strengthen the anterior fibers of the deltoid although assistant muscles, including the biceps brachii, coracobrachialis, middle fibers of the deltoid, clavicular fibers of the pectoralis major, upper and lower fibers of the trapezius and the serratus anterior mm. participate. Subject is supine with arms at side and palms facing the body and with the shoulders slightly abducted. The arm is slowly raised to flex the shoulder to 90° while maintaining the elbow extended and forearm in neutral. End position is held 2 - 3 seconds and then arm is slowly lowered to start point.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder forward flexion. As strength increases light-weight dumbbell can be introduced, grasped with palm facing the body, to increase exercise load and further the strengthening process.

### *Coracobrachialis: Shoulder Flexion and Adduction*

Exercise in shoulder flexion with shoulder adduction is used to strengthen the coracobrachialis m., with assistant muscles including the anterior fibers of the deltoid, clavicular fibers of the pectoralis major, and the short head of the biceps brachii mm participating.

The subject is supine, while shoulder is slightly adducted with external rotation while the elbow is flexed with the forearm supinated. While making a fist, the subject flexes and adducts the shoulder raising the hand above the shoulder, while maintaining slight external rotation. End position is held 2 - 3 seconds and then arm is slowly lowered to start point.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder forward flexion. As strength increases light-weight dumbbell can be introduced, grasped with palm facing upward, to increase exercise load and further the strengthening process.

## Latissimus Dorsi and Teres Major: Shoulder Extension

Shoulder extension exercise involves the prime movers, latissimus dorsi and teres major muscles with the teres minor, posterior fibers of the deltoid, and the triceps participating as assistant movers. The subject is lying prone (test can also be performed seated) with arms to the side with the shoulder in internal rotation and palms facing upward. The subject then slowly extends the shoulder through full range of motion while maintaining slight shoulder adduction. End position is held 2 - 3 seconds and then arm is slowly lowered to the floor.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder extension. As strength increases light-weight dumbbell can be introduced, grasped with palm facing upward, to increase exercise load and further the strengthening process.

## Posterior Fibers of Deltoid: Shoulder Horizontal Abduction

Horizontal abduction (horizontal extension) exercise of the shoulder strengthens the posterior fibers of the deltoid, infraspinatus, and teres minor muscles, with the teres major and latissimus dorsi muscles as assistant movers. The subject is prone with the shoulder abducted to about 75°, the elbow flexed 90°, and the forearm pronated and resting on floor. The elbow is then slowly lifted off the floor to horizontally abduct and slightly externally rotate the shoulder. End position is held 2 - 3 seconds and then elbow is slowly lowered to the floor.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder horizontal abduction.

As strength increasing this exercise is modified to extend the elbow to increase the resistive load while still abducting the shoulders to about 75°. The arm is then slowly lifted off the floor to horizontally abduct and slightly externally rotate the shoulder. End position is held 2 - 3 seconds and then elbow is slowly lowered to the floor. This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength is further increased, light-weight dumbbells can be introduced, grasped with palm facing downward, to increase exercise load and further the strengthening process.

This exercise can also be performed from the standing position by bending forward and allowing the arms to hang down. Shoulder is still maintained in abduction of about 75°, with elbows slightly flexed. Arms are raised to move shoulder into horizontal abduction.

## Pectoralis Major: Shoulder Horizontal Adduction

Exercising the shoulder in horizontal adduction (horizontal flexion) involves the clavicular and sternal heads of the pectoralis major muscle, anterior deltoid, and coracobrachialis muscles as prime movers, with the subscapularis and biceps brachii, short head muscles participating as assistant movers. These muscles are all exercised as a group with prime emphasis on the pectoralis major. If weakness is present in only one group of fibers of the pectoralis muscle, the individual clavicular and sternal heads can be exercised separately, since each head has a separate innervation. In this situation the humerus is positioned so that its direction of resistive force is aligned directly opposite to pull of the fibers in each portion of the pectoralis major.

### *Pectoralis Major: 90° Shoulder horizontal adduction*

With the subject supine with shoulder abducted to 90°, elbow flexed 90°, and forearm neutral and pointing straight up. While making a fist, the shoulder is slowly adducted horizontally through the full range of motion. End position is held 2 - 3 seconds and then arm is moved back to slowly lower the elbow to the floor.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder horizontal adduction. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing the body, to increase exercise load and further the strengthening process.

As strength increases, exercise can be performed with shoulder abducted to 90°, and the elbows extended with arms lying on floor with palms up. Arm is then raised to vertical. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing upward, to increase exercise load and further the strengthening process.

***Pectoralis Major (Clavicular Head)***

The subject is lying supine with the shoulder abducted to 70 - 75°, and elbow flexed 90°. While making a fist, the arm is moved through the full range of motion in the direction of horizontal adduction, forward flexion, and internal rotation with the hand traveling to a point above the contralateral shoulder. End position is held 2 - 3 seconds and then arm is moved back to slowly lower the elbow to the floor.

This exercise is repeated up to 8 repetitions and eventually performed for 5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder horizontal adduction. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing the body, to increase exercise load and further the strengthening process. As strength increases this exercise can be performed with the elbows extended.

***Pectoralis Major (Sternal Head)***

The subject is lying supine with the shoulder abducted to approximately 125 - 135° and elbow flexed 90°. While making a fist, the arm is moved through the full range of motion in the direction of horizontal adduction, extension, and internal rotation with the hand traveling toward the contralateral hip. End position is held 2 - 3 seconds and then arm is moved back to slowly lower the elbow to the floor.

This exercise is repeated up to 8 repetitions and eventually performed for 5 sets. As strength permits, shoulder, arm and back muscles should be contracted to provide IDR antagonistic resistance to shoulder horizontal adduction. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing the body, to increase exercise load and further the strengthening process. As strength increases this exercise can be performed with the elbows extended.

# 10

## Elbow

The elbow functions as a hinge-like joint that allows articulation of the ulnar and humerus bones (humeroulnar joint) by bending and straightening of the elbow in flexion and extension. This hinge action moves only in one plane. The radial bone also articulates with the humerus forming the radiohumeral joint. The elbow also provides the complex action of turning the forearm over in pronation or supination. This movement happens by virtue of articulation between the radius and the ulna occuring simultaneously at the elbow (superior radioulnar joint) and the wrist (inferior radioulnar joint). In the anatomical position of forearm supination, the radius and ulna lie parallel to each other. During pronation the ulna remains fixed while the radius rolls around it at both the wrist and the elbow joints. Forces transmitted through the elbow joint are bascially transferred between the humerus and the ulna. Little force is transmitted between the humerus and the radius. However, at the wrist joint, most of the force is transferred between the radius and the carpus, with the ulna taking very little part in the wrist joint.

The elbow has a joint capsule and key ligaments including the medial collateral ligament, lateral collateral ligament, annular ligament, an interosseous membrane, and the dorsal and palmar ligaments of the inferior radioulnar joint. Primary stability of the elbow is provided by the ulnar collateral ligament located on the medial side of the elbow. However, one of the most common injuries to the elbow occurs on the lateral aspect of the elbow known as lateral epicondylitis, or tennis elbow. The planes and axes of articulation, normal limiting factors to movement of the elbow and forearm, normal end feels and active range of motion for arm movements are noted in Table 10.1.

Neural supply to the elbow and the muscles moving the forearm include the branching of the ulnar nerve (C7 - 8, T1), radial nerve (C5 - 8, T1), and median (C5 - 8, T1) nerves to supply the follow nerves:

- Posterior, lateral and medial cutaneous nerves
- Musculocutaneous: Biceps brachii, long head; Biceps brachii, short head
- Radial: Brachioradialis; Triceps brachii, long head, and lateral; Triceps brachii, medial head; Triceps brachii, lateral head; Anconeus
- Posterior interosseous: Supinator
- Median nerve: Pronator teres
- Anterior interosseous: Pronator quadratus

## Elbow Physiology

Muscles moving the forearm act on the elbow joint to either extend or flex the forearm. They also act on the proximal radioulnar joint to pronate or supinate the wrist and forearm (See Table 10.2).

Table 10.1. Joint structures involved in movement of the elbow

| | Flexion | Extension | Supination | Pronation |
|---|---|---|---|---|
| Articulation | Humeroulnar, radiohumeral | Humeroulnar, radiohumeral | Radiohumeral, superior radioulnar, inferior radioulnar, interosseous membrane | Radiohumeral, superior radioulnar, inferior radioulnar, interosseous membrane |
| Plane | Sagittal | Sagittal | Horizontal | Horizontal |
| Axis | Frontal | Frontal | Longitudinal | Longitudinal |
| Normal limiting factors | Soft tissue apposition of anterior forearm and upper arm; coronoid process contacting coronoid fossa | Olecranon process contacting olecranon fossa; tension in elbow flexors | Tension in pronator mm., palmar radioulnar ligament of inferior radioulnar joint, oblique cord, and interosseous membrane | Contact of radius on ulna; tension in dorsal radioulnar ligament of inferior radioulnar joint, interosseous membrane, and biceps brachii mm. |
| Normal end feel | Soft/hard | Hard/firm | Firm | Hard/firm |
| Normal active range of motion | 0 - 150° | 150 - 0° | 0 – (80 - 90°) | 0 – (80 - 90°) |
| Capsular pattern | Elbow joint: flexion, extension, and rotation full and painless<br>Inferior radioulnar joint: full rotation with pain at extremes of rotation | | | |

Table 10.2. Function, muscle distribution (MD) assignment, and nerve root of primary movers (PM) and assistant/accessory movers (AM) for forearm and radio-ulna articulation

| Muscle | MD | Nerve Root | Flexion | Extension | Medial[1] Rotation | Lateral[2] Rotation |
|---|---|---|---|---|---|---|
| Biceps brachii, long head | ALH | C5, 6 | PM | | | AM |
| Biceps brachii, short head | AMH | C5, 6 | PM | | | AM |
| Brachioradialis | AMH | C5, 6 | PM | | | |
| Brachialis | PMH | C5, 6 | PM | | | |
| Triceps brachii, medial head | PMH | C6, 7, 8 | | PM | | |
| Triceps brachii, long head | PLH | C6, 7, 8 | | PM | | |
| Triceps brachii, lateral head | LH | C6, 7, 8 | | PM | | |
| Anconeus | LH | C7, 8, T1 | | AM | | |
| Supinator | ALH | C5, 6, (7) | | | | PM |
| Pronator teres | PMH | C6, 7 | | | AM | |
| Pronator quadratus | MH | C8, T1 | | | PM | |
| Wrist and finger flexors | | | AM | | | |
| Wrist and finger extensors | | | | AM | | |

1 = Pronation; 2 = Supination

## Disorders Affecting Elbow

There are many common problems associated with the elbow and the wrist joints. These include inflammation and pain in the elbow which is sometimes referred to as "tennis elbow," and similar disorders affecting the wrist, sometimes including tunnel carpal syndrome. All the muscles and joints of the forearm and wrist can experience pain, spasms, paralysis and sensory deficits as well as arthritic conditions, all of which impair the function of the elbow and wrist.

## Problems of Muscles Articulating Elbow

Specific disorders associated with the six longitudinal muscular distributions associated with articulation of the elbow joint and forearm includes:

Anterior medial hand (AMH) distribution:

- Acute cramps and spasms along the anterior lateral aspect of the radius and lateral cupital fossa

Anterior lateral hand (ALH) Intestine distribution:

- Pain, spasms and acute cramps along the lateral posterior aspect of the radius and lateral aspect of the elbow

Lateral hand (LH) distribution:

- Acute cramps and spasms along the posterior region of the forearm between the ulna and radius traveling up to the elbow

Posterior lateral hand (PLH) distribution:

- Pain in the posterior aspect of the medial epicondyle of the elbow which follows along the inner aspect of the arm to enter below the axilla causing pain below the axilla

Posterior medial hand (PMH) distribution:

- Acute cramps and pain in the muscles along the medial anterior region of the ulna and medial aspect of the elbow

Medial hand (MH) distribution:

- Acute cramps, spasms and pain along the anterior region of the forearm between the ulna and radius, up to the cupital fossa

## Pathology of Elbow and Forearm

### *Musculotendinous Lesions*

#### Lateral Epicondylitis

This condition occurs mostly in the dominant arm of middle-aged patients, being less common in males than in females, and occasionally may be bilateral. It is often seen in persons whose sports activities or occupation involves excessive forearm pronation and supination, or use of the wrist. Onset may be gradual being noticed initially in the elbow or forearm, or it may be sudden as seen in playing tennis especially following a change in action, a miss-hit, or following a direct impact to the epicondylar area. Pain is initially apparent over the lateral aspect of the elbow and if severe, it may radiate down forearm and into the dorsum of the hand, including the middle and ring finger. Rarely does the pain radiate up the arm. Wrist movements involving gripping or shaking the hand become difficult due to pain. X-rays of the elbow appear normal for the patient's age although calcification may be noted in small areas in the wrist extensors origin.

A nerve root irritation at C7 can also produce pain that reflects into the lateral aspect of the elbow. But, this particular condition is often associated with paresthesia or other neurological signs thereby helping to differentiate clinical findings.

### Medial Epicondylitis

This condition is not as common as lateral epicondylitis and manifests with pain over the medial compartment of the elbow involving the medial epicondyle which is the origin site of the forearm pronator and wrist flexors. This condition is also known as golfer's elbow although it occurs in people who have never played golf. Occurrence mainly involves middle aged patients whose occupational or athlete endeavors require strong hand grip and adduction movements of the elbow. Pain may radiate distally and is made worse wrist movements, especially involving gripping or repeated wrist flexion. Isometric contraction of the wrist flexors can reproduce the pain. It may also be reproduced by fully resisting forearm pronation or stretching the flexor muscles by fully extending the supinated forearm and then passively hyperextending the wrist.

### Biceps Tendinitis

This condition is somewhat uncommon with the patient complaining of pain that is usually localized to the center of the cupital fossa. Examiner can reproduce the patient's pain by resisting forearm supination or elbow flexion. Stretching the bicep tendon can also reproduce the pain. This is accomplished by the examiner extending the elbow and then applying full passive forearm pronation. Accessory movements of the radioulnar joint may indicate a painful restriction of movement.

### Triceps Tendinitis

This condition occurs infrequently and usually follows a sudden severe strain to the triceps tendon as the arm is fully extended, such as by throwing a javelin. With the patient standing, their pain can be reproduced by fully resisting elbow extension while elbow is flexed with forearm fully supinated. Palpation over the insertion of the triceps into the olecranon may reveal tenderness.

## Examination of Elbow

The elbow is examined prior to prior to any musculoskeletal assessments including possible function tests by having the patient move the elbow in flexion, extension, supination and pronation without moving in to areas of pain. General observation for possible deformities, swellings, and coloration changes are also noted.

### *Elbow Carrying Angle*

The forearms angle slightly away from the body when the arms are held relaxed along the body while standing in the anatomical position. This slight angularity makes it easier to carry something against the body and hence is referred to as the carrying angle. One type of deformity usually the result of a fracture causes the forearm to be angled toward the body. This is called a "gun stock" deformity since it gives the appearance of a gun stock and is classed as "cupitus varus." Normal carrying angle for males is 5° – 10°, while in females it is 10° - 15°.

- Carrying angles greater than 15° is classed as "cupitus valgus"
- Carrying angles less than 5° - 10° is classed as "cupitus varus"

## Active Movements (Range of Motion)

### *Elbow*

Elbow extension and flexion can be measured with the patient either supine or seated. In either case the examiner stabilizes humerus during active movement. Normal range of flexion is 0 - 150° with range of extension being just opposite (150 - 0°). Standard goniometer is used to measure range of flexion and extension. Fixed arm of goniometer is positioned parallel to shaft of the humerus with the axis over the lateral epicondyle.

#### Extension

Extension is measured with the arm in the anatomical position and the elbow extended 0°. In muscular males, with over development of the biceps brachii muscle, extension to 0° may not be possible.

- ➔ Patient substitute shoulder extension

#### Flexion

From the start position of 0° elbow extension, the forearm is moved in the anterior direction until the hand approximates chest or biceps brachii, to the full limit of elbow flexion.

- ➔ Patient substitute shoulder flexion

#### Hyperextension

Hyperextension of 10 - 15° is not uncommon in females because a smaller olecranon. When measured in supine position, humerus is supported on a towel or roll to allow additional motion in hyperextension. Measurement is started from 0° of extension. If measured from seated position, examiner stabilizes humerus at 0° of extension reference.

### *Forearm*

Pronation and supination of the forearm are measured with patient seated with shoulders adducted and elbow flexed to 90° with forearm in held in midposition. Subject grasps a pencil or similar object, protruding from radial aspect of the hand with fist tightly closed. This provides a visual reference for alignment of the hand. Examiner stabilizes patient's humerus. Range of motion can be measured with a standard goniometer or gravity sensitive bubble inclinometer. With use of standard goniometer, the stationary arm is held perpendicular to floor and moveable arm parallel to the pencil. When using an inclinometer, it is positioned on palmar or dorsal surface of the hand from the neutral position. Normal range for both supination and pronation from neutral position midpoint is 80 - 90°.

#### Supination

From the midpoint start position, the forearm is rotated externally so palm faces upward toward ceiling and the pencil is parallel to floor and pointing laterally.

- ➔ Patient may substitute altered grasp of pencil, wrist extension and/or radial deviation, external rotation and adduction of shoulder, and trunk side flexion

#### Pronation

From the midpoint start position, the forearm is rotated internally so palm faces downward toward floor and the pencil is parallel to floor and pointing medially.

➔ Patient may substitute altered grasp of pencil, wrist flexion and/or ulnar deviation, internal rotation and abduction of shoulder, and contralateral trunk side flexion

## Passive Movement with Overpressure

### *Elbow*

- Flexion: Normal end feel is soft/hard
- Extension: Normal end feel is hard/firm

### *Forearm*

- Supination: Normal end feel is firm
- Pronation: Normal end feel is hard/firm

## Resisted Isometric Movement (Elbow)

Muscle strength of the elbow and forearm is evaluated by resisted isometric tests, which are graded 0 - 5 (see Table 4.3). Principal signs of either pain or weakness, or both, are noted. Of the resisted isometric tests, extension, flexion, supination and pronation are conducted for the elbow.

### *Possible Wrist Involvement*

Because of the close association between the wrist and elbow, and the possibility that problems in wrist muscles may reflect at the elbow, resisted isometric tests are often tested at the wrist prior to testing the elbow. Initially, the patient is asked to strongly grip the practitioner's hand. If this reproduces elbow pain, then additional isometric contraction tests are conducted at the wrist.

Resisted extension and radial deviation of the wrist and extension of the fingers are tested if pain is felt over the lateral compartment of the elbow.

Resisted flexion and ulnar deviation of the wrist and flexion of the fingers are tested if pain is felt over the medial compartment of the elbow. Reproduction of these symptoms by the wrist indicates that the problem is mostly related to the wrist.

### *Isolating Problem to Elbow*

Pain on resisted flexion or extension may indicate possible tendinitis of the main muscles moving the forearm. The patterns of pain reflected at the elbow are consistent with the function of each particular muscle that articulates this joint. For example, pain on resisted flexion may manifest in tendinitis of either the biceps brachii, brachioradialis or brachialis muscles, while pain associated with resisted extension may be the result of tendinitis of the triceps brachii mm. Pain on resisted supination might implicate the supinator muscle, however, if pain on lateral rotation of the forearm is accompanied by pain on resisted flexion, the biceps brachii muscle may be indicated. Pain patterns are evaluated in terms of muscle function in order to isolate the particular muscle involved (see Table 10.2).

Painless weakness in the resisted flexion or extension of the forearm usually indicates a neural lesion although ruptures of the musculotendinous structures controlling the elbow do occur. Patterns of muscular weakness can also be noted to identify the particular muscle, nerve root and traditional musculotendinous distribution pathway. All of this information is essential to formulate an effective treatment approach, including the needling therapy strategy.

### *Elbow flexion*

The biceps brachii (long head: ALH, short head: AMH) muscle is the principal flexor of the elbow although the brachialis (PMH) and brachioradialis (AMH) are important accessory muscles to this movement. The biceps brachii is tested separately in flexion from the other two muscles which are examined as a group.

#### Biceps Brachii

In this test the patient is either supine or sitting with the shoulder adducted, with the elbow flexed 90° and the forearm supinated. Isometric resistance is applied to the anterior aspect of the forearm, just proximal to the wrist joint. Resistive force is applied in the direction of elbow extension and forearm pronation.

➔ Patient may substitute contraction of brachialis, since this muscle functions as an elbow flexor regardless of forearm positioning.

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. Patient is in a side-lying position with forearm supinated and flexes elbow through full range of motion while examiner supports weight of upper extremity.

➔ Patient may substitute contraction of brachialis, since this muscle functions as an elbow flexor regardless of forearm positioning.

#### Brachialis and Brachioradialis

As with the biceps brachii test, the patient is either supine or sitting with the shoulder adducted and the elbow flexed 90° with the forearm is pronated. Isometric resistance is applied to posterior aspect of forearm, just proximal to the wrist joint. Resistive force is applied in direction of elbow extension.

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. Patient is in a side-lying position while the examiner supports weight of upper extremity and stabilizes the humerus and the patient flexes elbow through full range of motion with forearm pronated.

### *Elbow Extension*

Triceps (medial head-PMH, lateral head-LH, long head-PLH) are the principal extensors of elbow. Anconeus (LH) is accessory muscle to this movement. Patient is supine with shoulder internally rotated and flexed to 90° and elbow flexed 90° so arm is above the chest. Resistance is applied in the direction of elbow flexion, on posterior aspect of forearm proximal to the wrist, while examiner stabilizes humerus.

Alternative to this, in case of weakness in shoulder muscles, patient can be placed in prone position with shoulder abducted, elbowed flexed 90°, and supinated forearm hanging straight down over edge of table. A towel or roll is used to support humerus for patient comfort while stabilizing humerus, especially when resistance is applied. Isometric resisted force is applied in the direction of elbow flexion, on posterior aspect of forearm proximal to the wrist, while examiner stabilizes humerus.

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. Patient is in a side-lying position while examiner supports weight of upper extremity and stabilized the humerus and patient extends elbow from fully flexed position, through full range of motion while forearm supinated.

➔ Patient may substitute scapular depression and shoulder external rotation, permitting gravity to complete ROM

### *Supination*

Muscles responsible for supination of the forearm are the supinator (ALH) and biceps brachii (long head - ALH, short head - AMH). Test is performed with patient seated, shoulder adducted, elbow flexed to 90°, and forearm supinated. Isometric resistance is applied on posterior surface of the radial distal end with counter resistance on anterior aspect of the ulna. Force is applied in direction of forearm pronation.

➔ Patient may substitute shoulder external rotation, shoulder adduction, and side flexion of ipsilateral trunk

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. Patient is supine with shoulder adducted, elbow flexed to 90° and forearm pronated. Forearm is pointing straight upward. Alternate to this, patient can be seated with shoulder and elbow flexed to 90° with forearm pronated. Patient supinates forearm through full range of motion while examiner stabilizes humerus and palpates supinator and biceps brachii muscles.

➔ Patient may substitute shoulder adduction and external rotation

Biceps brachii does not supinate forearm when elbow is in extension. Thus, the supinator muscle can be isolated in seated patient while shoulder is adducted and forearm extended so arm hangs straight down. Supinator can be isolated as patient supinates the forearm from the pronated position.

### *Pronation*

Pronator teres (PMH) and pronator quadratus (MH) muscles are responsible for pronation of the forearm. Test is performed with patient seated, shoulder adducted, elbow flexed to 90°, and forearm pronated. Isometric resistance is applied on anterior surface of the radial distal end with counter resistance on posterior aspect of the ulna. Force is applied in direction of forearm supination.

➔ Patient may substitute shoulder abduction and shoulder internal rotation.

If the isometric strength is less then Grade 2+, a gravity eliminated test may be indicated. Patient is supine with shoulder adducted, elbow flexed to 90° and forearm supinated. Forearm is pointing straight upward. Alternate to this, patient can be seated with shoulder and elbow flexed to 90° with forearm supinated. Patient pronates forearm through full range of motion while examiner stabilizes humerus and palpates pronator teres muscle.

➔ Patient may substitute shoulder abduction and shoulder internal rotation.

## Functional Assessment

Can involve simple movements such as flexing the elbow to touch shoulder, extending the elbow to touch front of body, and pronating and supinating the forearm with the elbow flexed 90° and with the elbow fully extended (0°). Possible painful arc (in degrees) is noted during elbow flexion.

### *Accessory Movements*

The small ROM in synovial and cartilaginous joints of the elbow beyond that which is achieved by active movements is evaluated and graded according to Table 4.5.

### *Humeroulnar Joint*

#### Longitudinal-Caudal

Longitudinal caudad accessory movement of the humeroulnar joint is produced by applying force along the forearm, while it is in flexion, to distract the joint. Pressure is applied in direction aligned with the humerus.

#### Extension-Adduction

Accessory movement of the humeroulnar joint, in adduction, is evaluated through the first 5° of flexion from the position of full extension. With the patient supine, the examiner holds the fully extended elbow while applying pressure to the arm in the direction of adduction by holding the wrist and hand. The elbow is then moved from full extension through the initial 5° of flexion. Examiner feels the accessory movement with the hand supporting the elbow.

#### Extension-Abduction

Accessory movement of this joint in abduction is just opposite to the procedure for testing adduction. The fully extended humeroulnar joint is held and supported by one hand while the examiner applies pressure to the wrist in the direction of abduction. The elbow is then moved from full extension through the initial 5° of flexion.

### *Radiohumeral Joint*

#### Anteroposterior

With the patient supine anteroposterior gliding movement is induced by applying thumb pressure over the head of the radius. Examiner's fingers surround the elbow to stabilize the distal end of the humerus and help palpate accessory movement.

#### Posteroanterior

Posteroanterior gliding movement is induced by applying thumb pressure to posterior surface of the radial head, while patient's arm is flexed and resting against the examiner.

#### Longitudinal caudal (distraction)

Longitudinal caudad movement is produced by pulling along distal region of radius while holding the humerus with examiner's other hand. Patient's arm can be held in extension or with a few degrees of flexion. Force is applied to distract radius longitudinally in respect to the humerus while examiner feels accessory movement with hand stabilizing the elbow.

#### Longitudinal cephalad (approximation)

With the patient supine and arm extended or flexed a few degrees, examiner applies longitudinal cephalad compressive force along the shaft of the radius by holding the distal region of the radius. Accessory movement of radius in respect to the humerus is detected by palpating the region of the lateral aspect of the elbow joint.

### *Superior Radioulnar Joint*

#### Anteroposterior

Anteroposterior movement is produced by applying pressure over the anterior surface of the head of the radius with the thumbs of both hands while stabilizing the ulna from behind with the examiner's fingers. Elbow is extended or slightly flexed and the forearm may be pronated, supinated, or held midway between the two extremes.

#### Posteroanterior

Posteroanterior movement is also applied to the head of the radius in opposite direction of the anteroposterior movement. With the patient's arm either held in slight flexion or rested against the practitioner, pressure is applied over the posterior surface of the radial head. Fingers surround the joint to stabilize the ulna on the anterior side and detect movement between the radius and ulna. Patient can also be positioned on their side with tested limb up, to perform this movement assessment.

#### Longitudinal Caudal (Distraction)

Longitudinal caudad movement is produced by pulling along the distal region of radius while holding the elbow with the examiner's other hand. Patient's arm is held in slight flexion. Force is applied to distract the radius longitudinally in respect to the ulna while the examiner feels accessory movement with the hand stabilizing the elbow.

#### Longitudinal Cephalad (Approximation)

With the patient supine and arm flexed to 90°, the examiner applies downward force by holding the distal region of the radius to produce longitudinal cephalad movement along the shaft of the radius. Accessory movement of the radius in respect to the ulna is detected by palpating the region of the superior radioulnar joint.

### *Inferior Radioulnar Joint*

Five accessory movements are routinely examined for this joint as noted in the following. Normally, the patient is supine with the elbow flexed 90° and the forearm held straight up for easy access by the examiner.

#### Anteroposterior

Anteroposterior movement is produced by grasping the ulnar between the thumb and side of the index finger, which is flexed, with one hand of the examiner while holding the radius in similar manner with the other hand. Thumb pressure is applied over the anterior surface of the ulnar while stabilizing the radius.

#### Posteroanterior

Posteroanterior movement is produced by grasping the ulnar and radius as described above, but from the posterior aspect of the wrist. Thumb pressure is applied over the posterior surface of the ulnar while stabilizing the radius.

#### Compression

Approximation of the inferior radioulnar joint surfaces is produced by laterally compressing the ulnar and radius toward each other. The examiner grasps the patient's hand from the posterior aspect with thumbs on the dorsal surface and fingers holding the palm. The examiner flexes his or her wrists so that the forearms are aligned perpendicular to the patient's forearm and the base of the examiner's hands apply pressure over the ulna and radius.

**Longitudinal Caudad**

Longitudinal caudal movement of the radius is produced by holding the forearm proximal to the wrist and deviating the wrist in the ulnar direction.

**Longitudinal Cephalad**

Longitudinal cephalad movement of the radius is produced by holding the forearm proximal to the wrist and deviating the wrist in the radial direction.

## Diagnostic Imaging

### *Plain Film Radiography*

**Anteroposterior View:** Used to note the relationship of the epicondyles, capitulum, trochlea, radial head, radial tuberosity, olecranon process, and coronoid process. Possible loose bodies, joint space narrowing, myositis osssificans, calcifications, or osteophytes should be noted.

**Lateral View:** Also used to note the relationship of the epicondyles, capitulum, trochlea, radial head, radial tuberosity, olecranon process, and coronoid process.

Axial View: This view obtained with the elbow flexed 45° to show the olecranon process and epicondyles.

### *Magnetic Resonance Imaging (MRI)*

Magnetic resonance imaging is used to differentiate bone and soft-tissue due to its high contrast of soft-tissue. MRI is used to discriminate among bone marrow, cartilage, tendons, nerves, and vessels and therefore demonstrate tendon ruptures, collateral ligament ruptures, cubital tunnel pathology, and epicondylitis.

# Management of Elbow Disorders

## Elbow Mobilization

Any of the physiological or accessory movements of the elbow and radioulnar joints described above can be applied to improve mobility and reduce pain in affected joints. Passive movement treatments are graded from I-V and consist of either small or larger amplitude oscillations that do not move into the restricted or painful area, except for grade V which involves a sharp thrust beyond the pathological limit of movement (See Table 5.1). Grade V mobilization techniques are not usually applied to the elbow.

## Needling Therapy for Elbow Problems

Appropriate local and adjacent, distal and proximal acupoints for the treatment of common elbow problems are noted in Table 10.3. Different sets of proximal and distal points are applied in the treatment of elbow problems depending on the associated three yang muscular distributions of the hand, which is either associated with the problem or contains the problem within the affected muscular distribution pathway.

### *Node Selection*

Candidate node selection for elbow problems (Table 10.3) addresses elbow pain and dysfunction reflecting in this area. These nodes represent three muscular distributions with appropriate proximal and distal nodes. Candidate local and adjacent nodes are considered depending on the specific area of the elbow in which pain is reflected. If elbow pain is accompanied with pain in the shoulder then appropriate nodes in this region may be added, such as Jianyu (ALH 15), Jianliao (LH 14), or Naoshu (PLH 10). If elbow problem is manifest within the entire joint and it is not obvious as to which muscular distribution in involved, then all the candidate local and adjacent nodes as well as the distal nodes may be considered.

Table 10.3. Selection of regional, proximal and distal nodes for treatment of elbow and forearm problems.

| Pain or Disorder of Elbow | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Quchi (ALH 11)<br>Zhouliao (ALH 12) | ALH* | Dazhu (PLF 11)<br>Feishu (PLF 13) | Hegu (ALH 4) |
| | Chize (AMH 5)<br>Tianjing (LH 10) | LH | Fengchi (LF 20)<br>Jianzhongshu (PLH 15) | Zhongzhu (LH 3) |
| | Xiaohai (PLH 8) | PLH | Tianzhu (PLF 10)<br>Jianzhongshu (PLH 15) | Houxi (PLH 3) |

* Can consider Huatuojiaji nodes at T1 and T3 level.

### Lateral Elbow

If problem principally manifests in the lateral epicondyle it mainly relates to the ALH distribution. Candidate local and adjacent nodes would include Quchi (ALH 11), Zhouliao (ALH 12), and Tianjing (LH 10), with proximal and distal nodes associated with the ALH distribution and perhaps LH (internal membrane) distribution. In addition the node Chize (AMH 5) can be considered. Wrist extensors may be involved in lateral epicondylitis with pain in the forearm. In this case the nodes Shousanli (ALH 10) or Shanglian (ALH 9) could be added, which also address problems in supination.

### Medial Elbow

If problem principally manifests in the medical epicondyle it mainly relates to the PLH distribution. Candidate local and adjacent nodes would include Xiaohai (PLH 8) and Tianjing (LH 10), with proximal and distal nodes associated with the PLH distribution. The node Shaohai (PMH 3) can also be considered and is specific for problems in the pronator teres muscle. Wrist flexors may be involved in medial epicondylitis with pain in the forearm. In this case the node Zhizheng (PLH 7) could be added. Neiguan (MH 6) added for the pronator quadratus.

### Olecranon Area

If problem principally manifests in the olecranon it mainly relates to the LH distribution. Candidate local and adjacent nodes would include Tianjing (LH 10), Xiaohai (PLH 8), and Zhouliao (ALH 12), and, with proximal and distal nodes associated with the LH (internal membrane) distribution. If pain is reflected into the forearm, Sidu (LH 9) can be considered.

## *Candidate Electroneedling (EN) Application*

One suggested lead placement for adding electroneedling is listed below for the three muscular distributions involving a proximal and local node. A possible alternative is provided involving a circuit from the local node to the distal node. Elbow problems may manifest within more than one distribution. In that situation two or even three candidate EN circuits could be employed. If more than one EN circuit is employed, then they have to be consistent with all using the proximal to local circuit or the local to distal circuit. Specific recommendations include the following:

**Frequency:** 2 Hz
**Mode:** Continuous
**Duration:** 20-30 minutes

Anterior lateral hand (ALH) distribution (lateral epicondyle of humerus):

- Dazhu (PLF 11) + lead, to Quchi (ALH 11) – lead
- Or Zhouliao (ALH 12) + lead, to Hegu (ALH 4) – lead

Posterior lateral hand (PLH) distribution (medial epicondyle of humerus):

- Jianzhongshu (PLH 15) + lead, to Xiaohai (PLH 8)– lead
- Or Xiaohai (PLH 8) + lead, to Houxi (PLH 3) – lead

Lateral hand (LH) distribution:

- Fengchi (LF 20) + lead, to Tianjing (LH 10) – lead
- Or Tianjing (LH 10) + lead, to Zhongzhu (LH 3) – lead

## Remedial Exercises for Elbow and Radio-Ulnar Articulation

Exercises of the elbow and forearm involve movements in extension, flexion, supination and pronation (See Table 10.2).

## Elbow Flexion

Prime movers in elbow flexion include the biceps brachii (long head and short head), brachialis, and brachioradialis muscles with several other muscles participating as assistant movers (See Table 10.2). The biceps brachii can be exercised separately in flexion from the other two muscles which are exercised as a group.

### *Biceps Brachii*

The subject is either seated or supine with the shoulder adducted, the elbow extended, and the forearm supinated. While making a fist, the forearm is slowly raised to the full extent of elbow flexion. End position is held 2 - 3 seconds and then forearm is slowly moved back to the start position.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder and arm muscles should be contracted to provide IDR antagonistic resistance to elbow flexion. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing up or forward, to increase exercise load and further the strengthening process.

### *Brachialis and Brachioradialis*

The subject is either seated or supine with the shoulder adducted and the elbow extended, but here the forearm is pronated or in neutral position. While making a fist, the subject slowly flexes the elbow through the full range of motion End position is held 2 - 3 seconds and then forearm is slowly moved back to the start position.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder and arm muscles should be contracted to provide IDR antagonistic resistance to elbow flexion. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing down or backward, to increase exercise load and further the strengthening process.

### Triceps: Elbow extension

Triceps (medial, lateral, and long heads) are the principal movers that extend the elbow. The anconeus and several other muscles of the forearm are assistant movers for elbow extension. The subject is supine with shoulder internally rotated and flexed to 90° so upper arm is pointed straight up. Elbow is flexed and forearm supinated with hand resting near opposite shoulder. While making a fist, the subject slowly lifts forearm to extend elbow through full range of motion and arm is fully extended vertically. End position is held 2-3 seconds and then arm is moved back to slowly lower the hand to the chest.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, shoulder and arm muscles should be contracted to provide IDR antagonistic resistance to elbow extension. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing the chest, to increase exercise load and further the strengthening process.

### Supinator and Biceps Brachii: Supination

Muscles responsible for supination of the forearm are the supinator and biceps brachii. The subject is seated, shoulder adducted, elbow flexed to 90°, and forearm pronated. While making and holding a fist, the subject slowly supinates the forearm on the count of 3 and holding the end position 2 - 3 seconds. Forearm is then slowly rotated back to the start position.

This exercise is repeated up to 8 repetitions and eventually performed for 5 sets. As strength permits, arm and forearm muscles should be contracted to provide IDR antagonistic resistance to supination. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing downward, to increase exercise load and further the strengthening process. Forearm supination exercise is normally combined with pronation exercise.

### Pronator Teres and Pronator Quadratus: Pronation

Pronator teres and pronator quadratus muscles are responsible for pronation of the forearm. The subject is seated, shoulder adducted, elbow flexed to 90°, and forearm supinated. While making and holding a fist, the subject slowly pronates the forearm on the count of 3 and holding the end position 2 - 3 seconds. Forearm is then slowly rotated back to the start position.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, arm and forearm muscles should be contracted to provide IDR antagonistic resistance to pronation. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing upward, to increase exercise load and further the strengthening process. Forearm pronation exercise is normally combined with supination exercise.

# 11.

# Wrist and Hand

The wrist joint is made up of the distal end of the radial and ulnar bones involving the radial and ulnar styloid processes of the forearm and the eight carpal bones (scaphoid or navicular, lunate, triquetrum, pisiform, trapezium, trapezoid, capitate, and the hamate). The wrist joints are referred to as the radiocarpal and midcarpal joints and structures involved in their movement are noted in Table 11.1. Joints within the carpus include the pisiform, midcarpal, common carpometacarpal, and trapeziometacarpal joints. Many ligaments connect these bones to each other. The wrist is a common source of fractures as well as ligament sprains which can occur without any evidence of bone injury; basically without bones fractures or cracks. In the case a sprain there is usually only a partial tearing of the ligaments such as in a First (1°) or Second (2°) degree sprain. In a severe or Third (3°) wrist sprain, there would be complete rupture of a ligament. Wrist injuries can also result in a strain or tearing of the muscle fibers in the area surrounding the wrist.

Repetitive motion associated with the constant use of computer keyboards and cash registers has resulted problems of both the wrist and hand. One condition resulting in pain and numbness is occurring more often. This is called carpal tunnel syndrome and results from irritating or compressing the median nerve which supplies movement feeling to the thumb and thumb side of the hand.

The hand contains a large number of small bones including the metacarpal bones which proximally articulates with the carpus and distally with the phalanges of the thumb and fingers. These form metacarpophalangeal (MCP) joints, proximal interphalangeal (PIP), and terminal interphalangeal (TIP) for second to fifth fingers. Characteristics of joint structures involved in movement of second to fifth fingers are noted in Table 11.2. Movement of the thumb is slightly different involving the carpometacarpal (CM), metacarpophalangeal (MCP), and interphalangeal (IP) joints. Characteristics of joint structures involved in movement of the thumb are listed in Table 11.3. Planes and axes of articulation, normal limiting factors to movement of wrist, fingers and thumb, normal end feels and active range of motion for these movements are noted in Tables 11.1, 11.2 and 11.3.

## Physiology of the Wrist and Fingers

### Muscles of the Wrist

Muscles moving the wrist have their origins on the distal part of the humerus and extend to the wrist, inserting mostly on the metacarpal bones. They function to extend, flex, abduct or adduct the wrist (See Table 11.4).

### Muscles of Thumb and Fingers

Thumb and fingers can be extended, flexed, abducted and adducted from their metacarpophalangeal joints as well as extended and flexed from their interphalangeal joints (See Table 11.5). In addition, owing to the fact that the thumb has two interphalangeal joints, it can also be rotated and circumducted.

Table 11.1. Joint structures involved in movement of wrist

| | Flexion | Extension | Radial Deviation | Ulnar Deviation |
|---|---|---|---|---|
| Articulation | Midcarpal, Radiocarpal | Midcarpal, Radiocarpal | Midcarpal, Radiocarpal | Radiocarpal |
| Plane | Sagittal | Sagittal | Frontal | Frontal |
| Axis | Frontal | Frontal | Sagittal | Sagittal |
| Normal limiting factors | Tension in posterior radiocarpal ligament and posterior joint capsule | Tension in anterior radiocarpal ligament and anterior joint capsule; contact between radius and carpal bones | Tension in ulnar collateral ligament, ulnocarpal ligament, and ulnar portion of joint capsule; contact between radial styloid process and scaphoid bone | Tension in radial collateral ligament and radial portion of joint capsule |
| Normal end feel | Firm/hard | Firm/hard | Firm/hard | Firm |
| Normal active range of motion | 0 - 80° | 0 - 70° | 0 - 20° | 0 - 30° |
| Capsular pattern | Flexion and extension equally restricted | | | |

Table 11.2. Normal limiting factors and characteristics of joint structures involved in movement of second to fifth fingers

| | Flexion | Extension | Abduction | Adduction |
|---|---|---|---|---|
| Articulation | Metacarpophalangeal (MCP), Proximal interphalangeal (PIP), Terminal interphalangeal (TIP) (second to fifth fingers) | MCP | MCP | MCP |
| Plane | Sagittal | Sagittal | Frontal | Frontal |
| Axis | Frontal | Frontal | Sagittal | Sagittal |
| Normal limiting factors | MCP: tension in posterior joint capsule, collateral ligaments, contact between the proximal phalanx and metacarpal<br>PIP: contact between middle and proximal phalanx; soft tissue apposition of middle and proximal phalanges; tension in posterior joint capsule, collateral ligaments<br>TIP: tension in posterior joint capsule, collateral ligaments, and oblique retinacular ligament | Tension in anterior radiocarpal ligament and anterior joint capsule; contact between radius and carpal bones | Tension in ulnar collateral ligament, ulnocarpal ligament, and ulnar portion of joint capsule; contact between radial styloid process and scaphoid bone | Tension in radial collateral ligament and radial portion of joint capsule |
| Normal end feel | MCP: firm/hard<br>PIP: hard/soft/ firm<br>DIP: firm | MCP: firm<br>PIP: firm<br>TIP: firm | Firm | |
| Normal active range of motion | MCP: 0 - 90°<br>PIP: 0 - 100°<br>TIP: 0 - 90° | MCP: 0 - 45°<br>PIP: 0°<br>TIP: 0° | | |
| Capsular pattern | Metacarpophalangeal and interphalangeal joints: extension, flexion | | | |

Table 11.3. Normal limiting factors and characteristics of joint structures involved in movement of the thumb

| | Flexion | Extension | Palmar Abduction | Adduction |
|---|---|---|---|---|
| Articulation | Carpometacarpal (CM)<br>Metacarpophalangeal (MCP)<br>Interphalangeal (IP) | CM<br>MCP<br>IP | CM<br>MCP | CM<br>MCP |
| Plane | CM: oblique frontal<br>MCP: frontal<br>IP: frontal | CM: oblique frontal<br>MCP: frontal<br>IP: frontal | CM: oblique sagittal | CM: oblique sagittal |
| Axis | CM: oblique sagittal<br>MCP: sagittal<br>IP: sagittal | CM: oblique sagittal<br>MCP: sagittal<br>IP: sagittal | CM: oblique frontal | CM: oblique frontal |
| Normal limiting factors | CM: Soft tissue apposition between thenar eminence and palm; tension in posterior joint capsule, extensor pollicis brevis, and abductor pollicis brevis<br>MCP: contact between first metacarpal and proximal phalanx; tension in posterior joint capsule, collateral ligaments, extensor pollicis brevis<br>IP: tension in posterior joint capsule, collateral ligaments; contact between distal phalanx, fibrocartilagenous plate, and proximal phalanx | CM: tension in anterior joint capsule, flexor pollicis brevis, and first dorsal interosseous<br>MCP: tension in anterior joint capsule, palmar ligament, and flexor pollicis brevis<br>IP: tension in anterior joint capsule, palmar ligament | Tension in fascia and skin of first web space, first dorsal interosseous, and adductor pollicis | Soft tissue apposition between thumb and index finger |
| Normal end feel | CM: soft/ firm<br>MCP: hard/ firm<br>IP: firm/ hard | CM: firm<br>MCP: firm<br>IP: firm | Firm | |
| Normal active range of motion | CM: 0 - 15°<br>CMP: 0 - 50°<br>IP: 0 - 80° | CM: 0 - 20°<br>CMP: 0°<br>IP: 0 - 20° | | |
| Capsular pattern | Carpometacarpal joint: abduction, extension<br>Metacarpophalangeal and interphalangeal joints: extension, flexion | | | |

### Muscles of Thumb and Fingers

Thumb and fingers can be extended, flexed, abducted and adducted from their metacarpophalangeal joints as well as extended and flexed from their interphalangeal joints (See Table 11.5). In addition, owing to the fact that the thumb has two interphalangeal joints, it can also be rotated and circumducted.

## Disorders of Wrist and Hand

### Disorders in Moving the Wrist

There are many common problems associated with the elbow and the wrist joints. These include inflammation and pain in the elbow which is sometimes referred to as "tennis elbow", and similar disorders affecting the wrist, sometimes including tunnel carpal syndrome. All the muscles and joints of the forearm and wrist can experience pain, spasms, paralysis and sensory deficits as well as arthritic conditions, all of which impair the function of the elbow and wrist. Specific disorders associated with the six muscular pathways of the arm and wrist includes:

Anterior medial hand (AMH) distribution:

- Acute cramps and spasms along the anterior lateral aspect of the radius from the region between wrist and lateral cupital fossa

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps along the lateral posterior aspect of the radius from the region between wrist and lateral aspect of the elbow

Lateral hand (LH) distribution:

- Acute cramps and spasms along the posterior region of the forearm between the ulna and radius traveling up from the wrist to the elbow

Posterior lateral hand (PLH) distribution:

- Pain in the posterior aspect of the medial epicondyle of the elbow which follows along the inner aspect of the arm to enter below the axilla causing pain below the axilla

Posterior medial hand (PMH) distribution:

- Acute cramps and pain in the muscles along the medial anterior region of the ulna from the wrist to the medial aspect of the elbow

Medial hand (MH) distribution:

- Acute cramps, spasms and pain along the anterior region between the ulna and radius, from the wrist to the cupital fossa
- Pain and dysfunction in the wrist including tunnel carpal syndrome

Table 11.4. Function, muscle distribution (MD) assignment, and nerve root of primary movers (PM) and assistant/accessory movers (AM) articulating the wrist

| Muscle | MD* | Nerve Root | Flexion | Extension | Ulnar[1] Deviation | Radial[2] Deviation |
|---|---|---|---|---|---|---|
| Flexor carpi radialis | MH | C6, 7 | PM | | | PM |
| Flexor carpi ulnaris | PLH | C8, T1 | PM | | PM | |
| Flexor digitorum superficialis | PMH | C7, 8, T1 | AM | | | |
| Flexor digitorum profundus | MH | C8, T1 | AM | | | |
| Extensor carpi radialis brevis | ALH | C6, 7, 8 | | PM | | AM |
| Extensor carpi radialis longus | ALH | C6, 7, 8 | | PM | | PM |
| Extensor carpi ulnaris | LH | C6, 7, 8 | | PM | PM | |
| Extensor digitorum (communis) | ALH | C6, 7, 8 | | AM | | AM |
| Extensor indicis | LH | C6, 7, 8 | | AM | | |
| Extensor digiti minimi | LH | C6, 7, 8 | | AM | | |
| Palmaris longus | PMH | C7, 8, T1 | AM | | | |
| Flexor pollicis longus | AMH | C7, 8, T1 | AM | | | |
| Abductor pollicis longus | ALH | C6, 7, 8 | AM | | | AM |
| Extensor pollicis brevis | ALH | C6, 7, 8 | | | | AM |
| Extensor pollicis longus | ALH | C6, 7, 8 | | AM | | AM |

*Muscle longitudinal distribution pathway; 1 = Adduction; 2 = Abduction

Table 11.5. Function, muscle distribution (MD) assignment, and nerve root of the primary movers (PM) and assistant/accessory movers that articulate the thumb and fingers

| Muscle | MD | Nerve Root | Extension | Flexion | Abduction | Adduction | Opposition |
|---|---|---|---|---|---|---|---|
| Extensor digitorum (communis) | ALH | C6, 7, 8 | PM | | AM | | |
| Extensor digiti minimi | LH | C6, 7, 8 | PM | | AM | | |
| Extensor indicis | LH | C6, 7, 8 | PM | | | AM | |
| Extensor pollicis longus | ALH | C6, 7, 8 | PM | | AM | | |
| Extensor pollicis brevis | ALH | C6, 7, 8 | PM | | AM | | |
| Abductor pollicis longus | ALH | C6, 7, 8 | PM[3] | | PM[3] | | |
| Abductor pollicis brevis | AMH | C7, 8, T1 | AM | AM[2] | PM[3] | | |
| Abductor digiti minimi | PLH | C8, T1 | | AM[2] | AM[2] | | |
| Adductor pollicis | ALH | C8, T1 | | | | PM[3] | PM[3] |
| Flexor pollicis longus | AMH | C7, 8, T1 | | PM | | | |
| Flexor pollicis brevis | AMH | C6, 7, 8, T1 | | PM | | | AM |
| Opponens pollicis | AMH | C6, 7, 8, T1 | | | | | PM[3] |
| Flexor digitorum superficialis | PMH | C7, 8, T1 | | PM | | | |
| Flexor digitorum profundus | MH | C7, 8, T1 | | PM | | | |
| Flexor digiti minimi | PMH | C8, T1 | | PM | | | |
| Opponens digiti minimi | PMH | C8, T1 | | | | | PM[3] |
| I & II Lumbricals | MH | C7, 8, T1 | PM[1] | PM[2] | | | |
| III & IV Lumbricals | PMH | C8, T1 | | PM[2] | | | |
| 1st dorsal interosseous | ALH | C8, T1 | AM[1] | AM[2] | AM[2] | | |
| 4th dorsal interosseous | LH | C8, T1 | AM[1] | AM[2] | AM[2] | | |
| 1st & 2nd palmar interosseous | MH | C8, T1 | AM[1] | AM[2] | | PM[2] | |
| 3rd palmar interosseous | PMH | C8, T1 | AM[1] | AM[2] | | PM[2] | |

*Muscle and vessel distribution pathway; 1. For 1st and 2nd lumbricals at interphalangeal joints; 2. For metacarpophalangeal joint; 3. For carpometacarpal joint of thumb

## Disorders in Moving the Thumb and Fingers

Disorders of muscular distributions in the hand and fingers can result in cramps, spasms and pain and dysfunction of the thumb and fingers. This can include inflammation, arthritic conditions and paralysis. Specific disorders related to the six muscular distributions to the thumb and fingers include the following:

Anterior medial hand (AMH) distribution:

- Acute cramps, spasms and pain in the thumb up to the wrist

Anterior lateral hand (ALH) distribution:

- Pain, spasms and acute cramps in the index finger and along dorsal region of the second (2nd) metacarpal up to the wrist

Lateral hand (LH) distribution:

- Acute cramps, spasms and pain in the region of the fourth (4th) finger and dorsal surface of hand up to the wrist

Posterior lateral hand (PLH) distribution:

- Pain in the little finger following up along the medial posterior aspect of the hand up to the wrist

Posterior medial hand (PMH) distribution:

- Acute cramps and pain in the muscles along the radial side of the fifth (5th) finger and medial palmar region of the hand up to the wrist

Medial hand (MH) distribution:

- Acute cramps, spasms and pain along region of middle finger and palmar surface of hand up to the wrist

## Pathology Affecting Wrist and Hand

### *Soft-tissue Lesions*

#### Musculotendinous Lesions

- Extensor Carpi Radialis
- Extensor Carpi Ulnaris
- Flexor Carpi Ulnaris
- Flexor Carpi Radialis

#### Ligamentous Sprains

- Inferior Radioulnar Joint
- Radiocarpal Joint
- Intercarpal Joints
- Metacarpophalangeal Joints

#### Compound Palmar Ganglion

This condition involves a chronic inflammatory synovitis of the flexor tendon sheath at the wrist with visible and palpable swelling proximal to the flexor retinaculum in the forearm and distal to it in the palm. The inflamed synovial membrane is thickened and may contain fibrin deposits. Rheumatoid arthritis is most common cause

#### Dupuytren's Contracture

This condition involves a shortening, thickening, and fibrosis of the palmar fascia, producing a progressive flexion deformity of a finger or fingers. This term is also applied to a flexion deformity of the toes involving the plantar fascia.

#### Volkmann's Ischemic Contracture

This condition involves a contraction of the fingers and sometimes the wrist, with loss in strength, developing rapidly after a severe injury in the region of the elbow joint, or due to the improper use of tourniquet. A similar condition may develop in the distal extremities involving the foot when similar vascular damage is sustained to the muscles of the foot.

#### de Quervain's syndrome

This syndrome consists of a painful tenosynovitis due to a relative narrowness of the common tendon sheath of the abductor pollicis longus and the extensor pollicis brevis. Pain due to this condition can be reproduced by patient grasping their thumb by fingers on same hand and examiner then moves the wrist into passive ulnar deviation.

**Bouchard's and Heberden's nodes**

These conditions involve degenerative bone disease where bony and cartilaginous enlargement occurs in the proximal interphalangeal (PIP) joints (Bouchard's nodes) or terminal interphalangeal (TIP) joints (Heberden's nodes) of the fingers.

**Chondrocalcinosis**

This consists of calcium deposits in cartilage. May involve an apparent hereditary condition similar to gout (pseudogout) but with crystals of calcium pyrophosphate, as opposed to urate crystals for true gout, in the synovial fluid. This leads to calcification and degenerative changes in the cartilage.

**Colles' or Smith's fractures**

Fracture of the distal end of the radius in which the lower fragment is displaced posteriorly. If it is displaced anteriorly it is a reversed Colles' or Smith's fracture.

***Joint Lesions***

Lesions of wrist and joints include soft-tissue and bony-tissue swelling as well as deformities, instability and ankylosis. These problems are often the result of various forms of arthritis, including rheumatoid, osteo, psoriatic and inflammatory types. Trauma and repeated stress injuries also account for joint lesions. Some of the more common changes noted by joint lesions are summarized in Table 11.6 for wrist and hand joints.

***Bone Disorders***

- Osteochondritis of Lunate
- Neurovascular Lesions
  - Shoulder-Hand Syndrome
  - Sudeck's Atrophy

***Nerve Entrapments***

- Carpal-Tunnel Syndrome
- Ulnar Nerve Compression
- Bowler' Thumb

## Examination of Wrist and Hand

### Observation

- Posture
- Deformities
- Swelling
- Muscle Wasting
- Skin Changes

### Active Movements (Range of Motion)

***Wrist and Carpus***

**Flexion and Extension**

Wrist flexion and extension ROM are measured with patient seated and forearm resting on a table in pronation. Hand is held over end of table with wrist in neutral position while examiner stabilizes forearm. Fingers are slightly extended for measurement of flexion and slightly flexed for measurement of extension.

Axis of goniometer is held at the level of the ulnar styloid process with stationary arm parallel to shaft of the ulna. Goniometer moveable arm is held parallel to longitudinal axis of fifth metacarpal. For flexion measurement, wrist is moved in volar direction to limit of motion (80°) and is moved in dorsal direction to limit of motion (70°) for extension. It is important to not to allow wrist deviation to occur if full range cannot be achieved.

Table 11.6. Summary of lesions affecting joints of the wrist and hand.

| Affected Joint | Swelling | Deformity | Instability | Ankylosis |
|---|---|---|---|---|
| Wrist and carpus | Soft-tissue swelling due to infective or inflammatory arthritis, tenosynovitis, ganglion or de Quervain's syndrome | Possibly due to trauma as in Colles' or Smith's fractures; flexion deformities as result of inflammatory arthritis or RA[1] may lead to volar subluxation or radial deviation of wrist | Instability of inferior radioulnar joint may follow triangular ligament rupture | May follow inflammatory arthritis |
| Carpometacarpal of thumb | Soft-tissue swelling usually results from RA; bony swelling more common in OA[2] | Deformity common in OA; adduction deformity of thumb common in RA | Lateral instability occurs in OA and inflammatory arthritis | |
| Metacarpophalangeal (MCP) | Soft-tissue swelling common in RA and other types of arthritis; bony swelling by OA is rare but can occur with chondrocalcinosis or trauma | Palmar and/or ulnar subluxation is common deformity in RA; flexor deformity can result from rupture of extensor tendon | Marked instability may occur in opera-glass hand | |
| Proximal interphalangeal (PIP) | Soft-tissue swelling due to RA producing spindle-shaped swelling; bony swelling may be Bouchard's node or erosive OA | Flexion, swan-neck or boutonniére deformities may result from RA | Lateral instability in RA and psoriatic arthritis | Uncommon but may occur in erosive OA and psoriasis |
| Terminal interphalangeal (TIP) | Soft-tissue swelling in psoriatic arthritis and sometimes in RA and tophaceous gout; bony swelling may be Heberden's nodes or erosive OA | Flexion deformity producing mallet finger | May occur in psoriatic arthritis or RA and also in OA | Usually due to psoriatic arthritis, may rarely occur in RA or gout |

1 - Rheumatoid Arthritis; 2 – Osteoarthritis

**Ulnar and Radial Deviation**

Wrist deviation in both ulnar (adduction) and radial (abduction) directions is measured in seated patient with forearm in pronation and hand in neutral position. Palmar surface rests lightly on a table and fingers are relaxed while examiner stabilizes forearm.

Goniometer axis is placed over dorsal aspect of wrist over the capitate bone. Stationary arm is placed along forearm midline with moveable arm parallel to longitudinal axis of third metacarpal. Wrist is adducted (referenced to anatomical position) to limit of motion in ulnar deviation (30°), while in radial deviation it is abducted to limit of motion (20°) to radial side. It is important to not to allow either wrist flexion or extension to occur if full deviation range cannot be achieved.

### *Finger Joints (2nd - 5th)*

Finger ROM measurements are conducted with patient in seated position with forearm resting on an examination table or with elbow slightly flexed and resting on table. Small goniometers are used which provide ease of measurement and better accuracy because of small size and complexities of the fingers.

#### Metacarpophalangeal (MCP) flexion

Wrist is slightly extended and MCP joint of finger being tested is positioned at 0° extension while examiner stabilizes appropriate metacarpal.

Axis of goniometer is placed on dorsal aspect of MCP joint being measured with stationary arm parallel to longitudinal shaft of related metacarpal. Movable arm is held parallel to longitudinal axis of proximal phalanx. Each finger being measured is moved to limit of motion in direction of palm (90°). Value of flexion ROM slightly increases progressively from index to fifth finger. During measurement, flexion of proximal interphalangeal (PIP) joint is allowed while terminal interphalangeal (TIP) joint remains in extension.

Alternate to method described above, goniometer axis can be placed on the lateral aspect of the MCP joint when measuring flexion ROM for either the index or fifth finger.

#### MCP extension

Wrist is slightly flexed and MCP joint of finger being tested is positioned at 0° extension while examiner stabilizes appropriate metacarpal.

Axis of goniometer is placed on volar aspect of MCP joint being measured with stationary arm parallel to longitudinal shaft of related metacarpal. Movable arm is held parallel to longitudinal axis of proximal phalanx. Each finger being measured is moved to limit of motion in direction of dorsum (45°). During measurement, flexion of proximal interphalangeal (PIP) joint is allowed.

Alternate to method described above, goniometer axis can be placed on the lateral aspect of the MCP joint when measuring extension ROM for either the index or fifth finger.

#### MCP adduction and abduction

Finger MCP adduction and abduction are measured with elbow flexed 90°, forearm pronated and resting on table. Wrist is in neutral position, fingers in the anatomical position, and examiner stabilizes the metacarpal bones.

Goniometer axis is placed over dorsal aspect of MCP joint being measured with stationary arm parallel to longitudinal shaft of related metacarpal. Movable arm is held parallel to longitudinal axis of proximal phalanx. Finger is moved away from midline of hand to limit of motion in abduction. Finger is then moved toward midline of hand to measure full limit of adduction. During adduction, other fingers are allowed to move to permit full adduction of tested finger.

Alternate to above method, finger and thumb abduction can be measured by placing patient's hand on a piece of paper, with fingers fully abducted, and tracing outline of the hand. Abduction in terms of linear distance between each finger and thumb tip is recorded in centimeters or inches. A straight line can also be drawn on hand outline along longitudinal axis of each finger and the thumb from which an angular measurement between each digit is derived by means of a protractor.

**Interphalangeal (PIP and TIP) flexion and extension**

Measurement is made with forearm resting on table in midposition or pronated. Fingers and wrist are initially held in anatomical reference of 0° extension. Proximal phalanx is stabilized by examiner while measuring PIP joints and middle phalanx is stabilized while measuring the distal or terminal interphalangeal (TIP) joints.

Axis of goniometer is placed on dorsal surface of PIP or TIP joint being measured with stationary arm parallel to longitudinal axis of proximal phalanx for PIP joint, and parallel to middle phalanx for measuring TIP joints. Likewise the movable arm is parallel to longitudinal axis of middle phalanx for PIP measurement and parallel to distal phalanx for TIP joints.

Middle phalanx is moved toward palm to full limit in flexion for PIP (100°) joints and distal phalanx is flexed to full limit for TIP joints (90°). Limits of extension for PIP and TIP joints are then checked.

**MCP and IP flexion**

Other measurements can be derived for flexion of the fingers that are useful in determining degree of impairment or disability of hand function, especially associated with problems of grasp. Patient is seated with elbow flexed with forearm resting on table in supination. Initially, the patient flexes the TIP and PIP joints while maintaining the MCP joints at 0° of extension. Ruler is placed vertically on the palmar surface to measure linear distance from palm to tip of the middle finger. Possible anomalies in other fingers are noted as well. Patient then flexes MCP, PIP and TIP joints and measurement is repeated from tip of middle finger and palmar surface.

***Thumb***

**Carpometacarpal (CM) flexion and extension**

Patient is seated with elbow flexed with forearm resting on table in midposition. Wrist is held in slight ulnar deviation with fingers in anatomical position while the thumb maintains contact with metacarpal and proximal phalanx of index finger.

Goniometer axis is placed over CM joint with the fixed arm parallel to longitudinal axis of radius. Movable arm is held parallel to longitudinal axis of thumb metacarpal. Thumb is flexed across palm to full limit of motion (15°) and then is extended from the start position away from the palm to full limit of extension (20°).

**MCP and IP flexion and extension**

Measurement is made with elbow flexed with forearm resting on table in midposition. Fingers and wrist are in anatomical position with MCP and IP joints held in extension (0°). Metacarpal is stabilized by examiner while measuring MCP joint and proximal phalanx is stabilized while measuring the interphalangeal (IP) joint.

Axis of goniometer is placed on dorsal or lateral aspect of MCP joint or IP joint of thumb with stationary arm parallel to longitudinal axis of thumb metacarpal for MCP joint, and parallel to thumb proximal phalanx for measuring IP joint. Likewise the movable arm is held parallel to longitudinal axis of proximal phalanx for MCP measurement and parallel to distal phalanx for thumb IP joint.

Interphalangeal joint of thumb can be actively hyperextended to 10° and passively extended to 30°. Measurement can be obtained by placing goniometer on lateral or volar surface of thumb.

**CM abduction**

Patient is seated with elbow flexed and the forearm resting on table in midposition. Wrist and fingers are in anatomical position while thumb maintains contact with metacarpal and proximal phalanx of index finger.

Axis of goniometer is placed over junction of first and second metacarpal bases. Stationary arm is held parallel to longitudinal axis of second metacarpal while the movable arm is parallel to longitudinal axis of thumb metacarpal. Goniometer in this position usually indicates 15 - 20°, which is recorded as the 0° position. Thumb is then abducted to limit of motion (70°) moving in a plane oblique to palm.

Alternate to goniometer method described above, a linear measurement of thumb abduction can be obtained by means of a ruler or tape measure. A ruler measurement from dorsal aspect of MCP joint midpoint of index finger to MCP of the thumb, while thumb is abducted, provides measure of abduction.

**Opposition**

Normal full range of motion in thumb opposition allows pad of thumb and fifth finger to touch. A deficit in opposition can be obtained by measuring linear distance between thumb pad and center of pad on tip of fifth finger.

## Passive Movement with Overpressure

### *Wrist and Carpus*

**Flexion and Extension**

**Ulnar and Radial Deviation**

### *Finger Joints (2nd – 5th)*

**MCP, PIP and TIP flexion and extension**

**MCP abduction and adduction**

### *Thumb*

**CM, MCP and IP flexion and extension**

**CM abduction and adduction**

## Resisted Isometric Tests

Muscle strength of the wrist, hand and fingers is evaluated by resisted isometric tests and graded 0 - 5 (see Table 4.3). Principal signs of either pain or weakness, or both, are noted. Of the resisted isometric tests, four are conducted at the wrist, three at the thumb, four at the metacarpophalangeal joints and two at the interphalangeal joints.

The four isometric tests performed at the wrist include flexion, extension, ulnar deviation and radial deviation. Pain on any of these tests indicates possible tendinitis of the main muscles moving the wrist. The patterns of pain are consistent with the function of each particular muscle. For example, pain on resisted extension may manifest in tendinitis of either the extensor carpi radialis or extensor carpi ulnaris muscles, while pain associated with resisted contraction in radial deviation, may be the result of tendinitis of either the flexor carpi radialis or extensor carpi radialis mm. Consequently pain patterns can be differentiated to isolate the particular muscle involved (see Table 11.7).

Table 11.7. Pain patterns in isometric tests of wrist are consistent with the function of muscles moving the wrist and pattern indicates possible site of tendinitis

| Muscles | MD* | Nerve Root | Flexion | Extension | Ulnar Deviation | Radial Deviation |
|---|---|---|---|---|---|---|
| Flexor carpi radialis | MH | C6, 7, 8 | P | O | O | P |
| Flexor carpi ulnaris | PLH | C7, 8, T1 | P | O | P | O |
| Extensor carpi radialis | ALH | C5, 6, 7, 8 | O | P | O | P |
| Extensor carpi ulnaris | LH | C6, 7, 8 | O | P | P | O |

*MD = Muscle distribution; P = pain; O = no pain

Painless weakness in the resisted contractions of the wrist usually indicates a neural lesion, since rupture of the musculotendinous structures controlling the wrist is rare. Patterns of muscular weakness can also be noted to identify the particular muscle, nerve root and traditional musculotendinous distribution pathway. All of this information is essential to formulate an effective treatment approach, including the needling therapy.

***Wrist flexion and radial deviation***

Flexor carpi radialis is one of principal wrist flexors and also produces radial deviation. Both the flexor carpi ulnaris and palmaris longus are accessory muscles to wrist flexion, but neither produce radial deviation.

Wrist flexion with radial deviation is evaluated with patient either seated or supine. In seated position, forearm is supinated and resting on a table, while wrist is extended in ulnar deviation. Fingers and thumb are relaxed and examiner stabilizes forearm proximal to wrist. For screening test, patient flexes and radially deviates the wrist through full range while maintaining relaxation of fingers and thumb. Examiner palpates anterolateral aspect of wrist in line with the second web space, radial to palmaris longus.

Isometric resistance is then applied distal to wrist over lateral aspect of palm or thenar eminence. Resistance is applied in direction of wrist extension and ulnar deviation.

➔ Patient may substitute flexion with palmaris longus and flexor carpi ulnaris. Flexion with ulnar deviation results if only flexor carpi ulnaris is employed. Flexor digitorum superficialis and profundus may substitute to initiate wrist flexion.

Failure of the gravity resisted isometric test indicates a gravity eliminated test for the flexor carpi radialis muscle should be considered. Patient is either seated or supine with forearm in neural position and resting on a table or powder board. Wrist is extended in ulnar deviation, fingers and thumb are relaxed, and examiner stabilizes forearm proximal to wrist. Patient flexes and radially deviates wrist through full range of motion while maintaining relaxation of fingers and thumb. Examiner palpates anterolateral aspect of wrist in line with the second web space, radial to palmaris longus.

➔ Patient may substitute palmaris longus, flexor carpi ulnaris, and flexor digitorum superficialis and profundus. Forearm pronation and thumb abduction by action of abductor pollicis longus may be substituted as wrist is flexed from anatomical position

***Wrist flexion and ulnar deviation***

Flexor carpi ulnaris is one of principal wrist flexors and also produces ulnar deviation. Both the flexor carpi radialis and palmaris longus are accessory muscles to wrist flexion, but neither produce ulnar deviation.

Wrist flexion with ulnar deviation is evaluated with patient either seated or supine. In seated position, forearm is supinated and resting on a table, while wrist is extended in radial deviation. Fingers and thumb are relaxed and examiner stabilizes forearm proximal to wrist. For screening test, patient flexes and ulnarly deviates the wrist through full range while maintaining relaxation of fingers and thumb. Examiner palpates anteromedial aspect of wrist proximal to pisiform bone.

Isometric resistance is then applied distal to wrist over medial aspect of palm. Resistance is applied in direction of wrist extension and radial deviation.

➔ Patient may substitute flexion with palmaris longus, flexor carpi radialis, and flexor digitorum superficialis and profundus; flexion with radial deviation results if only flexor carpi radialis is employed.

Failure of the gravity resisted isometric test indicates a gravity eliminated test for the flexor carpi ulnaris should be considered. Patient is either seated or supine with forearm in midposition and resting on a table or powder board. Wrist is extended in radial deviation, fingers and thumb are relaxed, and examiner stabilizes forearm proximal to wrist. Patient flexes and ulnarly deviates the wrist through full range while maintaining relaxation of fingers and thumb. Examiner palpates anteromedial aspect of wrist proximal to pisiform bone.

➔ Patient may substitute palmaris longus, flexor carpi radialis, and flexor digitorum superficialis and profundus.

***Wrist flexion - Palmaris longus***

Palmaris longus is weakest of three wrist flexors and is not isolated for individual muscle testing. Normally it can be palpated on midline of anterior wrist during testing of flexor carpi radialis and ulnaris. Palmaris longus is a vestigial muscle in about 10 – 13% of subjects, but its tendon prominently stands out when present. This can be checked by flexing wrist while cupping fingers and palm of hand to visually determine if tendon stands out.

***Wrist extension and radial deviation***

Extensor carpi radialis longus and brevis are principal muscles that produce wrist extension and radial deviation. Extensor carpi ulnaris is accessory to this movement but does not participate in radial deviation.

Wrist extension with radial deviation is evaluated with patient either seated or supine. In seated position, forearm is pronated and resting on a table, while wrist is flexed in ulnar deviation. Fingers and thumb are slightly flexed and examiner stabilizes forearm proximal to wrist. For screening test, patient extends and radially deviates the wrist through full range while maintaining relaxation of fingers and thumb. Examiner palpates dorsal aspect of wrist at base of second metacarpal for extensor carpi radialis longus and at base of third metacarpal for extensor carpi radialis brevis.

Isometric resistance is then applied distal to wrist over dorsal lateral aspect of hand over second and third metacarpal. Resistance is applied in direction of wrist flexion and ulnar deviation.

➔ Patient may substitute with extensor carpi ulnaris which produces extension with ulnar deviation.

Failure of the gravity resisted isometric test indicates a gravity eliminated test for the extensor carpi radialis longus and brevis should be considered. Patient is either seated or supine with forearm in midposition and resting on a table or powder board. Wrist, fingers and thumb are flexed and examiner stabilizes forearm proximal to wrist. Patient extends and radially deviates the wrist through full range of motion while maintaining relaxation of fingers and thumb. Examiner palpates dorsal aspect of wrist at base of second metacarpal for extensor carpi radialis longus and at base of third metacarpal for extensor carpi radialis brevis.

➔ Patient may substitute extensor carpi ulnaris.

***Wrist extension and ulnar deviation***

Extensor carpi ulnaris is principal muscle that produces wrist extension with ulnar deviation. Extensor carpi radialis longus and brevis are accessory to this movement but do not participate in ulnar deviation.

Wrist extension with ulnar deviation is evaluated with patient either seated or supine. In seated position, forearm is pronated and resting on a table, while wrist is flexed in radial deviation. Fingers and thumb are slightly flexed and examiner stabilizes forearm proximal to wrist. For screening test, patient extends and ulnarly deviates the wrist through full range while maintaining relaxation of fingers and thumb. Examiner palpates dorsal aspect of wrist proximal to fifth metacarpal and distal to ulnar styloid process.

Isometric resistance is then applied distal to wrist over dorsal medial aspect of hand over fourth and fifth metacarpals. Resistance is applied in direction of wrist flexion and radial deviation.

➔ Patient may substitute extensor carpi radialis longus and brevis which do not participate in ulnar deviation.

Failure of the gravity resisted isometric test indicates a gravity eliminated test for the extensor carpi ulnaris should be considered. Patient is either seated or supine with forearm in neural position resting on a table. Wrist, fingers and thumb are flexed and examiner stabilizes forearm proximal to wrist. Patient extends and ulnarly deviates the wrist through full range of motion while maintaining relaxation of fingers and thumb. Examiner palpates dorsal aspect of wrist proximal to fifth metacarpal and distal to ulnar styloid process.

➔ Patient may substitute extensor carpi radialis longus and brevis.

***Fingers***

Force of gravity is not considered an important factor in strength testing fingers and thumb since these structures are light in mass compared to the strength of their muscles.

### MCP Extension

MCP extension involves the extensors digitorum communis, indicis and digiti minimi. Patient is seated or supine with forearm pronated. Wrist is in neutral position with fingers flexed and examiner stabilizes metacarpals. Patient extends all four MCP joints while holding PIP joints in flexion. Examiner palpates extensor digitorum tendon to each finger on dorsum of hand proximal to metacarpal heads. Extensor indicis is palpated medial to extensor digitorum tendon to index finger. Extensor digiti minimi is palpated lateral to extensor digitorum tendon to fifth finger.

For strength evaluation, isometric resistance is applied on dorsal aspect of proximal phalanx of each finger, in direction of MCP flexion.

### MCP abduction

MCP abduction involves the dorsal interossei and abductor digiti muscles. Patient is seated or supine with forearm supported on table, either pronated for dorsal interossei testing or supinated for abductor digiti testing, with wrist in neutral position.

Fingers are extended and adducted for dorsal interossei test and thumb is in anatomical position. Examiner stabilizes dorsum of hand over metacarpal bones and wrist. Patient first abducts the index finger toward thumb and then abducts middle finger toward index finger. Middle finger is then abducted toward ring finger and then ring finger abducted toward fifth finger. Examiner may need to stabilize non-test digits. First interosseous is palpated on radial aspect of second metacarpal. Other interossei cannot be reliably palpated.

Forearm is supinated while examiner stabilizes wrist and lateral three metacarpals for testing abductor digiti. Patient abducts fifth finger while examiner palpates on ulnar aspect of fifth metacarpal.

For isometric testing, examiner applies resistance against proximal phalanx of finger being tested. Resistance is applied to radial side of index and middle finger, and to ulnar side of middle, ring and fifth fingers. Force is applied in direction of adduction.

➔ Patient may substitute extensor digitorum communis to abduct fingers.

### MCP adduction

MCP adduction involves the palmar interossei muscles. Patient is seated or supine with forearm supinated and supported on table. Wrist is in neutral position and fingers are abducted. Examiner stabilizes wrist and metacarpal bones. Patient then adducts index, ring and fifth finger toward middle finger. Palmar interossei muscles cannot be palpated.

Isometric testing is conducted by applying resistance against proximal phalanx of finger being tested. Resistive force is applied to ulnar aspect of index finger and on radial side for ring and fifth finger.

### MCP Flexion and PIP Extension

Lumbricals flex the MCP joints and simultaneously extend PIP joints of fingers. Interossei muscles which are isolated by abduction and adduction in preceding two tests also flex MCP joints and extend PIP joints. Weakness in present test following a strong result for interossei muscles, implicate the lumbricals. Flexor digiti minimi (MCP flexion) acts accessory to lumbricals.

Patient is seated with forearm supported on table either supinated or in midposition. Wrist is in neutral position, MCP joints extended and abducted, and PIP joints are slightly flexed. Examiner stabilizes metacarpals on palmar side and lumbricals cannot be palpated.

Patient flexes MCP joints while simultaneously extending PIP joints. Fingers are allowed to abduct to avoid influence from adjacent fingers in static adduction.

For isometric strength testing, resistance is directed toward MCP extension and PIP flexion. Resistive force is applied on volar surface of proximal phalanx and dorsal surface of middle phalanx.

➔ Patient may substitute extensor digitorum communis

**Little finger MCP flexion**

Flexor digiti minimi is principal flexor of little finger MCP joint. Other muscles accessory to this movement includes abductor digiti minimi, fourth lumbrical and fourth palmar interosseous muscles. Patient is seated with forearm supinated and supported on table and wrist is in neutral position with fingers extended. Examiner stabilizes metacarpals and palpates on hypothenar eminence medial to abductor digiti minimi. Patient flexes MCP joint of little finger while maintaining extension of PIP joint.

For isometric strength testing, resistance is directed toward little finger MCP extension. Resistive force is applied on volar aspect of little finger proximal phalanx.

➔ Patient may substitute flexor digitorum superficialis and profundus, thus it is important that flexion of PIP joint not occur. Patient may abduct little finger by abductor digiti minimi if flexion cannot be initiated.

**PIP flexion**

Flexor digitorum superficialis is principal flexor of PIP joints of fingers. Flexor digitorum profundus acts accessory to this movement. Patient is seated with forearm supinated and supported on table and wrist is in neutral position or slight extension with fingers extended. Examiner stabilizes metacarpals and proximal phalanx of finger being tested. Flexor digitorum superficialis is palpated on volar surface of wrist between palmaris longus and flexor carpi ulnaris tendons, or on proximal phalanx.

Patient flexes PIP joint of each finger while maintaining TIP joints in extension. Little finger is not isolated during test and may with ring finger since isolated action of fifth finger superficialis is not always possible. Fingers not being tested may be held in extension to rule out contribution of flexor digitorum profundus.

For isometric strength testing, resistance is directed toward PIP extension. Resistive force is applied on volar aspect of middle phalanx.

➔ Patient may substitute flexor digitorum profundus.

**TIP Flexion**

TIP flexion involves the flexor digitorum profundus muscle. Patient is seated with forearm supinated and supported on table and wrist is in neutral position or slight extension with fingers extended. Examiner stabilizes proximal and middle phalanx of each finger being tested. Flexor digitorum profundus is palpated on volar surface of middle phalanx.

Patient flexes each TIP joint through full range of motion. Isometric strength is assessed by applying resistive force on volar aspect of terminal phalanx in direction of extension.

***Thumb***

**IP Flexion**

IP flexion involves the flexor pollicis longus muscle. Patient is seated with forearm supinated and supported on table and wrist is in neutral position, and thumb extended. Examiner stabilizes wrist, thumb metacarpal, and proximal phalanx. Patient flexes IP joint through full range of motion while examiner palpates on volar surface of distal phalanx.

Isometric strength is assessed by applying resistive force on volar aspect of distal phalanx in direction of extension.

➔ Relaxation of thumb following IP joint extension may give false impression of flexor pollicis longus contraction.

**MCP Flexion**

Flexor pollicis brevis is second flexor of thumb and controls flexion of thumb MCP joint. Flexor pollicis longus acts accessory to this movement. Patient is seated with forearm supinated and supported on table and wrist is in neutral position, with thumb extended and adducted. Examiner stabilizes wrist and thumb metacarpal and palpates proximal to MCP joint on middle of thenar eminence, medial to abductor pollicis brevis. Patient flexes MCP joint through full range of motion while maintaining extension of IP joint to reduce effects of flexor pollicis longus.

Isometric strength is assessed by applying resistive force on volar aspect of proximal phalanx in direction of extension.

➔ Patient may substitute flexor pollicis longus

**IP Extension**

IP extension involves the extensor pollicis longus muscle. Patient is seated with forearm in midposition or slight supination supported on table and wrist is in neutral position. Thumb is adducted with MCP joint extended and IP joint flexed. Examiner stabilizes thumb metacarpal and proximal phalanx. Patients extends IP joint through full range of motion while examiner palpates on dorsal surface of proximal phalanx or on ulnar border of anatomical snuff box.

Isometric strength is assessed by applying resistive force on dorsal aspect of distal phalanx in direction of flexion.

➔ Placing thumb in adduction limits extensor action of abductor pollicis brevis. Rebound contraction of flexor pollicis longus may occur.

**MCP extension**

Extensor pollicis brevis is second extensor of thumb and it influences extension of MCP joint of thumb. Extensor pollicis longus acts accessory to this movement. Patient is seated with forearm in midposition or slightly pronated supported on table and wrist is in neutral position. Thumb MCP joint and IP joint are flexed. Examiner stabilizes first metacarpal while patient extends thumb MCP joint while maintaining IP joint in slight flexion. Examiner palpates on dorsoradial aspect of wrist at base of thumb metacarpal.

Tendon forms radial border of anatomical snuff box and is medial to tendon of abductor pollicis longus.

Isometric strength is assessed by applying resistive force on dorsal aspect of proximal phalanx in direction of flexion.

➔ **Patient may substitute extensor pollicis longus.**

**Radial Abduction**

Radial abduction involves the abductor pollicis longus muscle. Patient is seated with forearm in supination supported on table and wrist is in neutral position. Thumb is adducted against volar aspect of index finger. Examiner stabilizes wrist and second metacarpal. Patient abducts thumb in radial direction through full range of motion. Thumb is moved away from index finger at an angle of 45° towards extension. Examiner palpates on lateral aspect of wrist at base of thumb metacarpal, and on radial side of extensor pollicis brevis.

Isometric strength is assessed by applying resistive force on lateral aspect of thumb metacarpal in direction of adduction and flexion.

➔ **Substitution of palmar abduction may be attempted through action of abductor pollicis brevis.**

**Palmar Abduction**

Palmar abduction involves the abductor pollicis brevis muscle. Patient is seated with forearm in supination supported on table and wrist is in neutral position. Thumb is adducted against volar aspect of index finger. Examiner stabilizes wrist and second metacarpal. Patient abducts thumb through full range of motion. Thumb is moved away at a right angle from index finger. Examiner palpates on lateral aspect of thumb metacarpal.

Isometric strength is assessed by applying resistive force on lateral aspect of thumb proximal phalanx in direction of adduction.

➔ **Substitution of radial abduction may be attempted through action of abductor pollicis longus.**

**Adduction**

Adductor pollicis is principal thumb adductor, and flexor pollicis brevis acts accessory to this movement. Patient is seated with forearm supinated supported on table and wrist is in neutral position. Thumb MCP joint and IP joint are flexed and thumb is in palmar abduction. Examiner stabilizes wrist and second through fifth metacarpals. Patient adducts thumb while maintaining flexion of MCP and IP joints. Examiner palpates on palmar surface of hand between first and second metacarpals.

Isometric strength is assessed by applying resistive force on medial aspect of proximal phalanx in direction of palmar abduction.

➔ **Patient may substitute flexor pollicis longus and extensor pollicis longus.**

**Opposition with 5th finger**

Opponens pollicis and opponens digiti minimi function in opposition of thumb. Muscles accessory to this movement include abductor pollicis brevis, adductor pollicis brevis and flexor pollicis brevis. Patient is seated with forearm supinated supported on table and wrist is in neutral position. Fingers are extended and thumb MCP and IP joints are extended. Thumb is in palmar abduction since opponens pollicis cannot effectively oppose thumb until it is abducted. Examiner stabilizes distal forearm and thumb may be supported in abduction if abductor pollicis brevis is weak.

Patient flexes and medially rotates thumb metacarpal toward little finger while little finger flexes and rotates toward thumb so pads of thumb and little finger touch, while distal phalanges remain extended. Examiner palpates opponens pollicis lateral to abductor pollicis brevis on radial aspect thumb metacarpal shaft. Opponens digiti minimi is palpated on volar surface of fifth metacarpal shaft.

Isometric strength is assessed by applying resistive force simultaneously against both movements. Resistance is applied on volar surface of thumb metacarpal and fifth metacarpal.

➔ Patient may attempt flex thumb and little finger distal joints near end of range, giving appearance of full opposition

## Accessory Movements

Table 5.1

### *Radiocarpal Joint*

#### Anteroposterior (dorsal glide)

Anteroposterior movement or dorsal glide is produced by grasping the proximal carpals as close to the wrist joint as possible and applying pressure over the anterior surface of the carpus with one hand while stabilizing the forearm at the wrist with the other. Examiner's hand can grasp the patient's thumb with his or her thumb and index finger while applying pressure over the radiocarpal joint with the base of the examiner's hand.

#### Posteroanterior (volar glide)

Posteroanterior movement or volar glide is produced by grasping the proximal carpals as close to the wrist joint as possible and applying pressure over the posterior surface of the carpus with one hand while stabilizing the forearm with the other. Wrist of stabilizing hand is flexed with the base of the hand positioned just proximal to the wrist joint.

#### Medial Transverse (ulnar glide)

Medial transverse movement or ulnar glide is produced by grasping the proximal carpals as close to the wrist joint as possible and applying pressure over the medial aspect of the carpus while stabilizing the patient's forearm. Forearm rests on the ulnar side with wrist held extended over the end of the table.

#### Lateral Transverse (radial glide)

Lateral transverse movement or radial glide is produced by grasping the proximal carpals as close to the wrist joint as possible and applying pressure over the lateral aspect of the carpus while stabilizing the patient's forearm. Forearm rests on radial side with wrist held extended over the end of the table.

#### Supination

One hand of the examiner grasps the patient's forearm at the wrist, while the other hand grasps the proximal carpals from the dorsal surface. The patient's hand is then rotated in supination.

#### Pronation

One hand of the examiner grasps the patient's forearm at the wrist, while the other hand grasps the proximal carpals from the dorsal surface. The patient's hand is then rotated in pronation.

#### Longitudinal Caudad

While grasping the proximal carpals as close to the wrist joint as possible, traction is applied in the longitudinal caudal direction while stabilizing the patient's forearm resting pronated on the table with the wrist extended over the end of the table.

#### Longitudinal Cephalad

While grasping the proximal carpals as close to the wrist joint as possible, compression is applied to approximate the joint in the longitudinal cephalad direction. Patient's forearm is stabilized forearm resting pronated on the table with the wrist extended over the end of the table.

### *Intercarpal Joints*

The carpal bones are normal held together tightly. Producing and evaluating accessory movement in the intercarpal joints is therefore difficult and it takes much practice to perfect.

#### Posterior-anterior

Posteroanterior movement of any one carpal on another is produced by grasping the patient's hand just distally to the wrist joint and applying pressure over the dorsal surface.

#### Anterior-posterior

Anteroposterior movement of any one carpal on another is produced by grasping the patient's hand just distally to the wrist joint and applying pressure over the palmar surface.

#### Horizontal Extension

Horizontal extension is produced by grasping the patient's hand just distally to the wrist joint and applying pressure over the dorsal surface of one carpal bone as a fulcrum and extending the other carpal bones around it by pressure of the fingers on the palmar surface.

#### Horizontal Flexion

Horizontal flexion is produced by grasping the patient's hand just distally to the wrist joint and applying pressure over the palmar surface of one carpal bone as a fulcrum and cupping the other carpal bones around it by pressure of the practitioner's palm and fingers on the dorsal surface.

#### Longitudinal Caudal

Longitudinal caudal movement is produced by grasping the patient's hand over the metacarpal joints and applying traction in the longitudinal direction while stabilizing the forearm.

#### Longitudinal Cephalad

Longitudinal cephalad movement is produced by grasping the patient's hand over the metacarpal joints and applying compression in the longitudinal direction while stabilizing the forearm.

### *Carpometacarpal Joints*

Accessory movement is evaluated in the medial four carpometacarpal joints as follow:

#### Anterior-posterior

Anteroposterior movement of any one carpometacarpal joint is produced by grasping the patient's hand just proximal to the carpometacarpal joints and applying thumb pressure over the palmar surface of the metacarpal bone just distal to the joint in question while holding the patient's hand and fingers with the practitioner's mobilizing hand.

#### Posterior-anterior

Posteroanterior movement of any one carpometacarpal joint is produced by grasping the patient's hand with one hand just proximal to the carpometacarpal joints and applying thumb pressure with the other hand over the dorsal surface of the metacarpal bone just distal to the joint in question while holding the patient's hand and fingers with the practitioner's mobilizing hand.

#### Medial Rotation

Medial rotation of any one carpometacarpal joint is produced by grasping the patient's hand just proximal to the carpometacarpal joints with one hand and holding the proximal end of metacarpal bone in question with the thumb and index finger of the practitioner's other hand and rotating the metacarpal bone in the medial direction.

#### Lateral Rotation

Lateral rotation of any one carpometacarpal joint is produced by grasping the patient's hand just proximal to the carpometacarpal joints with one hand and holding the proximal end of metacarpal bone in question with the thumb and index finger of the practitioner's other hand and rotating the metacarpal bone in the lateral direction.

#### Longitudinal Caudal

Longitudinal caudad movement of any one carpometacarpal joint is produced by grasping the patient's hand just proximal to the carpometacarpal joints with one hand and holding the proximal end of metacarpal bone in question with the thumb and index finger of the practitioner's other hand and applying traction in the longitudinal direction.

#### Longitudinal Cephalad

Longitudinal cephalad movement of any one carpometacarpal joint is produced by grasping the patient's hand just proximal to the carpometacarpal joints with one hand and holding the proximal end of metacarpal bone in question with the thumb and index finger of the practitioner's other hand and applying compression in the longitudinal direction.

### *Metacarpophalangeal Joints*

#### Medial Rotation

Medial rotation is produced by stabilizing the metacarpals and rotating the proximal phalanx in the medial direction by means of the practitioner's thumb and index finger.

#### Lateral Rotation

Lateral rotation is produced by stabilizing the metacarpals and rotating the proximal phalanx in the lateral direction by means of the practitioner's thumb and index finger.

#### Longitudinal Caudal

Longitudinal caudad movement is produced by stabilizing the metacarpals and applying traction on the metacarpophalangeal joint by means of the practitioner's thumb and index finger pulling on the proximal phalanx in the longitudinal direction.

#### Longitudinal Cephalad

Longitudinal cephalad movement is produced by stabilizing the metacarpals and applying compression on the metacarpophalangeal joint by means of the practitioner's thumb and index finger pushing on the proximal phalanx in the longitudinal direction.

#### Posterior-anterior

Posteroanterior movement is produced by stabilizing the metacarpals and applying thumb pressure on the dorsal surface of the proximal phalanx just distal to the metacarpophalangeal joint.

#### Anterior-posterior

Anteroposterior movement is produced by stabilizing the metacarpals and applying thumb pressure on the anterior surface of the proximal phalanx just distal to the metacarpophalangeal joint.

#### Abduction

Abduction is produced by stabilizing the metacarpals and moving the proximal phalanx away from the middle finger.

#### Adduction

Adduction is produced by stabilizing the metacarpals and moving the proximal phalanx toward the middle finger.

### *Proximal and Terminal Interphalangeal Joints (PIP, TIP)*

Accessory movement of the proximal and distal interphalangeal joints (PIP, TIP) can be evaluated in terms of medial and lateral rotation, medial and lateral transverse movement and Posteroanterior and Anteroposterior movements. The same techniques used in section e. above are applied to the PIP and TIP joints except the stabilizing hand first holds the proximal and then middle phalanx respectively while evaluating the joint in question.

## Neurological Evaluation

### *Myotomes: Key muscle strength (graded 0 - 5)*

- Extensor carpi radialis longus and brevis muscles (C6)

- Extensor digitorum muscle (C7)
- Flexor digitorum superficialis and profundus (C8)
- Dorsal interossei muscles (T1)

## Diagnostic Imaging

### *Plain Film Radiography*

**Anteroposterior View.** This view is useful to show the shape and position the wrist and hand bones to note possible displacement or fractures, decrease in joint space, changes in bone density, and pathologies.

**Lateral View.** This view is useful to show shape and position of bones for presence of any fractures or displacements. This view also used to note relationship of the scaphoid and lunate to the radius and metacarpals, as well as for detecting swelling around carpal bones.

**Scaphoid View.** This view is useful to isolate the scaphoid to show possible fractures.

**Carpal Tunnel (Axial) View.** This view is useful to show possible fractures of the hook of hamate and trapezium, and to show margins of the carpal tunnel.

**Clenched Fist View.** This view is useful to show possible increased gapping between carpal bones, indicating instability.

### *Magnetic Resonance Imaging (MRI)*

Magnetic resonance images are useful in viewing wrist and hand soft-tissue including the ligaments and the median nerve in the carpal tunnel.

### *Computed Tomography*

Computed tomography used to visualize the bones and soft tissues by viewing cross sections of various features.

# Management of Wrist and Hand Disorders

The main therapeutic approach in addressing wrist and hand problems involves physical modalities of mobilization and needling therapy. Selection of candidate nodes for treatment of wrist (Table 11.8) and hand problems (Tables 11.9 and 11.10) vary slightly because the problems lie within the extremities. Essentially, the local and adjacent nodes for hand and fingers are normally used as distal nodes and therefore intermediate nodes are introduced. Electroneedling (EN) application is also considered after an initial course of needling has not produced the full therapeutic effect. Electroneedling may be considered early, including during the first treatment in complicated cases with an established history. Remedial exercises are also considered for rehabilitation.

## Wrist and Hand Mobilization

Any of the physiological or accessory movements described above in under passive and accessory movement can be applied to specific regions of the wrist, hand and fingers to improve mobility and reduce pain in affected joints. Passive movement treatments are graded from I-V and consist of either small or larges amplitude oscillations that do not move into restricted or painful area, except for Grade V which involves a sharp thrust beyond pathological limit of movement (See Table 5.1). Grade V mobilization techniques are not usually applied to wrist and hand.

### *Wrist Extension*

Some situations involve significant hypomobility of the wrist, such as occurs after wrist has becn immobilized with an orthotic or cast as result of a fracture or injury. Following technique is effective for progressively increasing wrist mobility and reducing pain and involves the patient immersing their hand, with the palm facing down, in a sink or pan filled with water heated to point that it can still be tolerated. While standing, patient presses their palm onto inside bottom of sink and then leans their body slightly forward while elbow remains fixed. This causes extension of wrist joint as patient moves forward. After reaching point of restriction, patient leans backwards to relieve pressure on wrist.

This procedure is continuously repeated to produce a slow and gentle oscillatory action of wrist extension and is repeated until water cools. Each oscillation always moves up to point of restriction which may result in increasing range of motion during the therapy. Just as with other mobilization techniques, this procedure is repeated over a course of treatments until problem is resolved or a different treatment approach is undertaken. Patient can be instructed in this technique to perform at home after the practitioner is satisfied that patient can perform procedure safely and effectively.

### *Radiocarpal and Midcarpal Joints*

#### Anterior-posterior (dorsal glide)

Dorsal glide of radiocarpal joint is especially effective in increasing wrist flexion. Anteroposterior movement or dorsal glide is produced by grasping proximal carpals as close to wrist joint as possible and applying pressure over anterior surface of carpus while stabilizing the forearm. Patient's arm can rest supinated on table with wrist extended over end of table. Practitioner applies pressure perpendicularly to carpus while stabilizing forearm with other hand. Traction is also maintained while applying pressure with mobilizing hand.

Same technique can be used to apply dorsal glide to midcarpal joints by placing practitioner's mobilization hand slightly distal to the wrist joint.

#### Posterior-anterior (volar glide)

Volar glide of radiocarpal joint is especially effective in increasing wrist extension. Posteroanterior movement or volar glide is produced by grasping proximal carpals as close to wrist joint as possible and applying pressure over posterior surface of carpus while stabilizing the forearm. Patient's arm can rest pronated on table with wrist extended over end of table. Practitioner applies pressure perpendicularly to carpus while stabilizing forearm with other hand. Traction is also maintained while applying pressure with the mobilizing hand.

Same technique can be used to apply volar glide to midcarpal joints by placing practitioner's mobilization hand slightly distal to wrist joint.

#### Medial Transverse (ulnar glide)

Ulnar glide of radiocarpal joint is especially effective in increasing wrist ulnar deviation. Medial transverse movement or ulnar glide is produced by grasping proximal carpals as close to wrist joint as possible and applying pressure over medial aspect of carpus while stabilizing patient's forearm resting on its ulnar border with wrist extended over end of table.

Same technique can be used to apply ulnar glide to midcarpal joints by placing practitioner's mobilization hand slightly distal to wrist joint.

**Lateral Transverse (radial glide)**

Radial glide of radiocarpal joint is especially effective in increasing wrist radial deviation. Lateral transverse movement or radial glide is produced by grasping proximal carpals as close to wrist joint as possible and applying pressure over lateral aspect of carpus while stabilizing patient's forearm resting on its radial border with wrist extended over end of table.

Same technique can be used to apply radial glide to midcarpal joints by placing practitioner's mobilization hand slightly distal to the wrist joint.

**Traction (longitudinal caudad)**

Traction of radiocarpal joint is effective in addressing general hypomobility or pain syndromes of wrist. While grasping proximal carpals as close to wrist joint as possible, traction is applied while stabilizing patient's forearm resting pronated on table with wrist extended over end of table.

Same technique can be used to apply traction to midcarpal joints by placing practitioner's mobilization hand slightly distal to the wrist joint.

***Metacarpal Joints***

Metacarpal dorsal and volar glides are general mobilization techniques for increasing intermetacarpal and carpometacarpal joint mobility.

**Dorsal glide**

Patient is seated with forearm pronated resting on table. Practitioner's fingers grasp volarly over thenar and hypothenar eminences while thumbs rests over dorsal surface of metacarpals. Thumbs press against dorsum of hand simultaneous to fingers pulling dorsally on metacarpals.

**Volar glide**

Volar glide is similar to above technique except practitioner's fingers are moved from thenar and hypothenar eminences to press into palm while thumb presses more medially and laterally on dorsum of hand. This technique is useful for improving cupping function of the palm.

***Metacarpophalangeal Joints***

**Posterior and Anterior Glide**

Finger flexion and extension can be increased by applying posterior and anterior mobilization to metacarpophalangeal joints. Either posteroanterior or anteroposterior movement can be applied to metacarpophalangeal joints by practitioner stabilizing patient's hand just proximal to joint and applying either pressure on dorsal or anterior surface of proximal phalanx just distal to joint.

**Joint Traction**

Metacarpophalangeal joint traction is useful for treatment of pain of general hypomobility. Patient is seated with forearm either in midposition or pronated resting on table. Practitioner grasps proximal phalanx as close as possible to joint while stabilizing associated metacarpal with other hand. Light traction force is applied in line with longitudinal axis of metacarpal and phalanx. Force can be applied in oscillatory manner.

#### Medial-Lateral Glide

Medial-lateral glide of metacarpophalangeal joints is effective in addressing pain or restricted motion, especially in abduction and adduction. Patient is seated with forearm resting on table. Practitioner grasps proximal phalanx as close to joint as possible while stabilizing appropriate metacarpal with other hand. Medial or lateral pressure is applied to perpendicularly to phalanx by thumb and index finger of practitioner while maintaining a slight traction force.

#### Joint Rotation

Rotation of metacarpophalangeal joints is effective in addressing pain or any restricted movement. Patient is seated with forearm resting on table. Practitioner stabilizes metacarpals while grasping proximal phalanx as close to joint as possible. Flexed TIP joint is held between practitioner's middle and ring finger to insure firm grasp. Rotational motion is applied to phalanx by thumb and index finger contacts, while sight traction force is maintained.

### *Interphalangeal Joints*

Traction, medial-lateral glides and rotation mobilization techniques applied to metacarpophalangeal joints can also be applied to interphalangeal joints by simply moving the practitioner's hand placement distally to specifically stabilize and manipulate the joints between affected phalanges.

## Needling Therapy for Wrist Problems

Appropriate local and adjacent, distal and proximal acupoints for the treatment of common wrist problems are noted in Table 11.8. Different sets of proximal and distal points are applied in the treatment of wrist problems depending on the associated three yang muscular distributions of the hand, which is either associated with the problem or contains the problem within the affected muscular distribution pathway.

Table 11.8. Selection of regional, proximal and distal nodes for treatment of wrist problems.

| Pain or Disorder of the Wrist | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Yangxi (ALH 5)<br>Yangchi (LH 4)<br>Yanggu (PLH 5)<br>Waiguan (LH 5) | ALH | Dazhu (PLF 11)<br>Feishu (PLF 13) | Hegu (ALH 4) |
| | | LH | Fengchi (LF 20)<br>Jianzhongshu (PLH 15) | Zhongzhu (LH 3) |
| | | PLH | Tianzhu (PLF 10)<br>Jianzhongshu (PLH 15) | Houxi (PLH 3) |

### *Node Selection for Wrist Problems*

Appropriate local and adjacent, distal and proximal nodes for the treatment of common wrist problems are noted in Table 11.8. Different sets of proximal and distal nodes are applied in the treatment of wrist problems depending on the associated three yang muscular distributions of the hand, which is either associated with the problem or contains the problem within the affected muscular distribution pathway. One or two local and adjacent nodes associated with the three medial muscular distributions of the hand are sometimes considered to be added in the treatment of wrist problems. Additional nodes may be considered depending on the specific problems as follows:

- Yanglao (PLH 6) may be added if pain is in inferior radioulnar joint or lateral aspect of the wrist
- Other nodes for pain in the lateral wrist include Taiyuan (AMH 9)
- If lateral wrist pain is accompanied with forearm pain or is due to wrist extension, nodes Sidu (LH 9) and Shanglian (ALH 9) may be added
- For medial wrist pain the node Shenmen (PMH 7) may be considered
- If medial wrist pain is accompanied with forearm pain or is due to wrist flexion, nodes Zhizheng (PLH 7) and Xiaohai (PLH 8) may be added
- The node Daling (MH 7) added for carpal tunnel syndrome, and Ximen (MH 4), Taiyuan (AMH 9), and Shenmen (PMH 7) may be added as well

### *Candidate Electroneedling (EN) Application for Wrist*

One suggested lead placement for adding electrostimulation is listed below for each of the three muscular distributions involving a proximal and local node. A possible alternative is provided involving a circuit from the local node to the distal node. Wrist problems may manifest within more than one distribution. In that situation two or even three candidate EN circuits could be employed. If more than one EN circuit is employed, then they have to be consistent with all using the proximal to local circuit or the local to distal circuit. Specific recommendations include the following:

**Frequency:** 2 Hz
**Mode:** Continuous
**Duration:** 20 - 30 minutes

Anterior lateral hand (ALH) distribution:

- Dazhu (PLF 11) + lead, to Yangxi (ALH 5) – lead
- Or Yangxi (ALH 5) + lead, to Hegu (ALH 4) – lead

Lateral hand (LH) distribution:

- Fengchi (LF 20) + lead, to Waiguan (LH 5) – lead
- Or Waiguan (LH 5) + lead, to Zhongzhu (LH 3) – lead

Posterior lateral hand (PLH) distribution:

- Jianzhongshu (PLH 15) + lead, to Yanggu (PLH 5) – lead
- Or Yanggu (PLH 5) + lead, to Houxi (PLH 3) -- lead

## Needling Therapy for Hand and Finger Problems

Regional selection of nodes is considered for pain and stiffness (see Table 11.9) or pain and numbness (see Table 11.10) of the fingers. The local and adjacent nodes in the region of the fingers are essentially distal points and thus intermediate nodes are introduced to provide adequate stimulation. Local and adjacent nodes are different for the fingers depending on whether the manifestations of stiffness or numbness predominate. The reasons for this are that nodes for stiffness have a stronger influence on the muscles and tendons while those for numbness have a stronger influence on nerves. Different sets of proximal and intermediate nodes are applied in the treatment of finger and hand problems depending on the associated three yang muscular distributions of the hand, which is either associated with the problem or contains the problem within the affected muscular distribution pathway.

Table 11.9. Selection of regional, proximal and intermediate nodes for treatment of pain and stiffness of the fingers.

| Pain & Stiffness of Fingers | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Intermediate Nodes |
|---|---|---|---|---|
| | Zhongzhu (LH 3)<br>Houxi (PLH 3)<br>Yanggu (PLH 5)<br>Hegu (ALH 4) | ALH* | Dazhu (PLF 11)<br>Feishu (PLF 13) | Shanglian (ALH 9) |
| | | LH | Fengchi (LF 20)<br>Jianzhongshu (PLH 15) | Waiguan (LH 5) |
| | | PLH | Tianzhu (PLF 10)<br>Jianzhongshu (PLH 15) | Zhizheng (PLH 7) |

*Can consider Huatuojiaji nodes at T1 and T3 level.

### *Node Selection for Finger Pain and Stiffness*

Candidate nodes in Table 11.9 address pain and stiffness related problems associated with the hand and fingers. In this situation the former distal nodes are now considered to be local and adjacent nodes. Proximal nodes for the three yang muscular distributions for shoulder, elbow, wrist, and finger problems remain the same. Intermediate nodes that have an influence on the hand and fingers are introduced for finger problems. The same analogy as used to decide which candidate nodes to use as previously discussed for the wrist are applied to the hand.

Pain and stiffness reflecting in the lateral aspect of the hand and finger would indicate the use of Hegu (ALH 4) and Zhongzhu (LH 3) for local and adjacent nodes, Shanglian (ALH 9) as an intermediate node, along with the proximal nodes for the large intestine distribution. For the medial hand, Houxi (PLH 3), Yanggu (PLH 5), and Zhongzhu (LH 3) could be considered as local and adjacent nodes, Zhizheng (PLH 7) as an intermediate node, along with the proximal nodes for the small intestine distribution. For pain and stiffness in the dorsum of the hand Hegu (ALH 4), Zhongzhu (LH 3), and Houxi (PLH 3) can be considered for local and adjacent nodes, with Waiguan (LH 5) as an intermediate node, along with the proximal nodes for the internal membrane distribution.

In condition of Dupuytren's contracture nodes need to be added that may influence the palmar tendons. This would include nodes such as Laogong (MH 8) and Shaofu (PMH 8) needled at a shallow angle parallel to the tendons in the directed toward the wrist. The Baxie node between the index and middle finger, middle and ring finger, and ring and little finger can also be considered.

### *Electroneedling (EN) Application for Finger Pain and Stiffness*

One suggested lead placement for adding electrostimulation is listed below for each of the three muscular distributions involving a proximal and local node. A possible alternative is provided involving a circuit from an intermediate node to the local node. Finger pain and stiffness may manifest within more than one distribution. In that situation two or even three candidate EN circuits could be employed. If more than one EN circuit is employed, then they have to be consistent with all using the proximal to local circuit or the intermediate node to the local node circuit. Specific recommendations include the following:

**Frequency:** 2 Hz
**Mode:** Continuous
**Duration:** 20 - 30 minutes

Anterior lateral hand (ALH) distribution:

- Dazhu (PLF 11) + lead, to Hegu (ALH 4) – lead
- Or Shanglian (ALH 9) + lead, to Hegu (ALH 4) – lead

Lateral hand (LH) distribution:

- Fengchi (LF 20) + lead, to Zhongzhu (LH 3) – lead
- Or Waiguan (LH 5) + lead, to Zhongzhu (LH 3) – lead

Posterior lateral hand (PLH) distribution:

- Jianzhongshu (PLH 15) + lead, to Houxi (PLH 3) – lead
- Or Zhizheng (PLH 7) + lead, to Houxi (PLH 3) – lead

Table 11.10. Selection of regional, proximal and intermediate nodes for treatment of pain and numbness of the fingers.

| Pain & Numbness of Fingers | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Intermediate Nodes |
|---|---|---|---|---|
| | Sanjian (ALH 3)<br>Yemen (LH 2)<br>Houxi (PLH 3)<br>Baxie (Extra) | ALH* | Dazhu (PLF 11)<br>Feishu (PLF 13) | Shanglian (ALH 9) |
| | | LH | Fengchi (LF 20)<br>Jianzhongshu (PLH 15) | Waiguan (LH 5) |
| | | PLH | Tianzhu (PLF 10)<br>Jianzhongshu (PLH 15) | Zhizheng (PLH 7) |

* Can consider Huatuojiaji nodes at T1 and T3 level.

### *Node Selection for Finger Pain and Numbness*

The node selection logic for addressing pain and numbness of the fingers is basically the same as noted above for pain and stiffness of the fingers. The only difference being that the Baxie nodes located in the web space of the fingers are added to the candidate local and adjacent nodes.

### *Electroneedling (EN) Application for Finger Pain and Numbness*

One suggested lead placement for adding electrostimulation is listed below for each of the three muscular distributions involving a proximal and local node. A possible alternative is provided involving a circuit from an intermediate node to the local node. Finger pain and numbness may manifest within more than one distribution. In that situation two or even three candidate EN circuits could be employed. If more than one EN circuit is employed, then they have to be consistent with all using the proximal to local circuit or the intermediate to local node circuit. Numbness also may be the result of neural or vascular influence and mixed mode of 2 Hz - 25 Hz may be considered. Specific recommendations include the following:

**Frequency:** 2 Hz, may also consider 2 Hz - 25 Hz mixed mode
**Mode:** Continuous, or mixed mode at 2 Hz - 25 Hz
**Duration:** 20-30 minutes

Anterior lateral hand (ALH) distribution

- Dazhu (PLF 11) + lead, to Sanjian (ALH 3) – lead
- Or Shanglian (ALH 9) + lead, to Sanjian (ALH 3) – lead

Lateral hand (LH) distribution:

- Fengchi (LF 20) + lead, to Yemen (LH 2) – lead
- Or Waiguan (LH 5) + lead, to Yemen (LH 2) – lead

Posterior lateral hand (PLH) distribution:

- Jianzhongshu (PLH 15) + lead, to Houxi (PLH 3) – lead
- Or Zhizheng (PLH 7) + lead, to Houxi (PLH 3) – lead

## Remedial Exercises for Muscles Moving the Wrist

Exercises performed at the wrist include flexion, extension, ulnar deviation and radial deviation and wrist rotation (see Table 11.4).

### Flexor Carpi Radialis: Wrist Flexion and Radial Deviation

Both the flexor carpi radialis and flexor carpi ulnaris are the prime movers for wrist flexion. The flexor carpi radialis and the extensor carpi radialis brevis and longus are the prime movers for radial deviation. The palmaris longus, flexor digitorum superficialis and profundus, and the flexor pollicis longus muscles participate as assistant muscles to wrist flexion, but do assist in radial deviation. Flexor carpi radialis is exercised in wrist flexion and radial deviation.

Subject is seated, forearm is supinated and resting on the opposite leg or knee with wrist in the neutral position and held in radial deviation. While making and holding a fist, the subject slowly flexes the wrist on the count of 3 and holding the end position 2-3 seconds. Wrist is then slowly returned to the neutral start position and can be further lowered into the wrist extension position, from which to start the next repetition.

This exercise is repeated up to 8 repetitions and eventually performed for 4-5 sets. As strength permits, forearm muscles should be contracted to provide IDR antagonistic resistance to wrist flexion and radial deviation. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing upward, to increase exercise load and further the strengthening process.

### Flexor Carpi Ulnaris: Wrist Flexion and Ulnar Deviation

Both the flexor carpi ulnaris and flexor carpi radialis are the prime movers for wrist flexion. The flexor carpi ulnaris and extensor carpi ulnaris are prime movers for ulnar deviation. The palmaris longus, flexor digitorum superficialis and profundus, and the flexor pollicis longus muscles participate as assistant muscles to wrist flexion, but do assist in ulnar deviation. Flexor carpi ulnaris is exercised in wrist flexion and ulnar deviation.

Subject is seated, forearm is supinated and resting on the opposite leg or knee with wrist in the neutral position and held in ulnar deviation. While making and holding a fist, the subject slowly flexes the wrist on the count of 3 and holding the end position 2 - 3 seconds. Wrist is then slowly returned to the neutral start position and can be further lowered into the wrist extension position, from which to start the next repetition.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, forearm muscles should be contracted to provide IDR antagonistic resistance to wrist flexion and ulnar deviation. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing upward, to increase exercise load and further the strengthening process.

### Extensor Carpi Radialis: Wrist Extension and Radial Deviation

The extensor carpi radialis longus and brevis, and extensor carpi ulnaris are the prime movers for wrist extension. Both the extensor carpi radialis longus and brevis are prime movers for wrist radial deviation. The extensor carpi ulnaris does not participate in radial deviation. Extensor carpi radialis longus and brevis are exercised in wrist extension and radial deviation.

Subject is seated, forearm is pronated and resting on the opposite leg or knee with wrist in the neutral position and held in radial deviation. While making and holding a fist, the subject slowly extends the wrist on the count of 3 and holding the end position 2 - 3 seconds. Wrist is then slowly returned to the neutral start position and can be further lowered into the wrist flexion position, from which to start the next repetition.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, forearm muscles should be contracted to provide IDR antagonistic resistance to wrist extension and radial deviation. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing downward, to increase exercise load and further the strengthening process.

### Extensor Carpi Ulnaris: Wrist Extension and Ulnar Deviation

The extensor carpi ulnaris and extensor carpi radialis longus and brevis muscles are the prime movers for wrist extension. Both the extensor carpi ulnaris and flexor carpi ulnaris are the prime movers for wrist ulnar deviation. The extensor carpi radialis longus and brevis do not participate in ulnar deviation. Extensor carpi ulnaris is exercised in wrist extension with ulnar deviation.

Subject is seated, forearm is pronated and resting on the opposite leg or knee with wrist in the neutral position and held in ulnar deviation. While making and holding a fist, the subject slowly extends the wrist on the count of 3 and holding the end position 2 - 3 seconds. Wrist is then slowly returned to the neutral start position and can be further lowered into the wrist flexion position, from which to start the next repetition.

This exercise is repeated up to 8 repetitions and eventually performed for 4 - 5 sets. As strength permits, forearm muscles should be contracted to provide IDR antagonistic resistance to wrist extension and ulnar deviation. As strength is increased, light-weight dumbbells can be introduced, grasped with palm facing downward, to increase exercise load and further the strengthening process.

# 12

# Thoracic Spine

The thoracic and lumbar (Chapter 13) spine are consists of twelve thoracic and five lumbar vertebrae and joints they form involving intervertebral discs and related ligaments. Thoracic vertebra have larger bodies than the cervical vertebra, have transverse and spinous processes, superior and inferior facets that form apophyseal joints, a spinal canal, and intervertebral foramen in conjunction with a vertebra above and below (See Figure 12.1). In addition, they have costal facets to accommodate the twelve ribs (See Figure 12.2. Features of joint structures involved in trunk movements of the thoracic and lumbar spine, and the lumbosacral articulation are noted in Table 12.1.

Main features of the thoraco-lumbar intervertebral joints are the intervertebral discs that hold the vertebrae together and provide cushioning to axial loads as well as bending that permit side flexion of the spine. The main structural element of the discs is called the annulus fibrosus which is comprised of concentric elastic fibro-cartilaginous outer layers (lamellae) which encloses the soft nucleus pulposus. In adults the annulus fibrosus represents the largest portion of the disc.

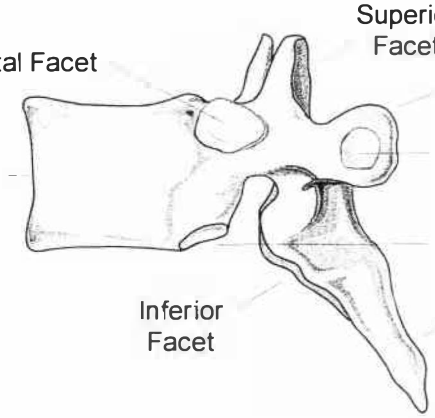


Figure 12.1. Features of thoracic vertebra

Lamellae are in successive layers similar to the skin of an onion and are separated by loose connective tissue. Fibers of the annulus are embedded in the cartilage end-plates and vertebra. The more superficial lamellae are firmly attached to the anterior margins of the vertebrae. There are approximately 12 lamellae in the lumbar discs. The intervertebral joints are held together by the following ligaments: anterior longitudinal ligament, posterior longitudinal ligament, intertransverse ligaments, ligamentum flavum, and supraspinous ligament.

Rib fractures in accidents or other blunt force trauma may be common but the upper thoracic spine (T1-10) is relatively strong being stabilized by the ribs and facets joints. Consequently, fractures occur more commonly in the lower thoracic vertebrae. Increased range of motion at the T12 - L1 junction allows acute hyperflexion and rotation during major trauma, usually by automobile accidents. Some 60-70% of thoracolumbar injuries occur in the T12 - L2 region. Since the spinal cord terminates at about this level, lower thoracic region fractures may result in bladder and bowel problems as well as decreased sensation and movement in the lower extremities.

The thoracic spine is also susceptible to arthritic conditions and osteoporosis. Vertebral body compression deformities are more common among elderly women as opposed to males. Problems can also occur in facet joints which are particularly painful. Herniated discs in the thoracic area are not nearly as common as in the lumbar spine.

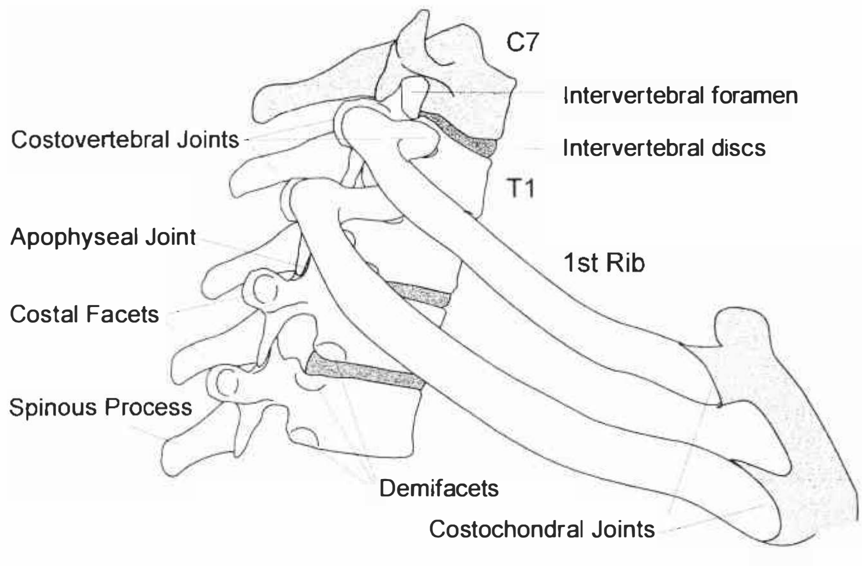


Figure 12.2. Costal Vertebral Joints and Costal Facets

Table 12.1. Features of joint structures associated with trunk movements involving the thoracic and lumbar spine and the lumbosacral articulation.

| | Flexion | Extension | Lateral Flexion | Rotation |
|---|---|---|---|---|
| Articulation | Lumbar spine, thoracic spine (mainly T6-12) | Lumbar spine, thoracic spine (mainly T6-12) | Lumbar spine, thoracic spine | Thoracic spine, lumbosacral articulation |
| Plane | Sagittal | Sagittal | Frontal | Horizontal |
| Axis | Frontal | Frontal | Sagittal | Vertical |
| Normal limiting factors | Tension in posterior longitudinal supraspinous ligament and interspinous ligaments, the ligamentum flavum and spinal extensor muscles; apposition of vertebral body anterior margins, anterior compression of intervertebral discs | Tension in the anterior longitudinal ligament, abdominal muscles, facet joint capsules and the anterior fibers of the annulus; contact between adjacent spinous processes | Contact between the iliac crest and thorax; tension in the contralateral trunk side flexors and spinal ligaments; tension in the lateral fibers of the annulus | Tension in the costovertebral ligaments and annulus fibrosus of the intervertebral discs; tension in the ipsilateral external and contralateral internal abdominal oblique muscles; apposition of the articular facets. |
| Normal end feel | Firm | Firm | Firm/soft | Firm |
| Normal active ROM | 0 - 80°<br>10 cm (4 inches) | 0 – (20 - 30°) | 0 - 35° | 0 - 45° |
| Capsular pattern | It is difficult to perform passive movements of the trunk due to its size and weight<br>It is also difficult to determine capsular patterns for the trunk. | | | |

# Physiology of Thoracic Spine

Major muscles of the trunk are those that move the vertebral column which function primarily to maintain the back in an erect position (See Table 12.2a). These muscles along with the spine form the main axial structure of the body. Muscles on the front portion of the trunk include the abdominal muscles that form the anterior wall of the abdominal cavity to hold and protect the abdominal organs. Additional muscles of the back are involved in elevating or depressing the ribs (See Table 12.2b). The thorax encloses the ribs and the pleural cavity to protect the lungs and contains the muscles related to respiration (See Table 12.2c). Their main function is related to the critical task of breathing.

Table 12.2a. Muscle distribution (MD) assignment, nerve root, and function of prime mover (PM) and accessory/assistant mover (AM) muscles of thoracolumbar spine

| Muscles | MD | Nerve Root | Erection | Extension | Flexion | Lateral Flexion | Rotation to Same Side | Rotation to Opposite Side |
|---|---|---|---|---|---|---|---|---|
| Rectus abdominis | ALF | T7 - 12 | | | PM | AM | | |
| External oblique | LF | T7 - 12 | | | AM | PM | | PM |
| Internal oblique | LF | T7 - L1 | | | AM | PM | PM | |
| Iliopsoas | ALF | L1, 2, 3, 4 | | AM | AM | | | |
| Semispinalis thoracis | PLF | T1 - 6 | PM | | | PM | | PM |
| Iliocostalis thoracis | PLF | T1 - 6 | PM | PM | | PM | PM | |
| Spinalis thoracis | PLF | T4 - 12 | PM | PM | | PM | | |
| Longissimus thoracis | PLF | T4 - L3 | | PM | | PM | PM | |
| Iliocostalis lumborum | PLF | T5 - L3 | | PM | | PM | PM | |
| Rotatores | PMF | T1 - 12 | | PM | | | | PM |
| Multifidus | PMF | T1 - 12 | | PM | | PM | | PM |
| Intertransversarii thoracis | PMF | T1 - 12 | | PM | | PM | | |
| Intertransversarii lumborum | PMF | T12 - L3 | | PM | | PM | | |
| Interspinales | PMF | Spinal | | PM | | | | |
| Quadratus lumborum | PMF | T12 - L3 | | | | PM | | |

Table 12.2b. Muscle distribution assignment and nerve root of muscles that elevate and depress the ribs

| Muscles | MD | Nerve Root | Elevation | Depression |
|---|---|---|---|---|
| Levatores costarum brevis | PMF | T1 - 6 | Upper ribs | |
| Levatores costarum longi | PMF | T6 - 10 | Lower 2-3 ribs | |
| Serratus posterior superior | PLF | T1 - 4 | | Upper ribs |
| Serratus posterior inferior | PLF | T9 - 12 | | Lower 3 ribs |

## Muscles of Respiration

The diaphragm (AMH distribution) is obviously the most essential muscle of respiration, and when pulled down by contraction, air is drawn into the lungs during inspiration (See Table 12.2c). The external intercostals (AMF) also contract during inspiration to increase the anterior-posterior as well as the lateral dimension of the thorax. Some individuals develop inefficient breathing styles by employing these latter muscles to a great extent.

Some pathological conditions of the lung, such as emphysema, also result in significant development of using the external intercostals in an attempt to increase lung intake.

During deep inspiration muscles that raise the sternum and thorax when the head is fixed, such as the sternocleidomastoid (PLF) muscles and muscles that raise the ribs such as the scalene muscles (LF, ALH, LH) that come into play. Forceful inspiration can also involve the pectoralis major and minor muscles which raise the ribs if the arms and shoulders are fixed.

Normal expiration is a passive process by relaxing the diaphragm and external intercostals. Forced expiration involves contraction of the transversus thoracis (AMH) muscles which narrows the chest and the internal intercostals (AMF) muscles which draw the ribs together. Forced expiration can also be assisted by contraction of the abdominal muscles, especially involving the obliques (LF).

Table 12.2c. Muscle distribution assignment and nerve root of muscles of inspiration

| Muscles | MD | Nerve Root | Inspiration | Expiration |
|---|---|---|---|---|
| Diaphragm | AMH | Phrenic: C3, 4, 5 | Draws in air during contraction | Passive expiration by relaxation |
| External intercostals | AMF | T1-T11 | Increases internal dimension of thorax | Passive expiration by relaxation |
| Internal intercostals | AMF | T1-T11 | | Forced expiration by drawing ribs together |
| Transversus thoracis | AMH | T3 - 6 | | Forced expiration by narrowing internal dimension of thorax |

## Muscles of the Abdomen

Abdominal organs are held in place and protected by the firm pressure of the abdominal wall. It is formed by the four large flat muscles that comprise the external oblique (T7 - T12), internal oblique (T7 - L1) and transversus abdominis (LF) and the rectus abdominis (ALF) muscles. The first three muscles wrap around the abdomen with their aponeuroses blending together at the midline, from right and left, to form the linea alba. Of these, the transversus is the innermost muscle with the external oblique being the outermost muscle.

The strap-like rectus abdominis muscle (ALF) extends up the length of the abdomen with the right and left sides divided by the linea alba. It is contained between the aponeuroses of the transversus and oblique muscles forming the rectus sheath. Contraction of the abdominal muscles assists in expiration, urination, defecation, vomiting, and childbirth (parturition). Bilateral contraction of the rectus abdominis muscles cause flexion of the spine. Unilateral contraction results in bending the spine to the side that is contracted. To a lessor extent the oblique muscles have a similar action on the spine.

## Muscles of the Back

The vertebral column is controlled by the muscles of the back (See Table 12.2). Those in the region of the cervical spine have been previously discussed in the section pertaining to the muscles controlling the head and neck. The remaining muscles related to the back are distributed in the thoracic and lumbar regions. They belong mostly to the posterior lateral foot (PLF) muscular distribution, especially the more superficial muscles. The deeper back muscles generally belong to the posterior medial foot (PMF) muscular distribution.

One problem for treatment this is that there are no neurovascular nodes for the PMF distribution on the region of the back. However, there are nodes on the legs that influence the deeper areas in the back, especially those muscles in the lower back region, including nodes Zhubin (PMF 9), Fuliu (PMF 7), and Taixi (PMF 3). All the Back Shu nodes influence both the PLF and PMF muscles distribution routes along the back. Nodes from Shenshu (PLF 23) and below also have influence on the muscles in the legs. These locations represent posterior rami of the spinal nerves while the leg nodes and muscles represent the anterior rami associated with the same or proximate segmental levels.

### Neurology

Muscles of the thoracolumbar spine are innervated by posterior rami emanating from spinal nerve root levels from T1 to L3 as noted in Table 12.2.

## Problems Affecting the Trunk and Back

Pain is the most common complaint of patients presenting with musculoskeletal problems of the trunk and back. Pain in the anterior trunk can be the result of strain of muscles serving this area, be reflected pain from internal organs, or be the result of problem in the thoracic spine. The thoracolumbar spine is subject to similar wear and tear as the cervical spine resulting in degenerative changes including arthritis, spondylosis, disc prolapse and other problems. Nerve root compression and irritation can result in radiculopathies affecting the thoracic area or radicular pain radiating into the legs in the case of lumbar problems.

### Disorders in Muscle Distributions of Trunk

Common disorders manifested in the longitudinal muscular distributions (See Chapter 2) associated with the trunk involve problems with the deeper and more anterior muscles. This includes the diaphragm, intercostals, the obliques and abdominal muscles. These are associated with the anterior medial hand (AMH), anterior medial foot (AMF), anterior lateral foot (ALF) and lateral foot (LF) muscle distribution pathways. Specific symptoms include the following:

Anterior medial hand (AMH):

- Acute cramps and spasms along sternum and in the diaphragm
- Severe pain that results in dypsnea affecting the region of the cardia
- Spasms and cramps in the sides of the ribs related to the diaphragm

Anterior medial foot (AMF):

- Stretching pain from below the umbilicus extending up through the ribs on each side (internal intercostals)
- Stretching pain extending from the breast around to the spine (external intercostals)

Anterior lateral foot (ALF):

- Incarcerated hernia
- Contractions and spasms of the abdomen

Lateral foot (LF):

- Contractions and pain in the lateral abdomen and hypochondrium, extending further upward to cause spasms in the breast and supraclavicular region.

## Disorders in Upper and Lower Back Muscles

The main symptoms related to musculoskeletal disorders involving both the PLF and PMF muscular distributions of the back include:

Posterior lateral foot (PLF):

- Muscular spasms and pain in the upper back, often radiating up to the neck and head.
- Inability to turn the upper body to the left or to the right.
- Abnormal curvature in the back due to contraction of the superficial muscles, resulting in the inability to bend forward.
- Abnormal lateral curvature in the back due to contraction of the muscles on one side, resulting in scoliosis.
- Low back pain, possibly radiating down one or both legs.

Posterior medial foot (PMF):

- Acute cramps and pain in the muscles of the upper back and nape of neck.
- Contraction of deeper muscles in the back with inability to bend backwards.
- Low back pain, possibly radiating down one or both legs.

## Pathology Affecting Thoracic Spine

Presently, thoracic and chest pain are the chief complaints related to the thoracic spine and are a common cause of disability. These can result from degenerative changes affecting all the joints of thoracic spine, hypomobility conditions, and muscular lesions. Intervertebral disc lesions are not common in the thoracic spine. Similar symptoms may arise from either visceral or musculoskeletal disorders. Sometimes visceral disease produces symptoms that mimic musculoskeletal problems, such as angina, leading an incorrect diagnosis and treatment. It is important to make certain that chest pain is not due to heart, lung or mediastinal structures. Visceral diseases are presently not addressed.

Thoracic pain is usually felt on either side of the spine, possibly radiating out several inches along the chest wall or be localized to one side of the spine. It may also be felt more diffusely over several thoracic intervertebral levels.

### *Thoracic Intervertebral-Disc Lesions*

Intervertebral disc lesions are uncommon in the thoracic spine, probably because the discs are relatively thin and because of reduced mobility as result of the splinting action of the ribs.

### Disc Prolapse

Prolapse of a thoracic intervertebral disc is relatively uncommon with the problem more likely to occur between T11 and T12. Clinical manifestations include local back pain and radicular pain which may follow along the intercostal space of the rib at the affected level. Prolapse at the T11- 12 disc may show signs of spinal cord compression with upper motor neuron lesion, sensory loss, and bladder symptoms.

### Senile Kyphosis

This condition occurs in older people of either gender involving severe degeneration of the mid-thoracic intervertebral discs. The condition produces the common feature of patients having rounded shoulder with a forward carriage of the head. X-ray findings show involvement of the anterior part of these discs indicating a loss of disc space. This condition is typically asymptomatic although patients can present with significant pain. Often aching pain has been present for many years that disturbs sleep and is worse with activity.

### Localized Degenerative Disc Lesions

These are also relatively rare with a higher incidence in people who are involved in activities of repeated thoracic rotation, such as with professional golfers. Radicular signs may be present indicating possible nerve root involvement. Pain radiates around the chest wall following the rib which may also be associated with numbness or paresthesia over the same area. Pain is often worse by lying down or by movement.

## *Thoracic Hypomobility Syndromes*

Hypomobility conditions of the thoracic spine may present with pain in the chest wall, or pain which radiates around the chest, or is felt to pass through from the back. The pain may also occur only as pain in the chest wall without any pain in the back.

### Chest Pain

Chest pain can have a sudden onset and may be severe at times. When aggravated by activities or breathing it is difficult to differentiate from possible visceral disease. Visceral referred pain may be found anywhere around the chest wall but the most common site is anteriorly over the costochondral area. Since pain in this region may also be caused by local lesions in the costochondral junctions, it is difficult to differentiate the cause of the patient's symptoms. Pain that does arise from hypomobility syndrome may indicate a localized area of tenderness and pain in the costochondral region which may also be referred pain.

### T4 Syndrome

This condition refers to symptoms involving a hypomobility lesion at the T4 level. Patient often manifests with arm pain or a vague discomfort in the arm with possible paresthesia that does not follow the dermatome pattern. There also may be diffuse posterior neck pain. Hypomobility at the T3 - 4, T4 - 5, and T5 - 6 level is the only positive finding which is relieved by needling therapy, manipulation, or mobilization techniques.

### Lower Cervical Spine

Pain referred from the cervical spine is typically experienced above or between the scapulae. However, this pain may be felt over the upper anterior chest wall which is episodic or brought on by exertion, making it difficult to distinguish from angina.

### *Thoracic joints*

#### Sternoclavicular Joint

Pain from the sternoclavicular joint can be referred into the upper costochondral area. This may be the result of an inflammatory synovitis due rheumatoid arthritis or spondyloarthritis that results in degenerative changes in this joint.

#### Manubriosternal Joint

The manubriosternal joint is generally classified as a cartilaginous joint although about 30% of the population has a synovial cavity present. Spondyloarthritis and rheumatoid arthritis can result in inflammatory lesions in this joint. Most common problem is ankylosing spondylitis along with bony sclerosis and joint erosion eventually leading to bony fusion.

#### Costovertebral Joint

These may be involved in inflammatory or degenerative joint disease with patients complaining of pain in this region. This condition develops early in ankylosing spondylitis due to synovitis. Examination may reveal local tenderness along with reduction in chest expansion. Measurement of chest expansion can be used to assess the progress of this disease.

Degenerative changes may also occur starting in the forth decade which are usually asymptomatic and only found by chance on x-rays. Symptoms of localized tenderness and pain may only occur after some type of local trauma.

#### Costochondral Joints

The seven upper ribs articulate anteriorly with the sternum through their costal cartilages. The junction (costochondral) between the ribs and the costal cartilages form a fibrocartilaginous joint where the cartilage and rib are slotted together. These costal cartilages (except for the first rib) also articulate with the sternum by means of a synovial sternocostal joint. Ribs 8, 9, and 10 articulate through their costal cartilage with the rib above it, but the last two ribs (11 and 12) are not attached.

Pain in the upper costochondral area may be referred, post traumatic, due to polyarthritis, or be due to a rare disorder called Tietze's syndrome. Pain referred from thoracic or cervical spinal lesions is perhaps the most common cause of upper costochondral pain, as previously described. Pain in the synovial sternocostal joint may be produced by spondyloarthritis or rheumatoid arthritis. Pain commonly associated with one or two prominent costochondral joints may occur after local trauma or a burst of coughing. This condition, sometimes confused with Tietze's syndrome, may be associated with thoracic hypomobility syndrome.

Pain may also manifest in the lower costochondral area associated with ribs 8, 9, and 10 commonly due to traumatic lesions, but can also be referred from lesions in the thoracic spine. The first situation may result from a direct or indirect trauma and can produce a painful clicking of costochondral junction. This condition is referred to as a clicking or slipping rib which produces sharp stabbing or aching pain which is made worse on movement but can also occur at rest.

#### Xiphoid Process

Pain in the xiphoid is usually post traumatic but can be the result arthritis

#### Scapulothoracic Joint (See Chapter 9)

### *Muscular Lesions*

#### Muscle Injury

Chest wall muscle injuries are not common but can involve the serratus anterior (MH), intercostal muscles (AMF), or the musculotendinous origins of the abdominal muscles (ALF, LF). These problems may be induced by exercise or by attacks of violent coughing.

One commonly occurring problem involves a periodic episode of a sudden, disabling, sharp, and cramping like muscular pain in the anterior chest wall. This condition often follows a sudden movement of the thorax or setting on a soft couch or chair. The cause and mechanism is not understood but may be the result of a mechanical derangement of a costal joint or perhaps a facet joint.

#### Postural Pain

Muscular pain can also develop without any particular underlying lesion of the cervical and thoracolumbar joints which is basically due to postural changes. Patient is likely to be a female and middle aged, although with the computer age, young to middle aged males are involved in keyboard activities while staring at poorly placed monitors. Stiffness and tenderness in shoulder girdle and thoracic muscles is a common complaint. The condition often becomes worse as the day progresses and the patient is aware that the pain is possibly related to their postural activities. These include sitting for prolonged periods, typing or other types of repetitive or continuous work. Pain may be aggravated by work demands, fatigue, emotional stress, workplace environment such as temperature, and even weather changes.

## Assessment of Thoracolumbar Spine

Assessment of thorax and thoracic spine also involves movement of the lumbar spine. If the patient history, observation, or examination indicates possible symptoms reflecting into or from the neck, upper limb, lumber spine, or lower limb, these structures must necessarily be examined as well.

### Observation

Typically, the patient needs to be suitably undressed so the spine and other features can be viewed for possible alignment abnormalities. The body is viewed anteriorly and posteriorly in the standing position and seated. The vertical alignment of the spinal column is examined to detect possible curvatures, listing, or twisting, and possible scoliosis. A weighted plume line can be used. The body is also viewed from the lateral aspect to assess cervical lordosis, thoracic kyphosis, lumbar lordosis, and sacral kyphosis (See Figure 1.2). Any misalignments are noted for the entire body including the position of head being forward or backward of normal, thoracic spine, lumbar spine, pelvis, hip joint, knee joint, ankle joint, amount patient is listing to right or left, and the length from both the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) to the floor.

Position of the scapula is also noted. The scapular spine is normally at the level of the T3 spinous process while the inferior angle is level with the T7 spinous process.

Medial border of the scapula should be about 5 cm lateral to the spinous process and be parallel to the spine.

### Kyphosis

Normally this term applies to the forward primary curvature of thoracic spine but is consider a problem when the curvature results in misalignment of the body with resulting functional and pain problems. Some individuals have congenital thoracic kyphosis and other deformities of the spine including scoliosis. Kyphosis comes about by degeneration of the thoracic vertebrae that is often accentuated by aging. Some conditions are referred to as senile kyphosis. These conditions can manifest with a rounded back and decreased pelvic tilt, a sharp angulation or hump back called "*gibbus*" or a dowager's hump seen in elderly women.

### Scoliosis

Scoliosis is a deformity where there are one or more lateral curves in the thoracic or lumbar curve. In the cervical spine it referred to as "*torticollis*" (twisted neck). The curvature can occur in the thoracolumbar, thoracic, or lumbar spine. Idiopathic scoliosis often occurs in young women and may be due to poor posture, problems in coordination and proprioception, osteoporosis, nerve root irritation, inflammation in the spinal area, diet, leg length discrepancies, or hip contractures, and possible contractures of other muscles. Congenital scoliosis can be the result of structural conditions due to failure of vertebral segmentation, wedge vertebra, or hemivertebra.

### Breathing

It is important to determine in what manner is the patient breathing. Problems in the thoracic and chest area can have an influence on breathing while poor breathing habits may have an effect as well. Lack of diaphragmatic breathing may result in problems in the in ribs, thoracic spine, and chest area. Children typically breathe abdominally while women may tend to breathe by using the upper thorax. Men may tend to be upper and lower thoracic breathers while in the elderly breathing may be in the abdominal and lower thoracic regions. Many trained athletes also have poor breathing habits that limit their performance. Examiner must note the rate, rhythm, and quality of breathing, and the effort to inhale and exhale. Any signs of rough breathing or cough should be noted since this may aggravate tissues and structures involved in breathing and aggravate painful conditions.

### Chest Abnormalities

There are certain abnormalities in the shape of the chest such as pigeon chest (pectus carinatum) where the sternum projects outward and downward. This increases the anteroposterior dimension of the chest but impairs breathing by restricting overall ventilation volume. Another chest deformity results in the sternum being displace posteriorly due to overgrowth of the ribs. This condition is known as a funnel chest (pectus excavatum) and decreases the anteroposterior chest dimension and may displace the heart. In this condition the sternum is depressed on inspiration affecting respiration and can lead to kyphosis. The barrel chest is another deformity that projects the sternum forward and upward thereby increasing the anteroposterior diameter. This condition is seen in conditions like emphysema.

## Active Movements of Trunk

Most active movements of the thoracolumbar spine are conducted with the patient standing, although some can be conducted in the seated position to eliminate contribution from the hip. As with all other movement assessment, the most painful movements are conducted last. Movement of the thoracic region is normally limited by the rib cage and the long spinous processes of the thoracic spine. If problems are possibly indicated above or below the thoracic spine, then scanning examinations should be considered for the cervical spine and upper limb or the lumbar spine and lower limb.

### *Costovertebral Expansion*

Movement of the costovertebral joints is determined by measuring chest expansion. A tape measure is placed around the patient's chest starting at the level of the 4$^{th}$ intercostal space on the back. The patient is then instructed to exhale as much as possible and hold it while the examiner take a measurement. The patient is then instructed to inhale as much as possible and hold it while the examiner takes a second measurement. Normal difference between exhalation and inhalation is 3 to 7.5 cm.

An alternate method is to measure exhalation and inhalation at three different positions on the chest. The tape measure is placed around the chest just below the axilla in the first position. The second measurement is taken at the nipple line or xiphysternal junction for midline expansion, and the third measurement at the level of the 10$^{th}$ rib. Care must be taken that the levels where the measurements are taken in consistent.

After completion of chest expansion measurements, the patient may be asked to cough to see if this produces pain, which could indicate possible respiratory problems.

### *Trunk Flexion*

The examiner must be sure to note whether trunk flexion occurs in the spine or the hips. Some individuals can touch the toes with a rigid spine if there is sufficient range of motion in the hip joints. On the other hand, tight hamstrings may limit forward flexion.

#### Thoracolumbar Flexion

From the standing position, with feet a shoulder width apart, the patient is instructed to gradually forward flex the body with both arms hanging down to the side relaxed while the examiner stabilizes the pelvis to prevent anterior pelvic tilting. End of motion occurs when resistance to further flexion occurs and examiner feels the pelvis starting to tip anteriorly. Normal end feel is firm and assessed by pushing down on C7 – T1 area.

Flexion range of motion is determined with the end of a tape measure held at the S1 spinous process and the other end at C7. As the patient forward flexes the end of the tape at C7 is allowed move while remaining on the C7 location. Normal of motion is about 10 cm.

Flexion is also measured by using two inclinometers adjusted to zero with one placed on the midsacrum and the other on C7. Total angle for forward flexion is the difference between the two readings (60°).

Forward flexion of the thoracolumbar spine is also evaluated in terms of the distance from the tip of the third finger to the floor. This measurement results in differences to due body size. One approach is to measure the distance of the third finger from the floor from the standing position before forward flexion of the body. Range forward flexion is then assessed by measuring the distance from the tip of the middle finger to the floor. Can measure distance for both hands.

#### Lumbar Flexion

Amount of total thoracolumbar forward flexion contributed by the lumbar spine is measured from the center of line (or dot) at drawn at the level of the PSIS on each side. Another line (or dot) is then marked across the spine measured 15 cm above the lower line. The tape measure is held on the upper line as the patient gradually flexes the forward as before. The tape measure is allowed to play out from the lower line to completion of forward flexion. Lumbar forward flexion is determined by subtracting 15 from the total measurement. This technique is a further modification of the Schober Test which uses a 10 cm starting separation. Lumbar forward flexion with this modified method is approximately 7 cm in males and 6 cm in women.

Lumbar flexion is also measured by using two inclinometers adjusted to zero with one placed on over the spinous process of T12 and the other placed over the midsacrum. The thin dimension of the goniometers is aligned with the spine. Total angle for forward flexion is the difference between the two readings.

### *Trunk Extension*

Extension or backward bending of thoracolumbar spine occur over twelve vertebrae with a total angle of 25 to 45°. In extension it is difficult visually detect movement between individual vertebrae.

#### Thoracolumbar Extension

From the standing position, with feet a shoulder width apart, the patient is instructed to gradually lean backwards to extend the body. Both arms are allowed to move forward or be placed on the hips while the examiner stabilizes the pelvis to prevent posterior pelvic tilting. End of motion occurs when resistance to further extension occurs and examiner feels the pelvis starting to tip posteriorly. Normal end feel is firm. As is done in forward flexion, a tape measurement between S1 and C7 is made before extension movement is conducted. The starting measurement is noted before backward extending the body and the second is noted at full extension. Difference between the two measurements is about 2.5 cm.

#### Lumbar Extension

Amount of total thoracolumbar extension contributed by the lumbar spine is measured from the center of line (or dot) at drawn at the level of the PSIS on each side. Another line (or dot) is then marked across the spine measured 15 cm above the lower line. The tape measure is held on the upper line as the patient gradually extends backward in thoracolumbar extension. The tape measure is allowed move below the lower reference point to completion of extension. Lumbar backward extension is determined by subtracting the measured value from 15. Total lumbar extension may be approximately 1.6 cm.

### *Thoracolumbar Spine Lateral Flexion*

Lateral flexion of the thoracolumbar spine ranges from 18 to 38° by using a goniometer and from 5 to 7 cm using a tape measure. The patient is standing with feet apart and the cervical, thoracic and lumbar spine in 0° of flexion, extension, and rotation. The examiner places both hands on the patient's pelvis to prevent lateral pelvic tilting. The patient then gradually bends the trunk to one side while the arms hang relaxed at the sides. End of lateral motion occurs when the heel on the opposite side starts to lift and the pelvis starts to tilt laterally. Normal end feel is firm or firm/soft.

If a goniometer is used it needs to have sufficiently long arms. A skin marking pencil can be used to mark the spinous process of C7 and S1. The fulcrum of the goniometer is centered on the spinous process of S1. The goniometer arms are perpendicular to the floor and in line with the spine with the upper arm pointing to the C7 spinous process. The upper arm is moved to be pointing at C7 through the range of motion while the lower arm is held perpendicular to the floor.

Lateral flexion can be measured with dual inclinometers with one placed flat against the body with the base at the spinous process of S1 with the other placed on the spinous process of T1 with its base held parallel to the floor. Both inclinometers are zeroed out before lateral flexion begins. The total angular measurement of lateral flexion is determined by subtracting the smallest number measured at S1 from the largest number.

Lateral flexion can also be assessed by using a tape measure to determine the distance of the middle finger to the floor in the standing position and measured again in full lateral flexion. Difference between the two measurements is recorded as the value for lateral flexion.

### *Trunk Rotation*

Thoracolumbar rotation normally takes place in the transverse plane around a vertical axis, usually with the patient seated. However, it can also be measured in the frontal plane about the horizontal axis using dual inclinometers with the patient bending over.

Patient is seated on a low stool with feet on the floor for stabilization with the cervical, thoracic, and lumbar spine at zero degrees of flexion, extension, lateral flexion, and rotation. Examiner stabilizes the patient's pelvis to prevent rotation while the patient avoids moving in flexion, extension, and lateral flexion of the spine. Patient is instructed to gradually rotate to the left or right (measurement is made for both directions of rotation). End of motion occurs when the patient's pelvis starts to rotate. Normal end feel is firm.

Thoracolumbar rotation can be measured with a universal goniometer with the fulcrum center placed over the superior aspect of the head with the goniometer arms parallel to an imaginary line between the two acromion processes. The acromion processes need to be aligned with an imaginary line between the two iliac crests. The fixed arm of the goniometer remains aligned with the iliac crests while the movable follows the reference location on the acromion process of the side being rotated. Care is taken to make certain the patient does not substitute shoulder retraction to increase apparent rotation. Rotation can be in the range of 30 to 45°.

A skin marking pencil is used to place a mark over S1 and C7. The patient is placed in forward flexion in the standing position such that the back is reasonably parallel to the floor. One inclinometer is placed vertically over S1 and the other over C7 with the long axis of the inclinometer perpendicular to the spine. Both inclinometers are zeroed out before the patient gradually rotates the thoracolumbar spine to the right or left. Total rotational angle determine by subtracting the value obtained at S1 from that obtained at C7.

## Passive Movements of Thoracic Spine

Passive movements of the thoracic spine intervertebral joints are tested at each joint level. Movement is felt between adjacent spinous processes. Flexion-extension, lateral flexion, and rotation are tested separately in the upper (C5 - T3) and lower (T3 - T11) thoracic vertebrae.

### *C5 - T3 Flexion-Extension, Side Flexion, and Rotation*

This test is performed with the patient seated with the examiner standing to one side placing the left hand just above the forehead to move the patient's head into flexion and extension. The fingers of the examiner's right hand are used to palpate over and between the spinous processes of the lower cervical and upper thoracic (C5 - T3) spines. Intervertebral movement is detected by the middle finger of the examiner's right hand on the spinous process while the index and ring fingers on either side of it between the spinous processes of two adjacent vertebrae. The quality of passive movement is assessed by examiner including if it hypomobile or hypermobile relative to adjacent vertebrae. Degree of hypomobility or hypermobility may indicate possible pathology.

Assessment of rotation and side flexion passive movement for the lower cervical and upper thoracic (C5 - T3) spines is performed as discussed above. The examiner moves the patient's head into rotation or side flexion in both directions. During side flexion the examiner using the thumb and index finger placed on each side of the spine to palpate on the lateral aspect of the intervertebral space. During rotation intervertebral movement is detected by the middle finger of the examiner's right hand on the spinous process while the index and ring fingers on either side of it between the spinous processes of two adjacent vertebrae. The degree and quality of left and right rotation and side flexion movement are compared at each level.

### *T3 - T11 Flexion and Extension*

These tests are performed with the patient seated with his or her hands clasped behind the head. Standing to the left side, the examiner places his or her left arm under the patient's left arm to grasp the patient's elbows. The examiner's right hand is placed across the spine just below the level being tested. The pad of the middle finger tip is placed in the far side of the interspinous space to palpate between adjacent spinous processes.

Flexion is produced by lowering the trunk from the neutral position by pushing down on the elbows until movement can be detected under the right middle finger. The patient is returned to neutral position by lifting under the elbows. An oscillatory movement can be produced through an arc of approximately 20°.

Extension is produced in a similar way by the examiner assisting in trunk extension with the left arm while the heel and ulnar border of the right hand is used steady the back. Simultaneously, the pad of the middle finger is placed between adjacent spinous processes to assess movement. Movement at one joint is evaluated at a time, thus, large trunk movements into extension is unnecessary.

### *T3 - T11 Lateral Flexion and Rotation*

These tests are performed with the patient seated with his or her hands clasped behind the head. Standing to the left side, the examiner places one arm around and over the patient's elbows to grasp the right shoulder while the heel of the right hand is placed on the left side of the patient's back. The pad of the flexed middle finger placed in the far side (right side) of the interspinous space of the joint being tested. The examiner then firmly holds across the patient's elbows and laterally flexes the patient's trunk pulling on the right shoulder toward the examiner while pressing downward with the heel of the right hand while lifting up with the left hand. The examiner can also press down on the patient's left shoulder with his or her axilla. The examiner's position can be reversed to assess passive lateral flexion to the right.

In passive rotation the examiner holds the patient in the same configuration as noted above for lateral flexion. The examiner rotates the patient's shoulders to the right or left by alternately pulling forward and pushing backward on the right shoulder. The patient's trunk is gently rotated back and forth through an arc of about 25° by the examiner's left hand and forearm. The intervertebral space being tested is palpated using the pad and the middle finger. Examiner compares the degree and quality of movement of each spinal segment. Movement in rotation of the upper spinous process is felt like a pressure against the pad of the upward directed middle finger.

## Resistive Isometric Thoracolumbar Movements

Resistive isometric movement of the trunk evaluates the strength of the muscles moving the thoracolumbar spine. Since the thoracolumbar spine functions as an integrated structure these tests are common to assessing problems either associated with the thoracic spine or lumbar spine. These tests measure isometric resistance in forward flexion, extension, side flexion, and rotation with the patient seated.

The presence of pain may restrict movement in many cases and testing is only conducted up to the point of pain. In some situations, especially involving intervertebral disc lesions, certain tests are contraindicated. With respect to extension, the prone push-up can be performed as a screening test to ensure the safety in conducting the resisted extension test.

- ➔ Prone press-up: the production of localized pain over the spine as result of extending the back by pressing up with the elbows from the prone position indicates that the pain is centralized and further back activities in extension are indicated. If the push-up causes pain to radiate to the lower limbs, then further extension activities are contraindicated.

The thoracic spine should be in neutral position and the most painful movements are to be done last. With the patient seated and the examiner standing to one side with one leg pressed behind the patient's buttocks, the examiner places both arms around the patient's upper chest and back. The examiner then instructs the patient, "Don't let me move you" as the examiner applies a force opposite to direction being isometrically tested (i.e. force directed toward extension to test isometric forward flexion) for all of the following motions:

- Forward flexion
- Extension
- Side flexion left and right
- Rotation left and right

## Resistive Isometric Thoracolumbar Specific Movements

These series of isometric movements of the trunk test for the same conditions noted in the preceding tests. These tests are conducted for the individual groups of muscles moving the thoracolumbar spine in the range of full to eliminated gravity to obtain a grade of 0 to 5 (See Table 4.3). The presence of pain may restrict movement in many cases and testing is only conducted up to the point of pain. In some situations, especially involving intervertebral disc lesions, certain tests are contraindicated. With respect to extension, the prone push-up can be performed as a screening test to ensure the safety in conducting extension tests, as noted above.

### *Trunk Flexion: Rectus Abdominis*

The primary muscle involved in testing trunk flexion in the supine position is the rectus abdominis muscle. Muscle acting accessory to assist trunk flexion include the iliopsoas, rectus femoris, internal abdominal oblique, and external abdominal oblique muscles.

Trunk flexion is performed from the supine position with knees and hips flexed so that the patient's feet are flat on the examination table. The patient attempts to perform a setup from the start position. The initial phase of the setup, from lying flat to about 45°, is the result of contracting the rectus abdominis muscles and no stabilization is provided. The last 45° of movement from the midpoint to the full setup position involves the iliopsoas muscle. Here, the examiner provides stabilization by holding the patient's feet down so that the hip flexors have a fixed reference.

During testing, the examiner palpates the rectus abdominis muscles lateral to the midline on the anterior abdominal wall midway between the sternum and the pubis for possible contractions.

**Screen position (grade 3)**

From the start position the patient posteriorly tilts the pelvis to flex the lumbar spine, then flexes the cervical spine, flexes the thoracic spine and holds his or her arms out in front of the trunk. The patient then slowly performs a setup by moving the thorax toward the thighs by first contracting the rectus abdominis muscle and then flexing the hip to obtain the full setup position. The examiner stabilizes the patient's feet during hip flexion. Successful completion of the screening test requires testing for grades 4 and 5, while failure requires assessment of a possible grade 0 - 2 condition.

➔ Patient may attempt to substitute hip flexor contractions (lumbar lordosis) to flex the trunk.

**Grades 4 - 5**

Both grade 4 and 5 tests are similar to the screening test, except the resistance is increased by changing the position of the arms. For a grade 4 assessment the patient slowly performs the setup while holding his or her arms folded across the chest. In the case of the grade 5 assessment, the patient's hands, with fingers interlocked, are placed on top of the head to increase the resistance load.

**Grades 0 - 2**

Failure to perform the grade 3 screening test requires further examination to determine the appropriate strength level. The patient remains in the start position, lying supine with knees and hips flexed with his or her feet flat on the examination table. For a grade 0 condition, the patient attempts to posteriorly tilt the pelvis but no is possible and no palpable contractions are evident. For a grade 1 condition, no movement is possible when attempting to tilt the pelvis and a flicker of muscle contraction may be apparent when the patient attempts to lift the head off the table.

***Trunk Rotation: Abdominal Obliques***

The external and internal abdominal oblique muscles are mainly involved in rotating the trunk. Other muscles operating accessory to trunk rotation include the rectus abdominis, semispinalis thoracis, multifidus, rotatores, and latissimus dorsi. Trunk rotation is tested against gravity and with gravity eliminated.

The start position is the same as testing the rectus abdominis muscles with the patient lying supine with knees and hips flexed with his or her feet flat on the examination table. The patient performs a setup, but in this situation the trunk is rotated either to the left or right. During the last 45° of movement from the midpoint to the full setup position the examiner provides stabilization by holding the patient's feet down.

When the trunk is rotated to the left, the right external abdominal oblique and left internal abdominal oblique muscles are contracted. Conversely, when the trunk is rotated to the right, the left external abdominal oblique and right internal abdominal oblique muscles are contracted. The position of the arms is varied, as in the case of testing the rectus abdominis muscle, to provide different levels of resistance. Gravity-eliminated testing of trunk rotation is performed from the seated position.

During testing, the examiner palpates the external abdominal oblique at the lower edge of the rib cage, and the internal abdominal oblique above and medial to the ASIS for possible contractions.

**Against gravity**

For the initial screening test (grade 3), the patient slowly performs a setup while the trunk is rotated either to the left or right while the arms are extended straight out toward the thighs. The test is then repeated while the trunk is rotated to the opposite direction from the first test. Successful completion is graded as 3, and further exclamation is conducted to determine if strength grades are higher.

The same test is conducted for a possible grade 4 or 5 and each is repeated with the trunk rotated to both right and left. The grade 4 test is performed with the patient holding his or her arms folded across the chest to provide additional resistance. Successful completion of grade 4 then requires testing for grade 5. In this case the test is repeated while the patient clasps his or her hands over the top of the head to increase the resistance load.

**Gravity-Eliminated**

Trunk rotation with gravity-eliminated is performed if the grade 3 screening test cannot be successfully completed. The patient is seated to stabilize the pelvis and his or her hands are held off the table and the feet are supported by a stool or other means. The patient attempts to rotate the thorax with slight flexion. Rotation to the left tests the right external abdominal oblique and left internal abdominal oblique muscles. Rotation to the right tests the opposite configuration.

Ability to rotate the thorax to full range of motion while confirming contraction of the abdominal oblique muscles is given a grade 2 score. Accessory muscles may be able to produce some rotation in the presence of weak abdominal oblique muscles. Thus, no rotation of the thorax or impaired rotation with flicker contraction of the abdominal obliques is assigned a grade 1 score. Inability to rotate the thorax or impaired rotation along with no palpable contraction of the abdominal obliques results in a grade 0 assessment.

Deviation of the umbilicus during testing can also provide information in the situation of marked weakness of the abdominal muscles. Normally the umbilicus is pulled toward the stronger muscles and away from the weaker muscles. The umbilicus can deviate toward a muscle that is shortened or being stretched. Muscle palpation is used to confirm possible deviation of the umbilicus due to muscle impairment.

***Trunk Extension: Erector Spinae***

Extension of the trunk mainly involves the spinae erector muscles which include the iliocostalis thoracis and lumborum, longissimus thoracis, spinalis thoracis, semispinalis thoracis, and multifidus. Accessory muscles to extension include the interspinales, latissimus dorsi, and the quadratus lumborum.

Neck and hip extensors are tested prior to trunk extension. If neck extensors are found to be weak, the head must be supported during trunk extension testing. If hip extensors are weak or paralyzed, the pelvis cannot be adequately fixed and trunk extension therefore may not be testable. The trunk extensors are tested as a group in the against gravity configuration.

**Screen position (grade 3)**

In this test configuration, the patient lies prone with a pillow under the abdomen and feet over the end of the examination table. The pelvis is stabilized with a strap around the table while the examiner stabilizes the legs proximal to the ankles. The patient holds his or her hands behind the back positioned over the pelvis and extends the trunk to lift the head and sternum to where the xiphoid is off the table. Ability to hold this position is graded as 3, after which further testing is performed to determine if the strength is either grade 4 or 5. No manual resistance is applied by the examiner and the amount of extension and the position of the hands are varied to increase the load for grade 4 and 5 assessment.

#### Grades 4 - 5

Testing trunk extension for grades 4 or 5 uses the same position as the screening test above. But here, the patient extends the trunk further, lifting the head higher off the table, while the hands are held over the lumbar region for grade 4 results. The same test is conducted for grade 5 score except the hands are clasped behind the head to increase the resistance.

#### Grades 0 - 2

Failure to successfully perform the screening test then requires determining whether the condition is either a grade 0, 1, or 2. For the grade 2 assessment, the patient is in the same test configuration except the arms are placed at the sides and the patient extends the trunk to the point where the upper sternum is off the table. There is no movement possible for a grade 2 condition, but possible muscle contractions may be palpated as the patient attempts to lift his or her head. In the case of a grade 0 condition, there are no observable or palpable muscle contractions or flickers.

### *Pelvic Elevation: Quadratus Lumborum*

Pelvic elevation is the function of the quadratus lumborum which is tested in the gravity-eliminated position, with and without resistance. Accessory muscles to this movement are the latissimus dorsi, contralateral hip abductors, internal abdominal obliques, and external abdominal oblique muscles.

Pelvic elevation is tested with the patient lying prone with his or her feet off the end of the table. The patient is stabilized on the table by the weight of the trunk and he or she can hold the edges of the examination table. The examiner palpates above the iliac crest, lateral to the paravertebral extensor muscle mass.

#### Gravity-eliminated

In this test the hip on tested side is held in slight abduction and extension, with the patient's leg supported by the examiner. The patient then elevates the pelvis by moving the iliac crest toward the ribs while the examiner palpates the quadratus lumbar on the tested side. The test is then repeated to assess the other side.

➔ The patient may contract the lateral fibers of the external abdominal oblique and internal abdominal oblique, latissimus dorsi, and erector spinae muscles to compensate for weak quadratus lumborum.

#### Resisted gravity-eliminated

The test configuration is identical to the gravity-eliminated quadratus lumborum test above. Resistance is applied at the anterior aspect of the femur distal end. If hip pathology is present, resistance can be applied on the posterolateral aspect of the iliac crest.

As a screening test (grade 3), a traction resistance force about equal to the weight of the leg is applied to the femur. Additional resistance is applied to obtain either a grade 4 or 5 assessment.

## Functional Assessment

The thoracic spine plays a key stabilization role during many specific activities. Hence, those activities involving the cervical spine, shoulder, and lumbar spine may be impaired by thoracic spine lesions. Functional activities involving these three areas can be considered if functional impairment seems related to the thoracic spine. Heavy work and activities such as lifting and rotating the thorax are likely to provoke thoracic symptoms

## Joint Play (Accessory) Movements

### *Thoracic Spine*

Passive accessory movement can be produced by application of thumb pressure to the spinous and transverse processes of the thoracic vertebra. The spinous processes are tested using posteroanterior and transverse pressures, which may be varied by angling the direction of the pressure either toward the head or feet. This is then followed by posteroanterior pressures against the transverse processes.

Accessory movements of the thoracic spine are similar to those previously described for the cervical spine in Chapter 7 and are essentially the same as mobilization techniques described under Mobilization. When these are used to examine accessory movement, the characteristics of end-feel, joint mobility and reproduction of symptoms are the parameters being evaluated. Mobilization techniques are used for treatment.

### *Costovertebral Joints*

Oscillatory posteroanterior pressures are used to test the costovertebral and intercostal movement. Thumb pressure is applied over the angle of the rib. This may be varied by angling the direction of the pressure either toward the head or feet, to attempt to reproduce the patient's pain.

## Special Tests

If there is suspicion of a thoracic spine problem related to spinal cord movement tests that stretch the cord can be considered including a range of straight leg raising tests including Lasegue's sign and Kernig's sign. The spinal cord can be stretched either by neck flexion from above or straight leg raising from below. Any of these tests, including the following, should be performed only if the examiner considers they are relevant to the case being evaluated.

### *Slump Test (Sitting Dural Stretch)*

The patient is seated on the examination table with legs hanging over edge, and is asked to "slump" the upper body causing the spine to flex and the shoulders to sag forward. The examiner then passively flexes the patient's neck and then passively extends the patient's knee starting with the unaffected side first. Passive ankle dorsiflexion may be added to provide more tension on the spinal dura from below. If no symptoms are provoked the first leg is allowed to relax while passive knee extension and possibly ankle dorsiflexion are performed on the other leg. The test is classified positive if production of the patient's pain or other symptoms is reproduced. This implicates impingement of the dura and spinal cord or nerve root. Pain is usually produced at the site of the lesion.

### *Passive Scapular Approximation*

With the patient lying prone the examiner passively approximates the scapulae by moving the shoulder up and back. Pain provoked in the scapular area indicates possible lesion of a T1 or T2 nerve root on the same side that the pain is being experienced.

### First Thoracic Nerve Root Stretch

This test is performed by the patient first abducting the arm to 90° and then flexing the pronated forearm to 90° which should not provoke any symptoms. The patient then fully flexes the elbow, putting the hand behind the neck. This action stretches the ulnar nerve and the T1 nerve root. Provoked pain into the scapular area or arm is considered a positive test.

## Neurological Evaluation of Thoracic Spine

### Myotomes (graded 0 - 5)

There are no convenient tests for muscles related to specific thoracic spinal nerves. Possible intervertebral disc prolapse in the thoracic spine and other conditions can potential result in pressure on the spinal cord to affect the upper motor neurons supplying the muscles of the hip and legs. Therefore, when thoracic problems involve suspected disc problems or if there is weakness, pain or dysfunction also noted in either the regions of the lumbar, hip or lower extremities, testing of these areas should be considered. Isometric tests to isolate specific spinal nerve roots supplying the lower back and extremities to be considered in conjunction with assessing the thoracic spine include:

- L2: Iliopsoas muscle - hip flexion
- L3: Quadriceps muscle - knee extension
- L4: Tibialis anterior muscle - ankle dorsiflexion and inversion
- L5: Extensor hallucis longus muscle - extension of big toe
- S1, 2: Gastrocnemius and soleus muscles - plantar flexion

### Key Reflexes (graded 0 - 4)

There are no single myotome reflexes to isolate a problem to a specific spinal root. But in the case where a thoracic problem has resulted in pressure applied against the spinal cord, upper motor neurons to the lower part of the body may be affected. If this is the case, then reflexes tested in the lower legs are affected. Reflexes to consider include:

- L4: quadriceps muscles - knee jerk
- S1, 2: Achilles' tendon - ankle jerk

## Diagnostic Imaging

### Plain Film Radiography

**Anteroposterior View:** This view is used to observe possible abnormalities of the thoracic spine including wedging of the vertebrae, reduced intervertebral disc space, presence of "bamboo spine" indicating ankylosing spondylitis, scoliosis, and symmetry of the ribs.

**Lateral View:** The examiner should look for a normal or mild kyphosis, wedging of the vertebrae, condition of intervertebral disc space, angles of the ribs, or osteophytes.

### Magnetic resonance imaging (MRI)

Magnetic resonance images are useful for delineating soft-tissues problems including herniated discs and spinal cord lesions as well as bony tissue. Presence of disc herniation should be confirmed by the clinical findings since presence of this condition noted by MRI may be asymptomatic.

### *Computed tomography*

Computed tomography is useful in evaluating the bony spine, facet joints, spinal contents, and surrounding soft-tissue in cross-sectional view, including axial views.

# Management of Thoracic Spine Disorders

## Mobilization

Mobilization techniques applied to the thoracic spine involves applying pressure over various regions of the vertebrae similar to procedures discussed for the cervical spine (See Chapter 7). The techniques used are posteroanterior central, transverse and posteroanterior unilateral vertebral pressure. All three of these procedures along with possible traction, are considered to address unilateral thoracic spine symptoms. In case of bilateral symptoms, posteroanterior central and transverse vertebral pressure to each side is considered along with possible traction.

### *Posteroanterior Central Vertebral Pressure*

This technique involves the application of oscillatory pressure on the spinous process by means of the therapist's body transmitted through the arms and thumbs. It is essential that the pressure be produced by the therapist's body weight and not by the thumbs alone. Posteroanterior central vertebral pressure is important for addressing all cases of thoracic pain, especially midline or bilateral pain. This technique is also important in treating poorly defined or widespread unilateral pain as well.

The patient lies prone and the therapists apply vertebral pressure by leaning over the thoracic spine or sacrum depending on accessibility from different positions. The goal is to apply pressure essentially at right angles to the area being mobilized.

#### Upper Thoracic Spine

The therapist stands at head of the patient and leans over to place his or her thumb pads over the spinous process. The fingers spread out over the rib cage on each side. Pressure is applied through the weight of the therapist basically at right angles to the upper thoracic vertebrae being treated.

#### Mid-Thoracic Spine

The therapist stands at the side of the patient and leans over to place his or her thumb pads over the spinous process aligned along the spine. The thumbs point to each other and the fingers are allowed to spread out over the spine above and below the mid-region being mobilized. Pressure is applied through the weight of the therapist basically at right angles to the vertebrae being treated.

#### Lower Thoracic Spine

The therapist, facing forward, stands at the side of the patient and leans over the sacrum to place his or her thumb pads over the spinous process. The fingers spread out over the rib cage on each side. Pressure is applied through the weight of the therapist basically at right angles to the lower thoracic vertebrae being treated.

### *Transverse Vertebral Pressure*

The therapist applies pressure to the lateral aspect of the thoracic spinous process in this technique. Oscillatory pressure is applied through the therapist's arms and thumbs by moving his or her trunk. Transverse vertebral pressure is used to address unilateral thoracic pain and may need to be combined with mobilization of the rib.

The upper thoracic vertebrae are accessible for transverse mobilization but this region of the thoracic spine has limited movement. The lower thoracic spine has greater capacity for movement and requires less pressure for transverse mobilization. The lateral aspects of the mid-thoracic spinous processes are relatively inaccessible, making transverse mobilization more difficult.

With the patient lying prone, the therapist stands at the side of the patient at the vertebral level requiring transverse mobilization. The therapist's thumbs are placed against the side of the spinous process with the fingers spread out over the back. Transverse pressure is reinforced by placing one thumb on top of the other.

### *Posteroanterior Unilateral Vertebral Pressure*

This mobilization technique involves oscillatory pressures to the vertebral transverse processes by movement of the therapist's trunk directed through the arms and thumbs. Only slight movement can be produced by this technique and it is used to address unilateral thoracic pain.

The patient lies prone with his or her head turned to one direction and arms over the side of the table. The therapist stands to one side, leaning over to apply the thumb pads over the transverse process. The thumbs face each other, tip to tip, with the fingers spread out over the back. Pressure is applied in a direct line through the shoulders and arms at right angles to the patient's body.

## Manipulation

Manipulation involves passive-movement techniques that include either small amplitude oscillations at the limit of range (Grade IV) or sharp thrusts beyond the pathological limit of movement (Grade V) (See Table 5.1). Grade IV and V movements are used to increase mobility.

There is some overlap between manipulation and mobilization techniques. Manipulation usually involves quick movements and thrusts, while mobilization involves oscillatory movements. Mobilization techniques involve Grade I and II movements that are used to reduce pain, and also involves Grades III and IV, used to increase mobility.

### *Non-Specific Posteroanterior Pressure*

This manipulation technique is performed with the patient lying prone and the therapist standing to the side. Using the dominant hand, the therapist places his or her pisiform bone against the patient's spinous process, applying pressure to stretch the intervertebral joint. When the joint is stretched to the limit a sudden, very small range, movement is applied.

### *Posteroanterior Central Pressure (T3 - T10)*

The patient initially sets up, with his or her hands linked behind the head, with legs extended down the length of the table. The therapist stands to the right side and reaches around the left side of the patient to place his or her right hand, made into a fist, along the patient's thoracic spine. The fist is formed by flexing the middle, ring and little fingers into the palm while the thumb and index finger remain extended. The right hand is positioned to where the patient's lower spinous process is grasped between the terminal phalanx of the middle finger and the palmar surface of the first metacarpal head. The index finger and thumb are used to maintain the fist position and aid in grasping the spinous process.

The patient is then lowered to where the therapist's fist is wedged between the patient's back and the treatment table, with the therapist's forearm projecting laterally. The therapist then grasps the patient's elbows with his or her left arm and hand, and gently rocks the upper trunk back and forth in flexion and extension to obtain the mid position of this movement. Once determined, the full weight of the patient's trunk rests on the therapist right fist and table. Manipulation is then applied by a quick downward thrust directed through the patient's elbows and upper arms.

### *Rotation (T3 - T10)*

Thoracic manipulation in rotation starts with the patient seated at the edge of the treatment table, while hugging his or her arms across the chest, and turning the trunk to the left. Standing behind the patient, the therapist reaches around the patient with his or her left arm to grasp the right upper arm and cradles the patient's left shoulder in his or her axilla. The therapist uses the right hand to apply pressure over the line of ribs on the patient's right side.

Clasping the patient with his or her left arm while simultaneously applying pressure with the right hand, a synchronous movement is produced by the therapist's trunk rotation. An oscillatory movement is established at the limit of rotation. Manipulations consist of applying oscillatory over-pressure into the limit of the range.

## Manual Thoracolumbar Traction

Thoracic spine traction is not as successful as either cervical or lumbar spine traction. This may be due to the influence of the thoracic cage which limits the degree of movement. Mobilization techniques are usually conducted before traction is considered, and then only when mobilization and other therapies including needling therapy have not resolved the problem. The main idea of applying traction is to position the joint being treated in a relaxed orientation midway between all of its ranges.

This procedure serves as both a screening assessment to observe possible changes in signs and symptoms, and as a trial treatment. Traction is considered to address conditions involving a wide distribution of thoracic pain usually due to either hypomobility lesions or disc degeneration. Traction can be considered even when disc problems are complicated by neurological changes and nerve-root pain. Relief of symptoms by traction indicates possible reduction in the size of a disc protrusion or the movement of a sensitive structure away from the point of pressure.

This technique is applied with the patient either seated or standing, depending on the relative sizes between the therapist and the patient. The patient crosses his or her arms across the chest to grasp the opposite shoulders. The therapist then stands behind the patient, reaching around to clasp the patient's elbows with both hands. The therapist then leans back to apply a traction force on the thoracolumbar spine while the patient relaxes his or her thorax. Relief of the patient's symptoms is a positive indication that traction can be considered to reduce symptoms.

The therapist can use manual traction as a mobilization technique for hypomobility problems. After placing the patient in manual thoracolumbar traction, the therapist gently rocks back and forth to apply an oscillatory force on the intervertebral joints.

## Needling Therapy for Thoracic Spine Problems

Muscle distributions of the trunk include the anterior and lateral muscles, and those of the back. Common disorders manifested in muscular distributions of the anterior and lateral aspect of the trunk involve problems with the deeper and more anterior muscles. This includes the diaphragm, intercostals, the obliques, and abdominal muscles. These are associated with the AMH, AMF, ALF, and LF muscular pathways.

### *Node Selection for Anterior Lateral Trunk*

Treating problems affecting the anterior and lateral trunk involves selecting candidate nodes that correspond to the spinal segmental levels associated with the particular muscular distributions. Although the diaphragm is not a skeletal muscle per se, it does belong to the AMH distribution. The diaphragm receives its innervation from the phrenic nerve emanating from the spinal cord level of C3 - 4. Hence, a proximal node should be selected that is above this level, such as Tianzhu (PLF 10). This is a key proximal node along with the communication node, Feishu (PLF 13) also being utilized to provide a wide coverage along the cervical and upper thoracic cord. Anterior and distal nodes to address pain and functional problems are selected relevant position of the diaphragm and key nodes on the upper extremity (See Table 12.3).

Table 12.3. Regional selection of nodes for treatment of anterior and lateral trunk.

| Anterior & Lateral Trunk | Anterior Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Diaphragm | Zhongting (RN 16)<br>Zhangmen (MF 13)<br>Burong (ALF 22) | AMH | Tianzhu (PLF 10)<br>Feishu (PLF 13) | Geshu (PLF 17)<br>Taiyuan (AMH 9)/<br>Yuji (AMH 10) |
| Intercostals* | Yuzhong (PMF 26)<br>Bulang (PMF 22)<br>Fuai (AMF 16)<br>Fujie (AMF 14) | AMF | Dazhu (PLF 11)<br>Pishu (PLF 20) | Zusanli (ALF 36) |
| Obliques & Transverse Abdominis | Riyue (LF 24)<br>Burong (ALF 22)**<br>Qichong (ALF 30)** | LF | Geshu (PLF 17)<br>Danshu (PLF 19)<br>Qihaishu (PLF 24) | Zulingqi (LF 41) |
| Rectus Abdominis | Burong (ALF 22)**<br>Guilai (ALF 29)** | ALF | Xinshu (PLF 15)<br>Weishu (PLF 21) | Zusanli (ALF 36) |

*Candidate anterior nodes can be replaced by either relevant ALF or PMF nodes.
**Nodes selected over this range depending on specific location of problem.

The internal and external intercostal muscles associated with the AMF distribution are supplied by the 1st - 11th intercostal nerves. Hence, proximal nodes Dazhu (PLF 11) and Weishu (PLF 21) are used to cover this spinal segmental range. Then at least two anterior nodes ranging from Yuzhong (PMF 26), Bulang (PMF 22), Fuai (AMF 16), and Fujie (AMF 14) are selected that cover range of the specific intercostals that are affected.

The external and internal obliques (LF), and the transverse abdominis muscles (LF) are supplied by branches of lower intercostal, iliohypogastric, and ilioinguinal nerves. Hence, Geshu (PLF 17) and Qihaishu (PLF 24) selected as proximal node range with Danshu (PLF 19) being considered as well. Anterior nodes include Riyue (LF 24) and other nodes selected in the range of Burong (ALF 22) to Qichong (ALF 30), depending the specific location of the problem being treated.

The abdominis rectus muscle associated with the ALF distribution is supplied by branches of 7th – 12th intercostal nerves. Hence, proximal nodes Xinshu (PLF 15) and Weishu (PLF 21) selected to cover this range. Anterior nodes are selected within the range of Burong (ALF 22) and Guilai (ALF 29), depending on the problem location.

### *Candidate Electroneedling (EN) for Anterior Lateral Trunk*

**Frequency**: 2 Hz
**Mode**: Continuous
**Duration**: 20-30 minutes
**Lead Placement**:

Anterior medial hand (AMH): Diaphragm

- Tianzhu (PLF 10) + lead, to Feishu (PLF 13)/Geshu (PLF 17) – lead (Bilateral)

Anterior medial foot (AMF): Intercostals

- When specific intercostals are affected: posterior nodes + lead to anterior nodes – lead at the same intercostal nerve level, such as Dazhu (PLF 11) + lead, to Yuzhong (PMF 26) – lead
- Or can use two posterior (+ lead) to anterior (– lead) circuits placed proximal (above) and distal (below) to the affected intercostal muscles being treated
- If herpes is present along a particular intercostal muscle, then may consider 2 Hz – 25 Hz mixed mode for treatment
- For general treatment: Dazhu (PLF 11) + lead, to Pishu (PLF 20) – lead

Lateral foot (LF): Obliques and transverse abdominis

- Posterior nodes from Geshu (PLF 17) to Qihaishu (PLF 24) + leads, to specific anterior nodes from Burong (ALF 19) to Qichong (ALF 30) – leads that cover range of problem being treated

Anterior lateral foot (ALF): Rectus abdominis

- Posterior nodes from Xinshu (PLF 15) to Weishu (PLF 21) + leads, to specific anterior nodes from Burong (ALF 19) to Guilai (ALF 29) – leads that cover range of problem being treated

### *Spinal and Upper Back Pain*

Thoracic and chest pain are the chief complaints related to the thoracic spine and are a common cause of disability. These symptoms may arise from either visceral or musculoskeletal disorders. Sometimes visceral disease produces symptoms that mimic musculoskeletal problems, such as angina, leading an incorrect diagnosis and treatment. It is important to make certain that chest pain in not due to heart, lung or mediastinal structures. Visceral diseases are presently not addressed. Assessment and treatment of spinal and upper back pain (See Table 12.4) follows the same general guidelines for any other part of the body. Treatment of spinal pain employs special nodes that have an influence on the spine itself including Jinsuo (DU 8) in the upper back and Yaoyangguan (DU 3) in the lower back.

Table 12.4. Candidate regional, proximal and distal nodes for spinal and upper back pain.

| Back Pain | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Spinal Pain | Shenzhu (DU 12)<br>Yaoyangguan (DU 3) | | Baihui (DU 20)<br>Renzhong (DU 26) | Shugu (PLF 65)<br>Kunlun (PLF 60) |
| Upper Back | Feishu (PLF 13)<br>Jinsuo (DU 8)<br>Ganshu (PLF 18) | PLF<br>PMF | | Feiyang (PLF 58)<br>Zhubin (PMF 9) |

### *Candidate Electroneedling (EN) for Spinal and Upper Back Pain*

**Frequency**: 2 Hz
**Mode**: Continuous
**Duration**: 20-30 minutes
**Lead Placement**:

Spinal pain:

- Shenzhu (DU 12) + lead, to Yaoyangguan (DU 3) – lead

Upper back pain:

- Feishu (PLF 13) + lead, to Ganshu (LF 18) – lead

## Remedial Exercises Muscles of the Trunk and Back

Exercises for the trunk and back are to restore strength and function to the muscles moving the thoracolumbar spine. Since the thoracolumbar spine functions as an integrated structure some of the routines are common to address problems either associated with the thoracic spine or lumbar spine (See Table 12.2). The greater incidence of weakness affecting the back generally involves the lower back region. Presence of pain may restrict movement in many cases and exercise is only performed up to the point of pain. In some situations, especially involving intervertebral disc lesions, certain exercises are contraindicated. Orthopedic tests provide a clear idea concerning the location and nature of the problem with the weak muscle groups identified. General findings usually indicate a sprain or strain, or involvement of either a herniated disc, spinal stenosis due to disc degeneration or a facet/subluxation syndrome. Certain remedial steps may be contraindicated for specific problems. Such as in situations where neural symptoms manifest when doing the "prone push-up" “sphinx” or the "cobra," indicates that exercises involving extension must be avoided.

## Back Flexion Stretches

These routines flex the back and put the back extensor muscles into stretch. Flexion stretches can be performed from either a standing or supine position. It is not necessary to do both routines and thus either can be employed.

### *Standing Back Flexion Stretch*

From the standing position, with hands on hips or on the legs, or with arms hanging down in front, slowly lean forward directing the head toward the floor to place the back into flexion. Hold the end position 10 - 15 seconds and then slowly return to the full standing position. Repeat 3 - 5 times.

### *Supine Back Flexion Stretch*

While lying supine with knees and hip flexed, grasp the legs and slowly pull up toward the chest while flexing the neck and upper back at the same time. Hold the end position 10 - 15 seconds and slowly return to the start position. Repeat 3 - 5 times.

## Strengthening Trunk Flexion

The primary muscle exercised to strengthen trunk flexion in the supine position involves the rectus abdominis muscle. Muscles participating as assistant movers to assist trunk flexion include the iliopsoas, rectus femoris, and internal and external abdominal oblique muscles. The upper and lower rectus abdominis fibers are exercised separately.

### *Upper Rectus Abdominis*

Trunk flexion is performed from the supine position with knees and hips flexed so that the feet are flat on the floor. The subject performs a partial setup from lying flat by raising the shoulders off the floor, but not exceeding about 45°. This is the result of contracting the rectus abdominis muscles. The arm can be placed in three different positions in order to increase the resistive load as strength is restored.

a) From the start position the subject posteriorly tilts the pelvis to flex the lumbar spine, then flexes the cervical spine, flexes the thoracic spine and holds his or her arms out in front of the trunk, pointing to the knees. The subject then slowly lifts the shoulders off the floor the maximum extent possible and holds the end position for 2 - 3 seconds. The shoulders are then slowly lowered to the floor. This exercise is repeated for up to 8-25 repetitions depending on level of fitness and eventually performed for 3 - 5 sets. As strength permits, back and abdominal muscles should be contracted to provide IDR antagonistic resistance to trunk flexion.

b) When strength increases, the preceding exercise is modified to place the arms crossed over the chest to increase the resistive load. Exercise is repeated for the same schedule as noted in the preceding exercise.

c) When strength further increases, the preceding exercise is modified to place the arms so that the hands can be placed on each side of the head or on top of the head. Care must be taken so subject does not use the hands to pull the neck into flexion during the exercise. Exercise is repeated for the same schedule as noted in the first rectus abdominis exercise.

#### *Lower Rectus Abdominis*

Lower abdominal strengthening exercises are performed with the subject supine. One leg is slowly raised to an angle of about 30 - 45°, while the knee is fully extended. Leg is held at the end position for 2 - 3 seconds and the leg is slowly lowered to the floor. This exercise is repeated for up to 8 - 16 repetitions and eventually performed for 3 - 5 sets. During each leg lift, the lower abdominal muscle is contracted (IDR) to achieve peak contraction. The subject places one hand to touch the lower abdominal muscle on the exercised side to assure that peak contraction is maintained.

At the end of each set, the leg is raised to the full range of hip flexion, with knee extended, while subject pulls lower leg into the extended position to stretch the hamstring muscles.

### Abdominal Obliques Stretches

The abdominal obliques can be stretched from either the standing or seated position.

#### *Standing Side-Bending*

From the standing position, the subject slowly leans to one side to lower the hand closer to the floor while the other arm is held up over the head to increase stretch. This position is held for 10 - 15 seconds while maintaining side bending forces and attempting to move the hand lower toward the floor during the whole time period. Repeat the stretch 4 - 6 times, alternatively stretching in each direction.

#### *Standing Rotation*

While standing, the subject rotates about the vertical axis approximately 75 - 90°, while the arms are either held stretched out from each side or both are stretched straight out in front of the body. Arms are held in the same orientation to the shoulders as the subject slowly rotates. The end position is held for 10 - 15 seconds while maintaining rotational forces and attempting to move further into rotation during the whole time period. Repeat the stretch 4 - 6 times, alternatively stretching in each direction.

#### *Seated Rotation*

Preceding stretches can also be performed in the seated position.

### Abdominal Obliques: Trunk Rotation

External and internal abdominal oblique muscles are exercised mainly by flexing the trunk while it is held in rotation. The rectus abdominis, semispinalis thoracis, multifidus, rotatores, and latissimus dorsi participate as assistant movers to trunk rotation. The subject is supine with knees and hips flexed with his or her feet flat on the floor. The subject then performs a partial setup, not exceeding about 45°, from lying flat by raising the shoulders off the floor while rotating the trunk to one side. Alternate to this, the subject can lower the flexed legs to one side so they rest on the floor. The partial setup is then performed with trunk straight as in the case of exercising the abdominis erectus muscle. In either configuration, the arm can be placed in three different positions in order to increase the resistive load as strength is restored. When the trunk is rotated to the left or the legs are lowered to the right, the right external abdominal oblique and left internal abdominal oblique muscles are being exercised. Conversely, when the trunk is rotated to the right or the legs lowered to the left, the left external abdominal oblique and right internal abdominal oblique muscles are being exercised.

a) The subject slowly performs a partial setup, but in this situation the trunk is rotated approximately 45° either to the left or right while directing both outstretched arms toward the side of the knee in the same direction that trunk is rotated. The subject then slowly lifts the shoulders off the floor the maximum extent possible with trunk rotated and holds the end position for 2 - 3 seconds. The shoulders are then slowly lowered to the floor while still pointing the arms to the side of the knee. This exercise is repeated for up to 16 repetitions for each side and eventually performed for 3 - 5 sets. As strength permits, back and abdominal muscles should be contracted to provide IDR antagonistic resistance to trunk flexion.

b) When strength increases, the preceding exercise is modified to place the arms crossed over the chest to increase the resistive load. Exercise is repeated with the trunk rotated for the same schedule as noted in the preceding exercise.

c) When strength further increases, the preceding exercise is modified to place the arms so that the hands can be placed on each side of the head or on top of the head. Exercise is repeated for the same schedule as noted in the first abdominal oblique exercise.

➔ Care must be taken so subject does not use the hands to pull the neck into flexion during the exercise.

## Back Extension Stretches

These stretches extend the back and put the abdominal muscles into stretch. It is not necessary to do all three routines and thus any one can be employed. The sphinx and prone push-up are easier to perform and more controllable.

### *Standing Back-Bending*

While standing with feet slightly apart, place hands on hips or extended straight up over the head, or on the hips, and then slowly lean body backwards to put back into extension. Hold end position 10 - 15 seconds and then slowly return to the standing position. Repeat 3 - 5 times.

### *Sphinx Position*

This technique puts the back into a mild extension stretch once the position is established. The subject is prone with hands on the floor, placed at the side level with the chest or shoulder. Arms are used to push chest off the floor while keeping the elbows flexed with the pronated forearms flat on the floor. The pelvis also rests on the floor and the low back and abdominal muscles are relaxed to increase the extension curvature of the back. This position is held 10 - 15 seconds and then the chest is slowly lowered to the prone start position. Repeat 3 - 5 times.

#### *Cobra (Prone Push-Up)*

The subject is prone with hands on the floor, placed at the side level with the chest or shoulder. Arms are used to push chest off the floor while keeping the pelvis on the floor and the low back and abdominal muscles relaxed. Head is kept down to prevent arching the neck backwards. Slowly raise the chest and hold the full extended position for 10 - 15 seconds and then slowly lower chest to the floor. Repeat 3 - 5 times.

### Strengthening Trunk Extension

Exercising the trunk in extension mainly involves the spinae erector muscles, including the iliocostalis thoracis and lumborum, longissimus thoracis, spinalis thoracis, semispinalis thoracis, and multifidus. Assistant muscles to extension include the interspinales, latissimus dorsi, and the quadratus lumborum. The trunk extensors are exercised as a group.

#### *Contralateral Arm and Leg Raise: Lizard on Hot Sand*

The subject is prone with both arms extended up over the head and resting on the floor. The head is held in neutral position while one arm is slowly lifted up and off the floor while at the same time the opposite leg is extended to lift off the floor. End position is held 2-8 seconds with the arm and leg slowly lowered to the floor. The opposite arm and other leg are then slowly lifted off the floor and held in the end position for 2 - 8 seconds before being slowly lowered to the floor. This exercise is repeated up to 8 repetition cycles including each side and eventually performed for 4 - 5 sets.

#### *Trunk and Leg Raise: Seal*

As strength increases the following exercise is then used to continue the recover process. The subject is prone with both arms held at the sides with dorsum of each hand resting on the floor. While the head is held in neutral position, it is slowly lifted off the floor by extending the trunk while at the same time both legs are extended up off the floor. Arms remain at the sides with the dorsum of both hands resting on the floor. End position is held 2 - 8 seconds with the head and legs then slowly lowered to the floor. This exercise is repeated up to 8 repetitions for each side and eventually performed for 4 - 5 sets.

#### *Trunk, Leg and Arm Raise: Swallow*

This is a variation of the preceding exercise, and introduces a slight increase the resistive load. The subject is prone with both arms held at the sides with dorsum of each hand initially resting on the floor. While the head is held in neutral position, it is slowly lifted off the floor by extending the trunk while at the same time both legs and both arms are extended up off the floor. End position is held 2 - 8 seconds with the head, legs and arms then slowly lowered to the floor. This exercise is repeated up to 8 repetitions for each side and eventually performed for 5 sets.

### Quadratus Lumborum: Pelvic Elevation

Pelvic elevation is the function of the quadratus lumborum with the latissimus dorsi, contralateral hip abductors, internal abdominal obliques, and external abdominal oblique muscles participating as assistant movers. The quadratus lumborum will normally be exercised and strengthened by trunk extension exercises. If there is weakness in the quadratus lumborum that is impairing to ability to perform adequate trunk extension exercise, this muscle can be addressed individually.

It is exercised from a standing position with the subject leaning against a wall for stabilization. While maintaining the body as near vertical as possible, the subject raises the leg which is hanging vertically down, by contracting the quadratus lumborum and slowly lifting the iliac crest on the exercise side. End position is held 2 - 3 seconds with the leg then slowly lowered to the floor. This exercise is repeated up to 8 repetitions for each side and eventually performed for 4 - 5 sets. As strength improves, strap-on leg or ankle weights can be introduced to increase the resistive load.

# 13

# Lumbar Spine

Anatomical features of the lumbar spine, including the osteology, arthrology, and mechanics, are discussed along with the details of the thoracic spine in Chapter 12. The lumbar vertebrae are larger (Figure 13.1) than those in the thoracic and cervical spine, and their intervertebral discs have approximately 12 lamellae.

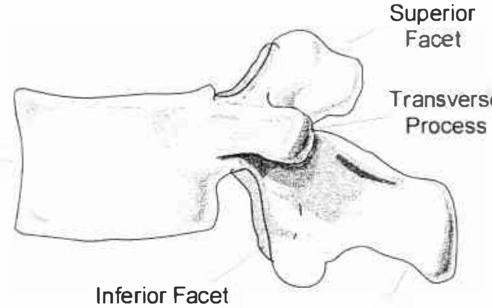


Figure 13.1. Features of lumbar vertebra

## Disorders of the Lumbar Spine

The main symptoms related to musculoskeletal disorders affecting the lumbar region involve both the posterior lateral foot (PLF) and posterior medial foot (PMF) muscular distributions. Specific problems associated with these muscular assignments are provided in Chapter 12. Deeper muscles of the lumbar region are assigned to the PMF distribution while the more superficial muscles belong to the PLF distribution (See Table 12.2). Problems in the lumbar spine are similar to those affecting the thoracic spine except the lumbar spine is susceptible to intervertebral disc prolapse. Problems associated with the lumbar spine include those that affect the vertebral column, lumbar intervertebral discs, and lumbar movement.

### Disorders of Vertebral Column

Problems that affect the lumbar vertebrae are mainly medical and rheumatological conditions. Some surgical condition such as fractures, dislocations, and structural scoliosis are not included in this text. Also, metabolic diseases such as metabolic bone disease, chondrocalcinosis, gout, acromegaly, and ochronosis, as well as Reiter's disease and psoriatic arthritis can affect the lumbar spine.

#### *Inflammatory Diseases*

**Spondyloarthritis**

This includes a group of diseases characterized by inflammation in the vertebral and peripheral joints and are usually classified as spondyloarthritis. They are also linked to inflammatory changes in the sacroiliac joints as well as being frequently associated skin, eye, mucus membrane, bowel, and urinary tract lesions.

Spondyloarthritis includes ankylosing spondylitis which is involved in inflammatory changes in the spinal joints and bilateral sacroiliitis. Pathological lesions occur in the central joints of the axial skeleton, such as the sacroiliac joint, symphysis pubis, and the intervertebral joints of the spine. In the spine these changes manifest as erosive lesions either anteriorly or posteriorly at the upper and lower vertebral body surfaces which eventually become ossified, giving rise to osteophytes.

Typically, ankylosing spondylitis has a history of episodic pain in the lower back radiating into the buttocks, thigh, and groin. The pain may also radiate down the posterior leg to be confused with true sciatica, but neurological signs are absent. Initially the disease presents with periodic attacks but later the pain becomes more constant. There is low back stiffness which may be worse in the early hours or on awakening. Subject may have to walk around when they first get up to loosen up the body to obtain relief. Severity of the inflammation correlates with the degree of stiffness, although most symptoms are exacerbated by immobility. Overall range of lumbar spine movements becomes reduced, especially in lateral flexion.

**Rheumatoid Arthritis**

This condition commonly involves the cervical spine possibly due to it mobility and the fact that there are 29 synovial joints between the skull and the first thoracic vertebra. However, this disease is rare in the thoracic and lumbar spine. The main lesion is a rheumatoid discitis, spreading in from adjacent apophyseal (facet) or costovertebral joints. In lumbar spine discitis there already may be disc degeneration and may be caused by vertebral instability with the resulting chronic trauma producing discovertebral destruction.

***Traumatic and Degenerative Conditions***

Numerous traumatic and degenerative conditions affect the lumbar spine including but not limited to spondylolysis, spondylolisthesis, ankylosing vertebral hyperostosis, and Scheuermann's disease.

**Spondylolysis**

This condition is caused by a defect in the pars interarticularis, the narrow strip of bone lying between the lamina and the inferior articular process below and the pedicle and superior articular process above. Etiology of this condition has been a subject of much debate but suspicion is now considering a stress fracture being the cause. Or it may be that there is some inherent weakness in the pars interarticularis. Spondylolysis is not uncommon in athletic injuries and occurs in weight lifters, rowers, and fast bowlers. Some indications suggest the fracture is the result of rotational stress since it occurs in the left pars interarticularis of fast right hand bowlers and in the right pars interarticularis in left hand fast bowlers.

This condition may asymptomatic but the patient usually complains of pain in the lower lumbar region localized to one side of the spine. Pain may radiate into the buttocks or leg especially after continuous use of the back. This condition does not usually produce nerve root pressure. When a patient with spondylolysis presents with clinical evidence of neurological signs this may be due to an associated disc prolapse. X-rays are needed to confirm the diagnosis. An oblique view X-ray of the lumbar spine is required to show the area that has the appearance of Scottish terrier dog. The spondylolysis appears as a collar around the dog's neck.

### Spondylolisthesis

This represents a vertebral subluxation consisting of a forward displacement of one vertebral body on the vertebral body below. Any vertebra can be involved but this condition most commonly occurs in the L5 vertebra. The degree of spondylolisthesis is viewed in terms of the distance the slipped vertebra moves on its lower counterpart which is divided into four degrees or grades. A displacement of one quarter of anteroposterior vertebral body distance is considered a first degree or grade 1 slippage, while slippage resulting in a full diameter displacement is a forth degree or grade 4. The five types of spondylolisthesis are: traumatic; congenital; spondylolytic; degenerative; and pathological.

Patient presents with back pain and possible leg pain, which may be related to the effect of the spondylolisthesis on spinal mechanisms. Symptoms may vary with the degree of the slip so that minimal movement could possibly have minimal effect on the surrounding tissues. But, soft tissues may be stretched or traumatized with increasing degrees of spondylolisthesis. When progression is slow a buttress of bone may form at the anterior border of the first sacral segment thereby reducing the tendency to slip. The diagnosis of spondylolisthesis may be suspected when the patient's history indicates low back pain that is made worse by standing and eased by sitting.

### Ankylosing Vertebral Hyperostosis

This condition may occur in middle age and involves laying down new bone on the anterolateral aspect of the vertebrae which produce bony bridges across the disc space. This may occur in any area of the spine but is most common in the thoracic spine. Sacroiliac joints are radiologically normal but degenerative changes may also occur in weight bearing joints. Patient presents with pain and stiffness although there is little correlation between the symptoms and x-ray findings. This condition may be a chance x-ray finding in asymptomatic patients.

### Scheuermann's Disease

This problem is of unknown etiology and produced by a vertebral epiphysitis (which is an inflammation of the epiphysis of the vertebra: osteochondrosis of the vertebra). Most common site of involvement is the lower thoracic vertebrae usually around T9. In the lumbar spine there is a decreasing incidence from L1 where it is common to L5 where it is rare. Usually affects several vertebrae.

Usual complaint is mild or moderate pain the thoracic spine and which sometimes radiates into the lower lumbar region. Pain usually follows physical actively, especially where it involves overuse of the spine. Typical findings include:

- Smooth, rounded dorsal kyphosis that is most evident on forward flexion
- Loss of spinal mobility including a loss of normal flexion, extension, and of passive intervertebral joint range
- Tightness of the hamstring muscles

X-ray changes are necessary to confirm the diagnosis which must include at least one of the following changes:

- Wedging of the vertebral body
- Kyphosis of the thoracic vertebrae or a loss in normal lumbar curve
- Irregular, narrowed intervertebral disc spaces
- Schmorl's nodes, which may be an indication of a milder form or precursor to Scheuermann's disease

## Disorders of Lumbar Intervertebral Disc

### *Intervertebral-Disc Prolapse*

Disc prolapse presents with back pain which may occur for no apparent reason, but many patients usually relate it to some seemingly minor strain or traumatic incident. This may have involved lifting, twisting, or bending activities. Pain may be described as dull or aching or even knife-like, cutting, or burning sensation in the low back, either on one side or in the midline. The initial pain symptoms are usually confined to the lower back, may be sudden and severe, or may develop gradually. Pain may be intermittent and relieved by changes in position, or by rest, but usually made worse by movement, straining, coughing, sneezing, or sitting. Also, pain may be severe enough to disturb sleep. Later, the back pain may be accompanied by leg pain, alterations sensation, and motor weakness (See Table 13.1).

Table 13 1 Nerve root pain, sensory loss, and motor weakness in intervertebral disc prolapse

| Involved Root | Pain Distribution | Sensory Loss | Motor Weakness | Reflex Change |
|---|---|---|---|---|
| L2 | Anterior aspect of upper thigh | Upper outer aspect of thigh | Flexion and adduction of hip | |
| L3 | Anterior thigh to anterior region of knee | Lower inner aspect of thigh and knee | Flexion, adduction, and internal rotation of hip | Knee jerk |
| L4 | Lateral aspect of thigh to medial side of calf | Medial aspect of calf and knee | Dorsiflexion and inversion of ankle and extension of knee | Knee jerk |
| L5 | From buttocks to lateral aspect of leg and dorsum of foot and great toe | Dorsum of foot and great toe. Anterolateral aspect of lower leg | Dorsiflexion of great toe and other toes, and dorsiflexion and eversion of ankle | |
| S1 | From buttocks to back of thigh and leg, lateral aspect of ankle and foot | Lateral aspect of ankle, foot, and posterior calf | Plantar flexion of ankle and toes, extension of hip and flexion of knee | Ankle jerk |

### *Lumbar Spondylosis*

Patient complains of either unilateral or bilateral back or leg pain with or without neurological signs. Character of pain may be reported as being dull and aching associated with stiffness, which is located in the lower lumbar midline possibly radiating into the buttocks or groin. Symptoms may get worse as the day progresses but on the other hand they may be aggravated after a night's rest, and then improve after moving around. It is not possible to determine the exact mechanism that produces the patient's symptoms since degenerative changes occur in the anterior and posterior areas of the intervertebral joint complex. Attacks of mechanical derangement of the lumbar may occur as result or recurrent synovitis in the apophyseal joints after overuse. If sciatica is present it may be due to encroachment of the intervertebral neural canal by osteophytic overgrowths which can arise from the vertebral and apophyseal joints.

### *Vertebral instability*

This condition produces mechanical spinal derangement following the initial stages of disc degeneration where fissures appear with softening and bulging of the disc. Occurs more commonly in males usually in the third and forth decade involving L4 - L5 disc. The instability causes increased strain on ligamentous support and soft tissues, which contribute to development of postural pain. This condition makes the spine more susceptible to trauma so that any unguarded or forced movements may result in apophyseal joint synovitis or subluxation with resulting mechanical derangement.

Pain may present as being constant, dull, aching, deep seated, and localized to the back or radiate into one or both buttocks and legs. Rarely, does it radiate below the knee and evidence of nerve root pressure is absent. The pain can be made worse by maintaining one posture for a long time such as standing or sitting. An alteration of posture such as arching the back or lying down may relieve the pain.

### *Isolated Disc Resorption*

This involves severe progressive degenerative changes in one intervertebral disc alone. Back and leg pain can develop due to altered spinal mechanics and not to disc prolapse. Some cases show that the disc is completely resorbed only leaving a rim of the annulus. Radiological findings show a marked loss of disc space, associated with a vacuum phenomenon, vertebral margin sclerosis, and often a retrospondylolisthesis which results in apophyseal joint overriding with resulting degenerative changes.

### *Spinal-Canal Stenosis*

This refers to limiting the space in the spinal canal by congenital defects or changes in the surrounding bony structures associated with degenerative disc and apophyseal joint changes along with possible thickening of the ligamentum flavum. The disc lesions commonly include a hard annular bulging along with osteophyte formation, or may be the result of a nuclear prolapse. Hypertrophic apophyseal joint changes can bulge into the spinal canal from their posterolateral angle to produce stenosis.

Patient symptoms may be similar to the condition of arterial insufficiency caused by intermittent claudication. Pain in one or both legs involving the whole leg is provoked after walking a certain distance. This may be accompanied with paresthesia and possible leg weakness. Pain is relieved by resting and patient may need to sit down immediately. Relieving pain in spinal canal stenosis may require a longer rest period as opposed to the rapid disappearance of pain in patients with peripheral vascular disease. Hence, it is often difficult to differentiate between these two condition based only on the history. Leg weakness may affect any part of the leg. Some patients may report experiencing a sudden loss in leg strength that resulted in them falling to the ground.

Stenosis can also occur in the neural root canal, especially at L5 and S1, where patients present with leg pain but do not have the symptoms usually seen in disc prolapse, such as pain be aggravated by straining or coughing.

### *Cauda Equina Compression*

This condition results from a sudden massive extrusion of nuclear material through the posterior longitudinal ligament. This may occur in younger patients following a sudden flexion strain. Patient complains of back pain that radiates into both legs and the buttocks. There are sensory and motor neurological changes in the legs as well as sensory changes in the sacral dermatomes of the scrotal and perianal area that can also be associated with urinary retention. Early recognition is critical in order to allow early surgical decompression before permanent damage occurs.

### *Juvenile Disc Syndrome*

Previous discussions on disc prolapse usually involves patients that are 20 years of age and older. Clinical presentation of disc problems in adolescent patients differs. Trauma appears to play a greater role in this problem which may be the result of direct trauma to the spine, or by indirect trauma such as falling onto the buttocks. Patient complains of pain that may vary to some extent while marked spinal stiffness and muscle spasms predominate. This may result in abnormal spinal movement with the possible manifestations of a shuffling gait. Scoliosis may present only on movement. Straight leg raising is markedly restricted but neurological deficits are uncommon.

## Movement Disorders in Lumbar Spine

After excluding patients with pathological disorders of the intervertebral discs and of the vertebral column as noted in the preceding information, there are still a large number of patients who symptoms do not place them in either category. Clinically, these patients could be classified in terms of having an alteration in the range of spinal movement which may be restricted (hypomobility) or increased (hypermobility). In the lumbar spine there an acute form of mechanical derangement that is referred to as acute low back pain (lumbago).

### *Acute Low Back Pain (Lumbago)*

The term lumbago could be used to describe any low back pain. But here it is used to denote a lumbar spinal problem characterized by sudden onset of severe persistent pain with marked restriction of lumbar movement, and a sensation of locking in the back. Attacks can range from severe and incapacitating or to one that is minor in nature. In serve cases the patient presents with an intense lower lumbar pain of sudden onset that may be bilateral. The pain and resulting locking sensation in the back may incapacitate the patient with the back stuck in one position, usually in flexion. Patient may even fall down or have to immediately lie down, may not be able to move, or may have to crawl to a couch or bed.

Attacks often occur after forward flexion of the body, even though the movement was slight. This could include brushing the teeth, standing up from a forward flexed position, coughing, sneezing, bending to lift a weight, or bending over a patient. The may be combined twisting motion. Pain is made worse by almost any back movement. Lumbar spine examination shows that active movements are very difficult to perform. There may be marked bilateral paraspinal muscle spasm, frequently more prominent on one side than the other, which is apparent on inspection.

### *Hypomobility Lesions*

This lesion is a chronic form of mechanical derangement of the intervertebral joint complex involving reduced range of joint movement. Clinical presentation includes pain that is localized in the back or referred into the buttock, leg, or abdominal region. Pain is reproduced while testing active spinal movements, which may show a pattern of restricted movement only in certain directions. There is a restricted range in accessory intervertebral movements with possible evidence of mechanical derangement of spinal movements. X-ray findings may be normal for the patient's age.

### *Hypermobility Syndrome*

This syndrome is defined as having a range of movement in excess of the usually accepted range, possibly involving spinal or peripheral joints. Movement throughout the hypermobile range can be controlled by muscular activity. This distinguishes it from joint instability which has an abnormal range of movement which may be excessive at times, but cannot be controlled by voluntary muscular control.

Hypermobility patients tend to be young females and the condition may affect spinal and peripheral joints or spinal joints alone. Hypermobility affecting the spinal joints manifests with back pain that is either continuous or recurrent. There is a general increase in the range of passive intervertebral movements as well as in spinal mobility. There may be an associated hypermobility of peripheral joints. X-ray findings and other studies are normal.

## Assessment of Lumbar Spine

### Observation

Typically, the patient needs to be suitably undressed so the spine and other features can be viewed for possible alignment abnormalities. The body is viewed anteriorly and posteriorly in the standing position and seated. The vertical alignment of the spinal column is examined to detect possible curvatures, listing, or twisting, and possible scoliosis. A weighted plume line can be used. The body is also viewed from the lateral aspect to assess cervical lordosis, thoracic kyphosis, lumbar lordosis, and sacral kyphosis (See Figure 1.2). Any misalignments are noted for the entire body including the position of head being forward or backward of normal, thoracic spine, lumbar spine, pelvis, hip joint, knee joint, ankle joint, amount patient is listing to right or left, and the length from both the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) to the floor.

Position of the scapula is also noted. The scapular spine is normally at the level of the T3 spinous process while the inferior angle is level with the T7 spinous process. Medial border of the scapula should be about 5 cm lateral to the spinous process and be parallel to the spine.

### Active Movements of Lumbar Spine

See information under Active Movements of Trunk in Chapter 12 on the thoracic spine.

## Passive Movements of Lumbar Spine

Two distinct passive intervertebral movements can used to assess the range of movement, reproduction of pain and symptoms, behavior of these clinical manifestations throughout the range of movement, presence of muscular spasms, and the end-feel of the movements. These movements consist of passive physiological and accessory (See following section) movements of the lumbar spine.

The passive range of physiological movements at each individual spinal joint is evaluated by the examiner by producing physiological spinal movements with one hand while feeling the relative movement between adjacent bony spinous processes with the fingers of the other hand. Flexion-extension, lateral flexion, and rotation are tested.

### *Flexion-Extension*

This test can be performed by moving either both legs of the patient or only a single leg. The following procedure involves moving only a single leg. For this movement test, the patient lies on the right side with the underneath leg held in slight flexion of the hip and knee. Standing in front of the patient's upper chest, facing towards the hips, the examiner's left forearm is placed across the thorax so that his or her left hand fingers can palpate the lumbar spinous processes. The patient's thorax is stabilized between the examiner's left arm and left side. The examiner then grasps the patient's above leg distal to the knee with his or her right hand.

Flexion and extension of the lumbar spine are produced by the examiner pulling up on the patient's left leg to produce flexion at the hip and then releasing the hip flexion. The examiner's left hand middle finger is placed in the interspinous space to feel the movement of lumbar flexion and extension by noting a corresponding opening and closing of the interspinous gap.

### *Lateral Flexion*

In this test the patient lies on the right side with his or her hips and knees flexed so that the lumbar spine is relaxed midway between flexion and extension. Standing in front of the patient, the examiner reaches across the patient's left side to align his or her left forearm along the spine with the fingers pointing to the feet. With the right hand, the examiner grasps under the patient's left ischial tuberosity. The pad of the examiner's left hand middle finger is placed facing upwards in the underside of the interspinous space to feel the bony margins of the adjacent vertebrae.

The examiner laterally flexes the patient's lumbar spine by grasping the pelvis and upper left leg with his or her right arm and side, and then pulling up with the right forearm so the patient's left ilium moves cephalad. The pelvis is then returned to its mid position by examiner pushing against the patient's upper left side with his or her right side. This oscillatory movement rocks the pelvis around the fulcrum created by the underside hip and femur and thus, lateral flexion is easy to produce and detect by palpation.

### *Rotation*

Active measurements of lumbar rotation often does not provide much diagnostic information, while testing the small range of passive rotation is valuable. The test configuration is similar to that noted above for lateral flexion and the examiner must confirm that the patient's left knee can slide forward over the underneath knee.

The examiner leans across the patient to align his or her left forearm along the patient's spine with the pad of the middle finger facing upwards in the underside of the interspinous space to feel the bony margins of the adjacent vertebrae. With his or her right hand, the examiner grasps over the patient's left greater trochanter, with the fingers spread out behind it.

The examiner stabilizes the patient's thorax with his or her left arm and side. The patient's pelvis is pulled toward the examiner with his or her right hand to rotate the left side of the pelvis and lumbar spine forward. The palpating finger keeps pace with the movement so that the displacement of the distal spinous process relative to the proximal spinous process can be detected. The pelvis is then returned to the start position by the heel of the examiner's right hand and forearm.

## Accessory Movements of Lumbar Spine

Passive accessory movement can be produced by application of thumb pressure or pressure by applying the pisiform of the hand, first over the patient's spinous processes of the lumbar vertebra and then over the transverse processes. The spinous processes are tested using posteroanterior and transverse pressures, which may be varied by angling the direction of the pressure either toward the head or feet. This is then followed by posteroanterior pressures against the transverse processes. These accessory movements are similar to those previously described above for the thoracic and cervical spine.

Accessory movements are performed with the patient lying prone, with hands by the sides and head turned in one direction. The three basic techniques are noted below, and these can be varied by directing the pressure against the bony structures either toward the head or feet:

- Posteroanterior pressure applied to the spinous process
- Transverse pressure applied to the lateral surface of the spinous process
- Posteroanterior pressure applied to the transverse processes

## Resistive Movements of Lumbar Spine

See information under Resistive Isometric Thoracolumbar Movements in the preceding Chapter on the thoracic spine.

## Peripheral Joint Scanning Examination

If examiner did not perform a scanning examination during the history and observation, it should be performed after completion of resistive isometric movements of the lumbar spine. The lower limb scanning test is applied to the sacroiliac, hip, knee, ankle, and foot joints. Test should be conducted quickly but if any deviations from normal found, a more detailed examination should be performed for the affected joint.

### *Sacroiliac Joints*

Examiner palpates the PSIS on one side with one thumb and palpates one of the sacral spines with the other thumb while the patient is standing. Patient then instructed to fully flex the hip on that side while noting if the PSIS drops as it normally should or whether it elevates indicating possible fixation of the sacroiliac joint on that side. The examiner then tests and compared the other side. The examiner next places one thumb on one of the patient's ischial tuberosities and one thumb on the sacral apex. The patient is instructed to flex the hip again on this side. If the thumb on the ischial tuberosity moves lateral, the motion is normal. If the sacroiliac joint on this side is fixed, the thumb moves up. The other side is then tested and compared. This test is referred to as Gillet's test or sacral fixation test.

### *Hip Joints*

The hip joints are actively moved through flexion, extension, abduction, adduction, medial rotation, and lateral rotation in a full as possible ROM. Any pattern of restriction or pain is noted. As the patient flexes the hip, the ilium, sacrum, and lumbar spine may be palpated to determine when movement in the sacroiliac joint starts on that side and at the lumbar spine during the hip movement. Both sides are tested and compared.

### *Knee Joints*

Patient actively moves the knee joint through a full range of flexion and extension as possible. Any abnormal signs, restriction of movement, or symptoms should be noted.

### *Foot and Ankle Joints*

Active full ROM is performed for plantar flexion, dorsiflexion, supination, and pronation of the foot and ankle as well as flexion and extension of the toes. Any alterations in signs and symptoms are be noted.

## Myotomes (graded 0 - 5)

Several different isometric tests involving muscles of the hip and lower extremity are used to evaluate possible weakness or dysfunction due to impairment of lumbar and sacral spinal nerves (see Table 13.2). Some of the tests involve more than a single muscle while others provide a clear indication affecting a particular myotome.

## Special Tests

### *Quadrant Position Test*

This test is intended to position the lumbar joints under maximum stress by means of passive movements. This is accomplished by passively moving the patient first into full lumbar extension, followed by lateral flexion and rotation toward the affected side. This position results in maximal reduction in the intervertebral foramen space.

The examiner stands behind and slightly to one side of the patient and then passively moves the patient into full lumbar extension with the examiner holding the patient's shoulder. Examiner's shoulder is positioned near patient's occiput to support the weight of the head. Overpressure is applied at the limit of this range and the patient is guided into the quadrant position by laterally flexing and then rotating the spine toward the affected side. Movement is continued until the limit of range is achieved and the patient is asked if their pain is reproduced.

### *Straight-Leg Raising (SLR) Tests*

The presence of a disc prolapse may produce pressure on the affected nerve root within its dural sleeve. The nerve root in question is not subjected to any increase in tension while the patient is lying supine or by raising the affected leg with the hip and knee flexed. However, the inflamed nerve root can be subjected to increased tension and caused to move in the intervertebral foramen when the leg is passively elevated with the knee extended. Reproducing the patient's pain is necessary for a positive sign. It is common for the range of straight-leg raising to be lower in patients with intervertebral disc prolapse which produces nerve root pressure at L4, L5, or S1.

The patient is lying supine in all the SLR type tests with each leg being tested separately starting with the unaffected or painless side first. To ensure that hip-joint movements are normal the hip is first placed in slight adduction and slight medial rotation before being passively flexed by raising the leg by the heel in one hand while the other hand is place proximal to the knee to maintain knee extension.

Table 13.2. Isometric tests for neurological assessment of lumbar spine

| Root | Muscle | MD | Movement | Isometric Test |
|---|---|---|---|---|
| L2 | Iliopsoas | ALF | Hip flexion | Patient is supine with hip and knee both flexed 90°, resistance to further hip flexion is applied just proximal to the knee |
| L3 | Quadriceps | ALF, AMF | Knee extension | The examiner slightly flexes the hip of the patient's test leg by slipping one arm under the lower thigh to grasp the opposite thigh, and the patient moves the leg to near full extension, while examiner applies a force on top of the leg just proximal to the ankle, to resist knee extension |
| L4 | Tibialis anterior | ALF | Ankle dorsiflexion & inversion | While supine, the patient holds the foot in dorsiflexion and inversion while the examiner applies force against the dorsomedial surface over the proximal end of the first metatarsal to resist movement |
| L5 | Extensor hallucis longus | MF | Big toe extension | Lying supine, patient holds the foot and toes in dorsiflexion while the examiner applies resistance against the nail of the big toe |
| L5, S1 | Extensor digitorum longus | ALF | Extension of toes | Lying supine, the patient holds the foot and toes in dorsiflexion while the examiner applies resistance against the dorsal surface of all toes |
| S1 | Peroneus longus and brevis | PLF | Ankle eversion | Lying supine, patient holds heels together while sides of the feet are twisted outward from each other, and the examiner applies resistance to the lateral border of the feet to push them together |
| L5, S1 | Hamstrings | PLF, PMF, LF | Knee flexion | Either prone or supine, the patient holds the knee flexed 90°, while the examiner applies resistance behind the patient's heel |
| L4, 5, S1, 2 | Gluteus maximus | PLF | Hip extension | Lying prone with knee bent, patient holds the hip extended while the examiner applies downward resistance on the back of the leg with one hand and palpates the gluteus maximus with the other |
| S1 | Gastrocnemius | PLF, PMF | Plantar flexion | Patient stands on one leg and attempts to raise his or herself up onto the toes through the full range, six times |
| S2 | Flexors digitorum & hallucis longus | AMF | Flexion of toes | Lying supine, the patient holds all toes into flexion while the examiner applies resistance against the plantar surface of all toes |

MD = Muscle Distribution

#### Standard SLR Test

Leg on the affected side (after testing the pain free side) is passively lifted by the heel while the examiner's other hand is placed proximal to the knee to keep it extended while the hip is in slight adduction and slight medial rotation. The pelvis in not allowed to rotate or rise. Elevation of the leg continues smoothly until pain and/or paresthesia are elicited and their distribution is consistent with the patient's presenting complaints. The range of the movement is estimated.

**SLR with Foot Dorsiflexion**

This is a slight variation of the above test where the affected leg is passively elevated as before to produce pain after which the foot is dorsiflexed which should cause the patient's pain to be exacerbated as the nerve root is further stretched. This would confirm that the pain is not being produced by muscle or ligamentous pull. One variation of this test is to initially raise the affected leg with the foot dorsiflexed until pain is provoked in which case the foot is returned to the normal position to see if the pain is relieved. Another variation is to provoke pain in the affected leg with the standard SLR and slightly lower to leg until the pain subsides, at which time the foot is dorsiflexed to reproduce the pain.

**SLR with Neck Flexion (Dural Stretch)**

This test is basically the same as the standard SLR where the affected leg is passively elevated as before just short of producing pain. The patient then flexes the neck, or the examiner may passively flex the patient's neck to stretch the dura and possible reproduce the leg pain.

**SLR with Popliteal Compression (Bowstring or Cram Test)**

In this variation, the affected leg is passively elevated just short of producing the patient's pain. The knee is then flexed and supported on the shoulder of the examiner, who then applies pressure over the popliteal fossa with both thumbs to reproduce patient's pain. Test considered positive if there is a tingling, burning sensation in the hip and buttocks, indicating possible sciatic nerve root impingement.

**Lasegue's Sign**

This variation of the leg test is performed in the supine position with the knee and hip flexed to 90° and supported by the examiner. The knee is then passively extended by the examiner, while stabilizing the leg with the other hand just above the knee, until the pain is reproduced.

### *Kernig/Brudzinski Test*

The patient is supine with hands cupped behind the head and is instructed to flex the head onto the chest. The patient then actively raises one extended leg by flexing the hip until pain is reproduced. At this point the patient is instructed to flex the knee and the pain should be relieved. A positive sign may indicate meningeal irritation, dural irritation, or nerve root involvement. This test is similar to some of the straight leg raising tests except the movements are actively performed by the patient. Kernig described the hip flexion component of this test while Brudzinski originally described the neck flexion aspect of this test.

### *Well Leg Raising Test (Fajersztajn/ Lhermitt's Test)*

This is also known as the cross leg test or cross over sign, the well leg raising test of Fajersztajn, sciatic phenomena, prostrate leg raising test, or Lhermitt's test. It involves provoking pain and other symptoms while raising the leg of the unaffected side. It often indicates a large intervertebral disc protrusion that lies medially to the nerve root on the affected side. Raising the unaffected leg also stretches the dura causing the roots on the opposite side to slide slightly downward and toward the midline. In the presence of a disc lesion this test increases root tension. The test is positive if pain extends from the back into the leg in the sciatic nerve distribution.

An intervertebral disc central protrusion will likely cause pain in the back; a protrusion in the intermediate area causes pain in the posterior aspect of the lower limb and low back; and a lateral protrusion will primarily cause posterior leg pain.

### *Prone Knee Bending*

Patient lies prone while the examiner passively flexes the knee as far as possible with the heel resting on the buttocks. This position should be held for 45 to 60 seconds unless pain is provoked sooner. At the same time the examiner should ensure that the patient's hip is not rotated. If the knee cannot be flexed beyond 90° because of pathological conditions, the test may be continued by flexing the hip along with maximum knee flexion possible. Unilateral lumbar pain may indicate an L2 or L3 nerve root lesion.

This test also stretches the femoral nerve. Pain in the anterior thigh may indicate tight quadriceps muscles. If the rectus femoris is tight, taking the heel to the buttocks may cause torsion to the ilium causing possible sacroiliac or lumbar pain.

### *Femoral Nerve Stretch Test*

Patient lies on the unaffected side with the leg slightly flexed at the hip and knee. Patient's back should be straight with the head slightly flexed. Examiner grasps patient's affected leg and extends the patient's knee while gently extending the hip to about 15°. Patient's knee on the affected side is then flexed further stretching the femoral nerve. Pain will radiate down anterior thigh if test is positive.

### *Valsalva Test*

While seated the patient is instructed to take in a full breath and hold it, and then bear down as if they were trying to move the bowels. If pain increases it indicates increased intrathecal pressure which leads to symptoms in the sciatic nerve distribution. Symptoms may be accentuated by first having the patient flex the hip to a position just short of causing pain. Test is positive if pain increases or there is a mass protrusion.

## Neurological Evaluation of Lumbar Spine

### *Key Reflexes (graded 0 - 4)*

1) L4: quadriceps muscles

2) S1, 2: Achilles' tendon

## Diagnostic Imaging

### *Plain Film Radiography*

**Anteroposterior View:** This view is used to note: vertebrae shape and possible deformities; presence of wedging; possible fractures; disc space; presence of bamboo spine; and osteophyte formation.

**Lateral View:** This view is used to note: evidence of spondylosis or spondylolisthesis (grade degree of slippage); vertebrae wedging; disc space; condition of intervertebral foramina; alignment of vertebrae; normal lordosis; and osteophyte formation.

**Oblique View:** This view is used to note evidence of spondylolisthesis of spondylolysis.

### *Magnetic resonance imaging (MRI)*

Magnetic resonance imaging is commonly used to examine the lumbar spine to view: the spinal cord within the spinal canal; presence of syringomyelia; spinal cord infarction; delineation of disc features, diagnose tumors; and examine effects of traumatic incidents.

### *Computed tomography*

Computed tomography (CT) scans can delineate spinal stenosis caused by bony outgrowths, disc protrusion, or tumor, and well as fractures. Axial views can delineate spinal anatomic details including the facet joints, paravertebral muscles, vascular structures, and internal organs.

### *Myelography*

A myelography examination can confirm the presence of spinal stenosis, tumor, protruding disc, and osteophytes but is not commonly used due to possible side effects and the fact the MRI and CT scans can provide the same information.

### *Discography*

A discography involves injection of a radiopaque dye into the nucleus pulposus to observe details of disc abnormalities. This technique is not commonly used.

## Management of Lumbar Spine Disorders

### Mobilization

Mobilization techniques for the lumbar spine are similar to what is applied in the thoracic region. Many procedures are available for use in the lumbar region and only the most common techniques are described below.

#### *Posteroanterior Central Vertebral Pressure*

This technique involves the application of oscillatory pressure on the spinous process by means of the therapist's body transmitted through the arms and hands. It is essential that the pressure be produced by the therapist's body weight and not by the arms and hands alone. Posteroanterior central vertebral pressure is important for addressing all cases of lumbar pain, especially midline pain with some radiation out to both sides. Thus, it is valuable to use in patients with a mechanical derangement of the lumbar intervertebral joint and is particularly valuable in patients with lumbar spondylosis.

The patient lies prone with the arms at the side and the head turned to side, while the therapist stands at the left side. The therapist leans over the patient to place his or her pisiform area of the left hand over the spinous process and reinforces it with pressure by the right hand. Pressure is applied through the weight of the therapist basically at right angles to the lumbar vertebrae being treated. The goal is to apply pressure essentially at right angles to the area being mobilized.

The therapist produces an oscillatory movement by rocking his or her upper trunk up and down, with the pressure being applied through the shoulders and arms.

### *Posteroanterior Unilateral Vertebral Pressure*

This mobilization technique involves oscillatory pressures to the vertebral transverse processes by movement of the therapist's trunk directed through the arms and thumbs. This technique is used to address hypomobility lesions involving the upper or middle lumbar spine associated with localized back pain and muscle spasm.

The patient lies prone with his or her head turned to one direction and arms to the side. The therapist stands on the side being treated, leaning over to apply the thumb pads lateral to the spinous process in question. The therapist positions his or her shoulders directly over the hands and applies pressure in a direct line through the shoulders and arms at right angles to the patient's body. The thumbs do not move independently.

### *Transverse Vertebral Pressure*

The therapist applies pressure to the lateral aspect of the lumbar spinous process in this technique. Oscillatory pressure is applied through the therapist's arms and thumbs by moving his or her trunk. Transverse vertebral pressure is used to address unilateral lumbar pain and is more useful for upper than for lower lumbar pain.

With the patient lying prone with arms to the side, the therapist stands at the right side of the patient with thumbs against the right side of vertebra requiring transverse mobilization. The therapist's thumbs are placed against the side of the spinous process to apply the oscillatory movement by motion of his or her trunk. Transverse pressure can be reinforced by the therapist placing one thumb on top of the other. The range of movement produced by this technique is greater at L1 than at L4.

### *Rotation*

Rotation mobilization is perhaps the most common effective technique for the lumbar spine. It is used for patients with unilateral back or leg pain and in patients who have central-back pain with a restriction of movement on one side only.

It is important to localize the rotation to the lumbar region. This is accomplished by appropriate positioning of the patient's thorax and pelvis while positioning the lumbar spine toward either extension or flexion by extension or flexion of the hip.

The patient lies on the side with a pillow under the head and the therapist applies an oscillatory movement to the pelvis. Initially the patient’s hips and knees are slightly flexed. If the patient is lying on his or her right side the therapist stands behind with the left hand placed on the left side of the patient's pelvis to rotate it back and forth while stabilizing the thorax with the therapist's right hand applied to the patient's left shoulder.

In using rotation to treat conditions involving the upper lumbar region, the spine is held in minimal extension by keeping the leg above the one interfacing with the table, either straight or in slight extension. In addressing lower lumbar region problems the above leg is flexed to move the lumbar toward flexion. The amount of leg flexion can be varied to focus the rotation mobilization to specific vertebrae. The above leg position can be varied from no flexion to full flexion with the leg hanging over the treatment table.

### *Longitudinal Movement (Traction)*

Application of a longitudinal traction force is especially effective in patients who experience a sudden onset of severe pain, either in the lower lumbar midline or radiating to one side, and in those patients who might not be able to be positioned for the other mobilization techniques.

A gentle and rhythmical longitudinal movement is induced by the therapist pulling on one or both of the patient's legs. As in other mobilization procedures, the therapist applies the force by holding the arms straight and then moving the trunk rhythmically backward and then relaxing the pull each time.

### *Spinal Traction*

(See section on manual thoracolumbar spine traction in Chapter 12)

## Manipulation

Manipulation of the lumbar spine is an extension of the mobilization techniques previously discussed. The main difference in manipulation is that a rapid thrust is often applied at the limit of normal range (Grade V movement, to increase mobility). Non-specific manipulation techniques, such as rotation and posteroanterior pressure, are directed to areas of the lumbar spine rather than localizing the therapy to a specific intervertebral segment.

### *Rotation*

In this procedure, the patient is supine while the therapist stands to the right side of the treatment table with his or her left hand stabilizing the patient's left shoulder. With the right hand the therapist positions the patient's left hip and knee into flexion at a right angle. The therapist rotates the patient's pelvis to the right limit of range by pulling the left knee across the body and down toward the floor.

At this point the therapist grasps the posterolateral aspect of the patient's left upper calf with his or her right hand and applies a counter-pressure with the left hand against the shoulder. The underneath leg can be appropriately positioned to place the lumbar spine into either extension to address the upper lumbar region or flexion to address the lower lumbar region.

An oscillatory rotational movement at the limit of range is applied by both hands once the patient is suitably positioned. A sudden downward and rotary thrust is added to the leg while maintaining a strong counter-pressure against the patient's left shoulder. It is essential for this movement to produce a rotation of the pelvis and lumbar spine and not simply adduction movement of the leg.

### *Posteroanterior Pressure*

This manipulation technique is performed with the patient lying prone and the therapist standing to the side. Using the dominant hand, the therapist places his or her pisiform bone against the patient's lumbar spinous process, applying pressure to stretch the intervertebral joint.

When the joint is stretched to the limit a sudden, very small range, thrust movement is applied. To increase the effectiveness of this procedure, the patient's legs or trunk may be supported in a position of extension.

## Needling Therapy for Low Back Problems

Assessment and treatment of the low back region follows the same general guidelines for any other part of the body. Since the muscles in the low back region are assigned either to the posterior lateral foot (PLF) or posterior medial foot (PMF) muscular distributions the nodes Feiyang (PLF 58) or Zhubin (PMF 9) are respectively selected as the candidate distal nodes (See Table 13.3). Low back pain is normally treated bilaterally even though the patient only complains of pain on one side. Lumbar pain frequently reflects in the sacral region and hence additional nodes are selected that have an influence on this region (See Table 13.1).

### *Acute Presentation*

In acute presentation of low back pain, which often involves severe pain and cramps, different special nodes may be considered. These are used reduce the symptoms to the level where the condition can be treated with the general nodes noted in Table 13.3. One of the most effective special nodes for reducing acute low back pain is the node Yaotongdian (low back pain spot) which is employed as follow:

Yaotongdian consists of special nodes on the dorsum of the hand located in the proximal aspect of the second and forth interosseus spaces. These are used specifically to reduce pain and spasms in the low back. Needles are inserted into each location at a 45° angle to the dorsum pointing toward the metacarpal heads while the needle handle leans distally. Needles are inserted while patient is seated with hands and fingers held straight out, and then strongly stimulated to obtain good needling reaction. While holding hands and fingers in same relative position, the patient stands and periodically slowly rotates body and hips and then slowly walks around. Needles are periodically stimulated to sustain the needle reaction. Needles are removed in approximately 15 minutes and normal treatment proceeds

### *Node Selection for Low Back Pain and Related Conditions*

Candidate local and adjacent nodes consist of nodes appropriately selected for their influence on the lumbar region as well as node Huantiao (LF 30). All these nodes also function as proximal nodes. Distal nodes are selected for either the PLF or PMF muscular distribution, depending on the assessment to determine the most likely distribution involved in the presenting complaint. Additional nodes can be added if the pain and other symptoms radiate into the sacrum. Also, additional node along the PLF muscular distribution may be added depending on specific patterns of pain and other symptoms.

Table 13.3. Candidate regional, proximal and distal nodes for low back pain and related disorders.

| Low Back Pain | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Shenshu (PLF 23)<br>Mingmen (DU 4) | PLF | | Feiyang (PLF 58) |
| | Dachangshu (PLF 25)<br>Huantiao (LF 30) | PMF | | Zhubin (PMF 9) |
| | With Kidney Xu | | | Taixi (PMF 3) |
| | Acute Presentation | | | Yaotongdian (Extra) |

### *Candidate Electroneedling (EN) Application Low Back Pain*

Electroacupuncture lead placement for low back pain is initially selected for the main nodes that cover the area of the low back bilaterally. Placement of the negative (-) lead can be changed to lower positions on the back and leg to address other specific symptoms using the following protocol:
**Frequency**: 2 Hz
**Mode**: Continuous
**Duration**: 20 – 30 minutes
**Lead placement** (bilateral):

- Shenshu (PLF 23) + lead, to Dachangshu (PLF 25) – lead
- If pain in buttocks present, especially involving the hip lateral rotators, the lower (negative) lead is moved after 15 minutes from Dachangshu (PLF 25) to Huantiao (LF 30)
- If sciatica is present, after 15 minutes switch – lead, from Dachangshu (PLF 25) to Feiyang (PLF 58) for another 15 minutes
- In the case with pain in the buttocks along with sciatica and the negative lead is switched from Dachangshu (PLF 25) to Huantiao (LF 30) after 10 minutes and then switched to Huantiao (LF 30) after another 10 minutes

### *Possible Treatment for Scoliosis*

Idiopathic scoliosis can be addressed with needling therapy, especially in the early stages of development. Needling therapy as well as EN can be considered. Node selection depends exactly what section of the thoracolumbar spine is involved. Needle selection is symmetric of each side of the spine, but EN is to be applied to the nodes on the affected weak side that involves the flaccid muscles. The stronger muscles on the good side cause the spine to bend toward that side and away from the weak side. There are few if any studies showing that scoliosis can be effectively treated with needling therapy or with exercise.

Some studies suggest that scoliosis may be the result of problems in coordination involving the proprioceptive system since many patients suffer with nystagmus. Also, there may be a postural component to this problem. Some studies that used a biofeedback type device to train patients to maintain better posture showed positive results. In addition, diet and behavior may have an influence since weak bones have also been suspected. Consumption of soft drinks that contains phosphoric acid is now known to weaken bones because it causes the body to lose calcium. These are popular drinks for young people. Also, smoking has a major impact on bone weakness due to the stimulation of parathyroid hormone. Finally, exercise is essential to help strengthened the weak muscle, but to date this has not shown to be the only answer. One study did show that thoracolumbar rotation exercises did tend to stabilize scoliosis.

The treatment protocol uses bilateral needling therapy including EN only on the affected side to address possible problems in the proprioceptive system while also strengthening the weak muscles as follows (See Table 13.4):

- Nodes Tianzhu (PLF 10) to influence coordination problems as mediated by the cerebellum
- Nodes on the thoracic spine at the upper level of the scoliosis that may be around Jueyinshu (PLF 14), Xinshu (PLF 15), or Dushu (PLF 16), only select one.
- Nodes on the lumbar spine at the lower level of the scoliosis that may be around Shenshu (PLF 23) or Qihaishu (PLF 24), only select one.
- Three intermediate nodes spaced between the upper nodes on the thoracic and lumbar spine
- Possibly consider Huantiao (LF 30) to influence posture
- Consider both Feiyang (PLF 58) and Zhubin (PMF 9) since the superficial back extensors and the deeper muscles are involved in this problem

Exercise is directed strengthening thoracolumbar rotation and back muscles on the weak side. Rotation is accomplished by having the patient while seating to cross their arms across the chest and slowly rotate to the left and then right through the full possible range of motion. Patient is trained to tighten the antagonistic muscles that oppose rotation. This may require some effort to get the patient to be able to dynamically resist voluntarily controlled axial rotation. Other exercises include lifting a light weight straight up from the shoulder while seated on the edge of the treatment table. Slowly build up the number of repetitions. Other additional exercises include lying prone with the arm on the weak side extended straight above the head. Patient lifts the arm off the floor through several repetitions. Then the patient extends the leg on the weak side by lifting it up off the floor. Several sets can be completed by first doing the arm lift followed by the leg lift and then repeat.

Table 13.4. Candidate regional, proximal and distal nodes for scoliosis.

| Scoliosis | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Cervical spine | Tianzhu (PLF 10) | PLF, PMF | | Feiyang (PLF 58) Zhubin (PMF 9) |
| Thoracic spine | Jueyinshu (PLF 14), Xinshu (PLF 15), or Dushu (PLF 16) | | | |
| Lumbar spine | Shenshu (PLF 23) or Qihaishu (PLF 24) | | | |
| Intermediate nodes | 3 selected between upper thoracic and lower lumbar nodes | | | |
| Buttocks | Huantiao (LF 30) | | | |

MD = Muscular Distribution

### *Candidate Electroneedling (EN) Application for Scoliosis*

Electroneedling lead placement for scoliosis is for the selected upper thoracic spine node and the selected lower lumbar spine node only on the side that has muscle weakness which is opposite to the strong side which is causing the spine to bend to the strong side,

using the following protocol:
**Frequency**: 2 to 25*Hz
**Mode**: Mixed mode
**Duration**: 20-30 minutes
**Lead placement** (unilateral):

- Positive lead (+) on the upper thoracic node and the negative (–) on the lower lumbar node.

*Increase amplitude only during the high frequency period of the mixed frequency mode.

## Remedial Exercises

See Chapter 12

14

# Pelvis

The pelvis basically consists of the sacrum including the coccyx and the innominate bone. It forms two major joints in the body consisting of the lumbosacral joint that articulates with the fifth lumbar vertebra and the hip joint which articulates with the femur. There are three other important joints, along with their ligaments, that basically hold the pelvis together including the sacroiliac, symphysis pubis, and sacrococcygeal joints. Major ligaments of the pelvis include:

- Interosseous ligament (Syndesmosis: a type of fibrous joint in which intervening fibrous connective tissue forms an interosseous membrane or ligament)
- Dorsal ligaments
- Sacrotuberous ligament
- Sacrospinous ligament
- Iliosacral ligaments (anterior and posterior sacroiliac ligaments)
- Inguinal ligament

The sacroiliac joint consists of a synovial joint formed between the lateral aspect of the upper sacral vertebrae and the medial surface of the ilium. The sacroiliac joint is unique in that the space formed between the sacrum and ilium above this synovial joint is joined by a strong interosseous ligament (syndesmosis) which occupies about one third of the vertical distance between these two bones. The articular surfaces are slightly irregular and interlocked giving stability to the joint. The bony surfaces are lined by articular cartilage which is thicker on the sacral side of the joint. The joint is surrounded by a synovial membrane lined capsule. Stability of sacroiliac joint relies on two ligaments that connect the sacrum and ilium which lie anteriorly and posteriorly to the joint. The posterior sacroiliac ligament is strong while the anterior ligament is thin and weak.

## Physiology of the Pelvis

The pelvis serves as a major structural component of the body that supports the weight of the upper body and transmits this load through to the legs and ground. Although the pelvis serves as the origin and insertion site for numerous muscles, there are no intrinsic muscles that articulate the bones comprising the pelvis. However, there is slight but critical movement in the sacroiliac joint and in the symphysis pubis during pregnancy. The sacroiliac joints basically connect with the spinal column and are the most likely source of pain and other problems. Problem affecting the hip and the hip joint are discussed in Chapter 15.

### Surface anatomy

The pelvis surface anatomy can easily be palpated and identified including the following important landmarks:

- Iliac crest
- Anterior superior iliac spine (ASIS)
- Posterior superior iliac spine (PSIS)

- Coccyx
- Ischial protuberance
- Pubis

## Problems of Sacroiliac Joint

This joint is the main source of pathology in the pelvis which is similar in nature to problems affecting other joint of the spine. However, there is little movement in the sacroiliac joint and in that sense the problems are focused on this area, and are limited.

### *Sacroiliac Pain*

This is the most common complaint of the sacroiliac joint and is normally characterized as a dull ache that is usually felt in the buttocks but can be referred to the groin. The pain can be referred to the lower abdominal region as well, and may also radiate into the posterior aspect of the thigh but normally does not go below the knee. Pain may be felt in the iliac fossa which is usually due to tenderness over the iliacus muscle. This condition may cause confusion with intra-abdominal problems. Patients may also feel pain anteriorly over the adductor tendon origin or the pubic symphysis. There is often a history of buttock pain in subjects with inflammatory sacroiliitis which alternates from one side to another, which is worse at night. There may be associated back stiffness that is not related to postural problems. Neurological symptoms ofparestheiasis and numbness are absent in patients with sacroiliac problems even if they may report a dull, heavy feeling in the leg.

Pain felt in the sacroiliac area may be referred from the lower lumbar spine or hip joint. Therefore it is essential to perform a clinical assessment of both of these areas before assessing the sacroiliac joint. It is not uncommon for degenerative hypomobility lesions of the lumbosacral joint to reflect into the sacroiliac joint mimicking possible sprain. Pain as the result of mechanical lesions of the sacroiliac joint is typically unilateral and can be exacerbated by movements which stress the sacroiliac joint.

### *Inflammatory disease*

Inflammatory disease of the sacroiliac joint with spondyloarthritis including variety sources such as ankylosing spondylitis, Reiter's disease, Still's disease, Behcet's disease, psoriatic arthritis, and arthritis associated with inflammatory bowel disease, such as ulcerative colitis, and Crohn's disease. Spondyloarthritis includes ankylosing spondylitis which is involved in inflammatory changes in the spinal joints and bilateral sacroiliitis.

### *Infections*

These usually involve only one sacroiliac joint caused by tuberculosis or staphylococcal infections. These conditions now occur more rarely than in previous years.

### *Hypomobility Lesions*

This is a mechanical derangement lesion of the sacroiliac joint that remains an infrequent but relatively important cause of pain in the lower back. This usually occurs in younger people and may be associated with activities that put rotation stress on the sacroiliac joint as tennis, golf, and ballet dancing. It can also follow pregnancy, childbirth, or trauma. It may also be the result of structural deficits such as unequal leg length, or an unsymmetrical development of the pelvis. Sacroiliac tests should reproduce the patient's symptoms that may be addressed by mobilization techniques.

### *Hypermobility Lesions*

This lesion of the sacroiliac joint is rare and can occur in one or two ways. The first of these usually occurs in athletes and is secondary to instability in the pubic symphysis. The condition may be complicated by a mechanical derangement of one or both sacroiliac joints and may also be associated with osteitis condensans ilii. The second situation usually occurs during or soon after pregnancy with the patient complaining with sacroiliac pain that is made worse by walking or standing. Manual therapeutic methods usually exacerbate the symptoms.

### *Degenerative Changes*

These changes would be expected to occur in the articular cartilage of the sacroiliac synovial joints. Changes are first seen in the iliac surface where the cartilage is thinner as opposed to the sacral side. Cartilage changes are similar to what is seen in the peripheral joints with an eventual fibrous ankylosis of the joint cavity. X-rays show a loss or irregularity of the joint space, subchondral sclerosis, and osteophyte formation. Degenerative changes are increasingly more common with advancing age, which may be secondary to conditions where movement of the sacroiliac joint is decreased. This condition is seen in people who are immobilized including patients with hip joint diseases. It is common to find degenerative changes in the contralateral sacroiliac joint in patients with unilateral hip disease.

### *Osteitis Condensans Ilii*

This condition is characterized by a condensation of bone on the iliac side of the sacroiliac joint. Etiology is uncertain but may represent a bony response to unequal stress on this joint. Detection of the problem is usually a coincidental radiological finding and not particularly associated with the patient's symptoms. This occurs most often in young adults, especially after childbirth when complaints in pain in the back and sacroiliac joint are common.

# Assessment of Sacroiliac Joint

## Observation

Posture of the patient is first examined looking for any abnormalities in posture, patient listing, body alignment, spinal curvatures, and deviations from the frontal and sagittal planes. Distance of the PSIS and ASIS to the floor is measured on each side. The symphysis pubis is also palpated to determine if both sides of the joint are level. The ischium on each side is palpated to determine their alignment. Pelvic alignment while standing and sitting with forward bending is assessed as well as measurements of leg length.

### *Pelvic Movement*

Several tests can be employed that assess the function and status of the anterior and posterior sacroiliac innominate rotation displacement with respect to the sacrum, including fixation of the sacroiliac joint (hypomobility), by detecting movement of the PSIS or ischium. These tests can be performed with the patient standing or sitting.

#### Standing (Gillet's Test)

Examiner palpates the PSIS on one side with one thumb and palpates one of the sacral spines with the other thumb while the patient is standing. Patient then instructed to fully flex the hip by pulling the leg with the knee flexed, up to the chest on that side while noting if the PSIS drops as it normally should or whether it elevates indicating possible fixation of the sacroiliac joint on that side. The examiner then tests and compares the other side.

The examiner next places one thumb on one of the patient's ischial tuberosities and one thumb on the sacral apex. The patient is instructed to flex the hip as before again on this side. If the thumb on the ischial tuberosity moves laterally, the motion is normal. If the sacroiliac joint on this side is fixed, the thumb moves up. The other side is then tested and compared. This test is referred to as Gillet's test or sacral fixation test.

**Sitting Forward Bend (Piedallu's Sign)**

This test is conducted with the patient sitting on a firm surface to keep the muscles (hamstrings) from affecting pelvic flexion symmetry while increasing stability of the ilia. The examiner palpates the PSIS and compares their heights. If the PSIS on the affected or painful side is lower than the other, the patient is instructed to bend forward while remaining to be seated. If the PSIS that was in a lower aspect now becomes higher than the other, this a positive test confirming sacroiliac joint hypomobility on the affected side. This indicates an abnormality in torsion movement of the sacroiliac joint.

This test can also be performed from the standing position with the examiner holding the pelvis from the posterior aspect with fingers on the iliac crests and each thumb placed on one of the posterior superior iliac spines (PSIS). The patient is then instructed to bend forward slowly while the examiner maintains the hands on the pelvis and thumbs on both posterior superior iliac spines (PSIS). If the PSIS levels are equal when standing but unequal with forward bending, the test is considered positive. This finding implicates possible unilateral sacroiliac joint hypomobility with either anterior sacral innominate displacement on the higher side, or posterior sacral innominate displacement on the lower side.

### *Leg Length Measurement*

This measurement should always be performed if the examiner suspects a lesion in the sacroiliac joint. Nutation (backward rotation) of the ilium on the sacrum will result in a decrease in leg length as will contranutation (anterior rotation) on the opposite side. If the iliac bone is lower on one side of the symphysis pubis, that leg will usually be shorter. True leg length is measured with the patient supine with the anterior superior iliac spines (ASIS) level and the patient's lower limbs perpendicular to the line joining the two the anterior superior iliac spines. Using a flexible tape measure, the examiner obtains the distance from the ASIS and the lateral or medial malleolus on the same side. The measurement is repeated on the other side. A difference of 1 to 1.3 cm is considered normal.

### *Leg Length Reversal (Supine to Set Test)*

The patient lies supine with the legs straight with the body while the examiner compares the relative length and symmetry of the two legs. The patient is then instructed to sit up and the examiner observes if one leg moves up (proximal) farther than the other leg. This situation indicates that there is a functional leg length difference resulting from a pelvic dysfunction as result of pelvic torsion.

If the leg on the affected side appears Longer than the other leg when the patient is supine but Shorter when sitting, this is a positive test implicating Anterior innomination rotation on the affected side (LSA). On the other hand, if the leg on the affected side appears Shorter than the other leg when the patient is supine but Longer when sitting, this is a positive test implicating Posterior innomination rotation on the affected side (SLP).

## Passive Movement Tests

Movement of the sacroiliac joint is normally slight, but can be assessed by a series of passive tests. These are designed to reproduce the patient's symptoms and help differentiate between lumbar and sacral problems. Movement of the sacral area has an obvious affect on the lumbar region and therefore false-positive and false-negative findings are not uncommon.

### *Posteroanterior Sacral Glide (PA Oscillation)*

With the patient lying prone the examiner imparts rhythmical oscillation of the sacrum by applying posteroanterior pressure over the sacrum. This is accomplished by examiner by placing the heel of his or her hand over the patient's sacrum and then placing the other hand over the first hand for stabilization. The examiner's arms are held extended and his or her body weight is used to impart a springing movement that produces a shearing movement of the sacroiliac joint and produces movement in the lumbosacral joint. This technique is considered one of most useful tests to apply to the sacroiliac joint.

### *Cephalad Sacral Glide*

This procedure stresses the sacroiliac joint by stabilizing the ilium of the prone lying patient with one hand of the examiner and then moving the sacrum in the cranial direction. The examiner places the stabilizing hand against the ilium on one side and applies counteracting force toward the feet. The examiner's other hand is placed over the apex of the sacrum to direct sacral movement toward the head.

### *Caudal Sacral Glide*

This procedure is opposite to the one just described above and stresses the sacroiliac joint by stabilizing the ischium of the prone lying patient with one hand of the examiner and then moving the sacrum in the caudal direction. The examiner places the stabilizing hand against the ischial tuberosity on one side and applies counteracting force toward the head. The examiner's other hand is placed over the head of the sacrum to direct sacral movement toward the feet.

### *Anterior SI Joint Distraction (Pelvic Rock)*

This procedure produces anterior distraction of the sacroiliac joint by putting pressure against each anterior superior iliac spine ASIS. With the patient lying supine, the examiner leans over the patient with his or her arms crossed to place the right hand on the patient's right ASIS and the left hand on the left ASIS. Anteroposterior pressure is applied which seems like the two iliae are being spread apart.

➔ Reproduction of the patient's symptoms by anterior sacroiliac joint distraction indicates possible involvement of the anterior sacral ligament, which could include a potential tear in this ligament.

### *Posterior SI Joint Distraction (Iliac Compression)*

This procedure is basically opposite to the one just described above and involves posterior distraction of the sacroiliac joint by putting lateral pressure against each iliac crest. With the patient lying supine, the examiner leans over the patient placing his or her hands against the lateral aspect of each iliac crest and applying a medially directed force. This compresses the iliac crests like squeezing them together.

This test can also be performed with patient lying on one side with the examiner applying a downward pressure on the lateral aspect of the iliac crest to produce the effect of compressing the two together by resistance of the other iliac crest against the table.

➔ Reproduction of the patient's symptoms by posterior sacroiliac joint distraction indicates possible involvement of the posterior sacral ligament, which could include a potential tear in this ligament.

### Active Movement Tests

There is controversy and speculation over the role of movement in the sacroiliac joint and whether active muscle testing is appropriate to stress this joint. However, there is little doubt about the importance of movement in the sacroiliac joint, which is only a few millimeters, and its essential role in normal movement of the lumbar spine. Sacroiliac movement as well as that of the symphysis pubis is important in pregnancy. However, there are active and resisted isometric movements that can be performed with muscles that attach to the pelvis with the intention of applying stress to the sacroiliac joint.

### Resisted Isometric Movements

Certain resisted isometric tests of muscles that move the spine or hip can be used to apply stress on the pelvis and the sacroiliac joint. These tests can be performed with the patient in a supine position to include the following resisted isometric movements:

- Forward flexion of the spine by contraction of the abdominals to apply stress on the symphysis pubis
- Flexion of hip by the iliacus to stress the sacroiliac joint
- Extension of hip by gluteus maximus to stress sacroiliac joint
- Abduction of hip by gluteus medius to stress sacroiliac joint
- Adduction of hip by adductors to stress the symphysis pubis

### Functional Assessment

The sacroiliac joints do not work in isolation so it is difficult to perform a meaningful functional assessment of the pelvis. From a functional viewpoint the sacroiliac joints should be considered as part of the lumbar spine or associated with the hip joint depending on the details of presenting clinical problem.

### Special Tests

Additional tests are usually necessary to obtain more information in order differentiate sacroiliac joint pain from pain originating with the lumbar spine. The first of these tests, involving passive extension of the hip is usually always performed, even when suspecting the presenting back pain is due to the lumbar problems. The other tests involve contraction of the hip adductors and abductors and other movements to test the ligaments of the pelvis and the sacroiliac joint.

### Passive Hip Extension

Patient is supine and positioned to one edge of examination table. Examiner passively lowers the leg, with knee flexed, to move leg and hip into full extension. Reproduction of the patient's pain is a positive sign. Test often follows just after the straight leg raise (SLR) test performed in conjunction with assessment of the lumbar spine.

### Gaenslen's Test

The patient is side lying with the upper leg straight with the knee hyperextended while the unaffected underside leg hyperflexed by pulling the knee up to the chest. The examiner stabilizes the pelvis with one hand while extending the affected leg. It is considered a positive test if pain is provoked. Source of pain may be due to an ipsilateral sacroiliac joint lesion, hip pathology, or an L4 nerve root lesion.

A variation of this test and the passive hip extension test is performed with the patient supine with the hip on the affected leg extended over the edge of the table. The patient first draws both the affected and unaffected legs up to the chest. The affected leg is then slowly lowered until it hangs down in extension over the table edge. This test position may inhibit the amount of extension. The other leg is tested in the same manner. Pain in the sacroiliac joint is considered a positive test.

### Isometric Contraction of Hip Adductors

The patient is supine with hips flexed 45° and knees flexed 90°, with feet flat on examination table. Hip adductors are isometrically contracted by the patient attempting to squeeze the examiner's fist placed between the knees.

### Isometric Contraction of Hip Abductors

The patient is supine with hips flexed 45° and knees flexed 90°, with feet flat on examination table. Isometric contraction of hip abductors is produced when examiner's hands are placed on lateral aspect of the knees to fully resist patient's attempt spread knees apart.

### Gillet's Test

This test to assess possible sacral fixation (See discussion under Sacroiliac Joints on page 345)

### Goldthwait's Test

With the patient supine the examiner places one hand under the lumbar spine so that each finger is placed in the interosseous spaces of L2 - L3 (DU 4: Mingmen), L3 - L4, L4 - L5 (DU 3: Yaoyangguan), and L5 - S1 (Shiqizhui). The examiner then uses the other hand to conduct a straight leg raising test. If pain is provoked before movement in the intervertebral spaces is detected, the problem lies in the sacroiliac joint. If pain is provoked only after movement in the intervertebral space, the problem lies in the lumbar spine. As with any straight leg raising tests, pain may be referred along the course of the sciatic nerve.

### Yeoman's Test

With the patient prone, the examiner flexes the patient's knee 90° while simultaneously extending the ipsilateral hip. Provocation of pain in the sacroiliac joint indicates possible pathology in the anterior sacroiliac ligaments. Provoked pain in the lumbar region is indicative of lumbar problems.

### *Trendelenburg's Test or Sign*

The patient is standing and is asked to stand or balance first on one leg and then on the other. The examiner observes the movement of the pelvis while the patient is balanced on one leg. If the pelvis on the side of the non-stance leg rises, the test is negative. However, if the pelvis on the side of the non-stance leg falls, the test is considered positive indicating weakness or instability of the hip abductors, mainly the gluteus medius muscle on the stance side.

## Neurological Evaluation

### *a. Myotomes (graded 0 – 5)*

L5: Extensor hallucis longus muscle - extension of big toe

L5, S1: Extensor digitorum longus - extension of toes

L5, S1: Hamstrings - knee flexion

S1: Peroneus longus and brevis - ankle eversion

S1, 2: Gastrocnemius and soleus muscles - plantar flexion

S2: Flexors digitorum & hallucis longus - flexion of toes

### *Key Reflexes (graded 0 - 4)*

S1, 2: Achilles' tendon - ankle jerk

## Diagnostic Imaging

Plain film radiography anteroposterior view of the pelvis is used to: delineate any fractures; ankylosis of the sacroiliac joints (ankylosing spondylitis); displacement of one sacroiliac joint; displacement of the symphysis pubis; demineralization or sclerosis of one or both pubic bones at the symphysis pubis; and relationship of the sacrum to the ilium.

# Management of Sacroiliac Joint Disorders

## Mobilization

### *Posteroanterior Pressure*

In this technique, the patient lies prone with arms by the side. The therapist leans over the patient from the left side to place his or her left hand over the sacrum and reinforces it with the right hand. The therapist's shoulders are positioned over the hands to apply oscillatory posteroanterior pressure. Pressure is applied to the dorsal surface of the sacrum in a small amplitude oscillatory manner.

### *Posterior Innominate Rotation*

These procedures involve backward rotation of the iliac crest to address hypomobility of the sacroiliac joint by correcting sacroiliac innominate anterior displacement. Mobilization therapy is applied in the direction of posterior innominate rotation and is effective for correcting anterior sacroiliac joint disorders.

#### Side Lying

The patient is lying on the unaffected side with a pillow to support the head while the practitioner stands in front of the patient situated between the patient's legs in order to use the uppermost leg to support posterior innominate rotation. Practitioner grasps the patient's pelvis with palmar contact over the anterior iliac crest and the ischial tuberosity. Practitioner applies a rotary forcc through the palms with forearms parallel to the direction of force. An anteroposterior force is applied to the anterior iliac crest while a posteroanterior force is applied to the ischium.

**SI Gapping (supine)**

With the patient supine, the hip is flexed approximately to 100° and slightly abducted with the knee fully flexed. Standing to the opposite side, the practitioner places one hand around the ilium with fingers on the PSIS. The other hand is placed on the patient's knee to use practitioner's body weight to apply a force through the femur in direction of the umbilicus to rotate the innominate bone posteriorly. Applied force can be oscillated while practitioner palpates sacroiliac joint gapping and accessory movement.

**Supine (self-mobilization)**

While lying supine the patient draws the knee on the affected side up to the chest while bringing the upper back off the table (or mat). This position is sustained for several seconds and then slowly released by lowering the leg. Patient can oscillate the sacroiliac joint on the affected side by partially easing off on the knee, especially if there is pain, and then bringing it back to the chest. This technique is useful for sacroiliac hypomobility problems by restoring anterior sacral innominate displacement.

**Standing (self-mobilization)**

This mobilization is similar to the preceding test except the patient is standing with one foot flat on a table with the hip and knee fully flexed. Patient shifts weight forward onto the flexed leg while using the arms to draw the knee to the chest. This position is held for several seconds and then slowly released. Patient can oscillate the sacroiliac joint on the affected side during weight shift and leg pull to ease any pain or other symptoms. This technique is useful for sacroiliac hypomobility problems by restoring anterior sacral innominate displacement.

***Anterior Innominate Rotation***

This involves forward rotation of the iliac crest. Mobilization therapy applied in the direction of anterior innominate rotation and is effective for correcting sacroiliac joint hypomobility disorders by correcting posterior innominate displacement.

**Side Lying**

The patient is lying on the unaffected side with a pillow to support the head while the practitioner stands in front of the patient. Practitioner grasps the patient's pelvis with palmar contact over the posterior iliac crest and the groin. Practitioner applies a rotary force through the palms with forearms parallel to the direction of force. A posteroanterior force is applied to the posterior iliac crest while an anteroposterior force is applied to the groin. This method is effective for sacroiliac hypomobility by correcting posterior sacroiliac innominate displacement.

**Through Hip Extension**

Patient is prone with the leg of the unaffected side fixed on the table. Practitioner stands to the unaffected side with one hand placed over the iliac crest of the opposite (affected leg) to stabilize the pelvis. Practitioner grasps the femur while cradling the patient's flexed knee with the forearm. Practitioner presses on the ilium anteriorly with the stabilizing hand while extending the hip with the other hand to rotate the ilium anteriorly. This method is effective for sacroiliac hypomobility by correcting posterior sacroiliac innominate displacement.

## Sacroiliac Manipulation

The same procedure used in manipulation of the lumbar spine in rotation is appropriate to treat hypomobility lesions of the sacroiliac joint.

## Needling Therapy for Sacral Problems

### *Node Selection for Sacral Pain*

Candidate node selection for pain in the sacral area and related problems are selected to cover the whole sacrum (Table 14.1):

- Nodes above the sacrum such as Pangguanshu (PLF 28), Shenshu (PLF 23), and Mingmen (DU 4) are considered as proximal nodes
- Feiyang (PLF 58) and Zhubin (PMF 9) used as distal nodes
- If sacral pain occurs along with low back pain, most of these nodes can be added to the low back nodes previously discussed under low back pain
- Can consider substituting particular Baliao nodes (PLF 31 - 34) if pain is concentrated in specific region of sacrum
- With pain in coccyx consider adding Changqiang (DU 1), Xialiao (PLF 34), and Huiyang (PLF 35)

Table 14.1. Regional and distal nodes considered in treatment of sacral pain.

| Sacral Pain | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Yaoyangguan (DU 3)<br>Guanyuanshu (PLF 26) | PLF | Pangguanshu (PLF 28) | Feiyang (PLF 58) |
| | Zhonglushu (PLF 29)<br>Yaoshu (DU 2) | PMF | Shenshu (PLF 23)<br>Mingmen (DU 4) | Zhubin (PMF 9) |

MD = Muscular Distribution

### *Candidate Electroneedling (EN) Application for Sacral Pain*

**Frequency**: 2 Hz

**Mode**: Continuous

**Duration**: 20 - 30 minutes

**Lead** placement (bilateral):

- Guanyuanshu (PLF 26) + lead, to Zhonglushu (PLF 29) – lead
- If pain radiates into the leg then after 15 minutes switch – lead from Zhonglushu (PLF 29) to Feiyang (PLF 58) for another 15 minutes

# 15

# Hip and Thigh

The main feature of the hip is to provide an articulation for the femur as well as attachment sites for the key muscles involved in the movement of the thigh. This is a similar situation to the scapula and the humerus bone. The hip joint (iliofemoral joint) is a synovial ball and socket mechanism permitting motion in three planes, including flexion and extension in the sagittal plane, abduction and adduction in the frontal plane, and rotation in the horizontal transverse plane. Normal limiting factors and characteristics of the joint structures involved in movement of the hip joint are noted in Table 15.1

The pelvis is a bony ring structure composed of the two innominate (hip) bones and the sacrum (Chapter 14). This structure holds and protects the lower abdominal viscera and provides a base of origin for the thigh musculature. The arch-like construction of the pelvis transmits the body weight to the legs and ground while standing and supports the weight of a seated individual. The sacrum is key to the structural efficiency of the pelvic arch by directing the forces of the body weight bilaterally to the innominate acetabulum and consequently to the femurs. The acetabulum is a cup-shaped indentation on the lateral side of the innominate bone that forms the socket for the hip joint.

The innominate bones display a broad irregular shape to accommodate the attachment of large thigh muscles such as the gluteus maximus, medius and minimus, and the iliopsoas muscles. The bony ring of the pubic beam and ischium provide attachment for the hamstrings and thigh adductor muscles.

The femur is the longest bone in the body and contributes to the striding gait of humans. The femur is also the strongest bone and must withstand significant forces of strong muscle contractions, as well as accommodate the weight of the body. The femurs extend obliquely from the pelvis, medially toward the knees to bring the legs closer together in order to more efficiently support the body.

The hip joint has two close-packed positions with one at 90° of flexion and slight abduction and lateral rotation. The other close-packed position occurs at complete extension, internal rotation, and abduction. The hip joint is completely slack at the "rest" position at 10° flexion, 10° abduction, and 10° external rotation. Patients with an inflamed hip may hold the hip in the rest position to help reduce pain.

## Hip Physiology

The principle function of the legs and feet are to provide the capability of efficient bipedal locomotion. Walking is probably the most common human activity and can be performed for considerable periods of time without inducing fatigue. Disorders involving either the legs or feet often manifest as problems or difficulties in locomotion. Muscles of the hip function to extend, flex, abduct, adduct and rotate the thigh. Some of the thigh muscles cross the knee joint where they assist to extend and flex the lower leg.

Table 15.1. Normal limiting factors and characteristics of joint structures involved in movement of the hip joint

| | Flexion | Extension | Abduction | Adduction | Internal Rotation | External Rotation |
|---|---|---|---|---|---|---|
| Articulation | Iliofemoral | Iliofemoral | Iliofemoral | Iliofemoral | Iliofemoral | Iliofemoral |
| Plane | Sagittal | Sagittal | Frontal | Frontal | Horizontal | Horizontal |
| Axis | Frontal | Frontal | Sagittal | Sagittal | Longitudinal | Longitudinal |
| Normal limiting factors | Soft tissue apposition of the anterior thigh and the abdomen (with knee flexed) | Tension in the anterior joint capsule, the iliofemoral, ischiofemoral and pubofemoral ligaments, and iliopsoas | Tension in ischiofemoral and pubofemoral ligaments, the inferior band of the iliofemoral ligament, the inferior joint capsule, and hip abductors | Soft tissue apposition of the thighs With the opposite leg in abduction or flexion: tension in the iliotibial band, the superior joint capsule, superior band of the iliofemoral ligament, the ischiofemoral ligament and hip abductors | Tension in the ischiofemoral ligament, the posterior joint capsule, and the lateral rotators | Tension in the iliofemoral and pubofemoral ligaments, and the anterior joint capsule |
| Normal end-feel | Soft | Firm | Firm | Soft/firm | Firm | Firm/ soft |
| Normal active range of motion | 0 - 120° | 0 - 30° | 0 - 45° | 0 - 30° | 0 - 45° | 0 - 45° |

## Muscles Moving the Thigh

Muscles related to movement of the thigh have their origins on processes of the lumbar spine, sacrum and the pelvis (See Table 15.2). The iliopsoas (ALF), consisting of the psoas major and minor, and iliacus muscles represent the principle flexor of the thigh. There are no neurovascular nodes (acupoints) on this important muscle and therefore when it needs to be treated ALF nodes in the lumbar region and distal ALF nodes on the foot and leg need to be considered.

The gluteus maximus is an important extensor and works in conjunction with the hamstrings, which include the biceps femoris, long head (PLF), biceps femoris, short head (LF), semitendinosus (PLF) and semimembranosus (PMF). The gluteus maximus comes into play when powerful extension of the thigh is needed, such as occurs in running.

The gluteus medius and minimus (LF) muscles are unique in the bipedal human primate. They are important for stable and smooth walking. When they are disordered or paralyzed, it represents a serious problem for the hip and results in an ungainly, lurching gait.

# Disorders Affecting the Hip

In addressing problems affecting the hip it is important to consider the lumbar spine and sacroiliac joint as a possible source. Trauma may be the most common source of pain although many disease conditions including arthritis affect the hip. Hip problems are viewed in terms of pain and dysfunction due to the muscles (including the muscular distributions) that articulate the thigh as well as other sources of hip disorders. This includes intrinsic and extrinsic sources of pain, bone and joint lesions, soft tissue lesions, and entrapment of the lateral cutaneous nerve.

Table 15.2. Function, nerve root, and muscle distribution (MD) assignment of prime mover (PM) and associate/assistance mover (AM) muscles of the hip and those that extend over knee (K) joint to influence movement of lower leg

| Muscle | MD* | Nerve Root | Extension | Flexion | Abduction | Adduction | Medial Rotation | Lateral Rotation |
|---|---|---|---|---|---|---|---|---|
| Psoas major | ALF | L1, 2, 3, (4) | | PM | AM | | | AM |
| Iliacus | ALF | L(1), 2, 3, 4 | | PM | AM | | | AM |
| Rectus femoris | ALF | L2, 3, 4 | K | PM | AM | | K | |
| Sartorius | AMF | L2, 3, (4) | | AM & K | AM | | | AM |
| Pectineus | AMF | L2, 3, 4 | | PM | | PM | | AM |
| Tensor fasciae latae | LF | L4, 5, S1 | | AM | AM | | AM | |
| Gluteus maximus, upper | PLF | L5, S1, 2 | PM | | AM | | | PM |
| Gluteus maximus, lower | PLF | L5, S1, 2 | PM | | | AM | | PM |
| Biceps femoris, l. h. | PLF | L5, S1, 2 | PM | K | | | | AM & K |
| Semitendinosus | PLF | L5, S1, 2 | PM | K | | | AM & K | |
| Semimembranosus | PMF | L5, S1, 2 | PM | K | | | AM & K | |
| Gluteus medius, ant | LF | L4, 5, S1, 2 | | AM | PM | | AM | |
| Gluteus medius, post. | LF | L4, 5, S1, 2 | AM | | PM | | | AM |
| Gluteus minimus, ant. | LF | L4, 5, S1, 2 | | AM | AM | | PM | |
| Gluteus minimus, post | LF | L4, 5, S1, 2 | AM | | AM | | | AM |
| Piriformis | PLF | L(5), S1, 2 | AM | | AM | | | PM |
| Quadratus femoris | PLF | L4, 5, S1 | | | | | | PM |
| Gemellus superior | PLF | L5, S1, 2 | | | AM | | | PM |
| Gemellus inferior | PLF | L4, 5, S1 | | | AM | | | PM |
| Obturator internus | PLF | L5, S1, 2 | | | AM | | | PM |
| Obturator externus | ALF | L3, 4 | | | | AM | | PM |
| Adductor longus | PMF | L2, 3, 4 | | AM | | PM | AM | |
| Adductor brevis | PMF | L2, 3, 4 | | AM | | PM | AM | |
| Adductor magnus, upper | PMF | L2, 3, 4 | | AM | | PM | | AM |
| Adductor magnus, lower | PMF | L4, 5, S1 | AM | | | PM | AM | AM |
| Gracilis | MF | L2, 3, 4 | | AM & K | | PM | AM & K | |

Muscle fibers: ant. = anterior fibers; post. = posterior fibers; upper = upper fibers; lower = lower fibers; l.h. = long head

## Problems in Muscles Moving the Thigh and Knee

Specific disorders of the six longitudinal *Neijing* muscular distributions of the hip and knee include the following:

Posterior lateral foot (PLF):

- Pain in the buttocks sometimes radiating down the posterior thigh.

Lateral foot (LF):

- Stretched muscles and acute cramps in the lateral aspect of the thigh.
- Tight and stretched muscles in the anterior aspect of the thigh, and posteriorly in the sacral region.
- Pain extending above to cause pain in the lateral abdomen and hypochondrium.

Anterior lateral foot (ALF):

- Acute cramps and spasms in the rectus femoris muscle.

- Swelling and edema in the anterior aspect of the thigh.

Anterior medial foot (AMF):

- Stretching pain sensation along the inner thigh.
- Cramping pain around the genitalia.

Medial foot (MF):

- Pain and acute cramps of the inner thigh.
- Dysfunction of the sexual organs including impotence in the case of internal injury.

Posterior medial foot (PMF):

- Acute cramps and pain in inner aspect of thigh and pubic region.

## Pathology of the Hip

Trauma to the hip is a common source of pain and dysfunction; however, one must consider possible contribution from the lumbar spine and sacroiliac joint areas. Soft-tissue lesions include tendinitis of muscles moving the thigh and bursitis as well. The hip joint is also affected by inflammation of the joint capsule. Typically, diagnosis and confirmation of hip problems requires x-ray, tomography, bone scans, MRI, and appropriate laboratory tests.

### *Intrinsic Hip Disorders*

Pain arising from the hip joint may be felt at several sites the most common being in the groin or lateral aspects of thigh. Less common area of pain includes the deep buttocks, back of thigh, or in medial aspects of thigh. Pain may also radiate down leg, with the degree and extent of radiation pattern related to degree of underlying inflammation.

Characteristic of hip pain manifests as pain brought on by walking or standing that is relieved by rest suggests mechanical derangement of lumbar spine or hip. It may also display constant pain that disturbs sleep usually indicating an inflammation or neoplastic lesion. Hip pain occurring at night often involves an inflammatory component related to overuse during day, and is common in osteoarthritis.

Sources of hip pain may include osteoarthritis of hip or soft tissue lesions involving tendons and bursae. Another possible source includes polymyalgia rheumatica commencing with bilateral hip joint and muscle pain, with stiffness, and high erythrocyte sedimentation rate (ESR), which is common in the older age group. Pain can also be caused by a complete or sometimes incomplete fractures of hip which are common in elderly (diagnosis requires X-rays, including a lateral view of the femoral neck). The hip and groin regions are commonly a source of metastatic deposits or primary tumors, such as multiple myeloma (tumor composed of cells type normally found in bone marrow), and these conditions often present with hip pain at night. X-ray, bone scans or MRI should always be considered where malignancy is suspected, in patients presenting with hip pain.

### *Extrinsic Hip Disorders*

These can include hip pain referred from upper lumbar spine area (L2), possibly indicating secondary deposits or a psoas abscess. Nerve root pressure at L3 may also present as hip pain, but usually pain radiates down front of the thigh and may be aggravated by coughing, bending or straining, and quadriceps weakness or wasting is present, or diminished knee jerk is present. Sacroiliac arthritis may occasionally present as hip pain as well as intra-abdominal causes, such as due to appendicitis or intrapelvic diseases. Problems in local structures, such as femoral hernia or lymphadenopathy (disease of the lymph nodes) may reflect as hip pain.

***Bone Disorders***

**Avascular Necrosis of Femoral Head**

This condition is believed to follow interruption of vascular blood supply, which can be the result of trauma, or a rare complication of some diseases. The underlying cause is often unknown which is then classed as being primary or idiopathic. The initial pathological changes involve subchondral osteolysis in the femoral head, while the articular cartilage appears normal in early stages. The underlying subchondral bone rapidly becomes necrotic and liable to collapse. The degeneration continues to progresses and the femoral head becomes irregular in shape. All these changes are consistent with an ischemic necrosis of bone due to vascular occlusion but, has not been demonstrated in all cases.

**Paget's Disease**

This commonly involves bones of the hip and presents with pain that is often worse at night. The pain may be of bony origin as result of Paget's disease or its complications such as fracture or osteosarcoma.

**Acute Osteoporosis**

This condition occurs mostly in middle-aged men often in absence of any recognizable cause or rarely after trauma. The patient may present with severe pain and stiffness in hip and thigh. Onset is sudden but gradually becomes progressive over following months so that walking becomes increasingly difficult. The course of recovery is usually slow over several months. X-ray changes are necessary for diagnosis and show rarefaction in the hip and especially the femoral head, but joint space is preserved.

**Stress Fractures**

This condition of the femoral neck is not uncommon and tends to occur in young active males or elderly patients with osteoporosis. Two types of fractures are noted including a compression fracture occurring in lower border of neck in the young, or a transverse fracture across upper border of neck in the elderly. The first type of stress fracture responds well to rest while the second type tends to become displaced requiring surgical intervention.

***Joint Lesions***

**Osteoarthritis**

This is one of the most common forms of hip disorder, which may be bilateral, occurring patients of either gender after the age of 50 of any body type. The condition can be divided into primary causes involving an intrinsic disorder affecting the articular cartilage, and secondary cause after a disease or misalignment of the hip joint. Onset of the problem tends to be insidious with pain being a usual presenting complaint; degree of pain often correlated with radiological changes. Pain often related to movement or weight bearing and may appear after unaccustomed or prolonged activity. The pain tends to get worse as day progresses but can be relieved by rest; but later it may be present at night and disturbs sleep. Patients may have considered initial restriction in hip movement as consequence of natural aging until restriction starts limiting functional activities, including walking and other daily activities

#### Monoarthritis

This is an uncommon and unique form of arthritis involving only one hip usually affecting the middle-aged. The onset of pain and stiffness is rapid that gradually settles down after 2-3 years with x-rays showing narrowing of joint space with destructive changes in the acetabulum and femoral head without osteophyte formation. There may be inflammatory changes and ESR levels are always elevated. This disorder is distinct from other hip diseases such as: infections, chondrocalcinosis, rheumatoid arthritis, and spondyloarthritis

#### Septic Arthritis

This condition is relatively uncommon in the hip and usually caused by *Staphylococcus aureus*, but other causative factors can include: gonococcal, streptococcal, and pneumococcal infections. Another but rare cause is tuberculosis of the hip. The patient presents with sudden onset of severe hip pain usually worse at night with marked restriction of hip movement. In addition, they may have an increased temperature, leucocytosis, and elevated ESR levels. This usually requires surgical drainage, immobilization, and full antibiotic course of treatment.

#### Instability of Symphysis Pubis

This condition may follow confinement or trauma; or in athletes especially football players, runners, and fast walkers; or may follow surgery on the sacroiliac joint. The patient may have restricted ipsilateral hip movement and presents with pain in one or both groins which may radiate widely to lower abdomen, thigh adductor region, hip, testis, or perineum. It may also cause low back pain when associated with a lesion of the sacroiliac joint. The pain is made worse by adopting certain postures such as standing on one leg; or by exercise, straining, walking upstairs; or thrusting the hip forward. The pain is typically so severe that running or kicking is impossible and may cause patient to limp.

Pain and tenderness may be reproduced by pressure applied over symphysis pubis; pain and tenderness also over the pubic attachment location of the adductor longus and rectus abdominis muscles. The pain is also reproduced by passive abduction of the patient’s hip, resisted adduction, and by resisting patient’s attempt of sitting up. Diagnosis is confirmed by x-ray observing the gap of the symphysis pubis and also by comparing relative height of the pubic bones when the patient is standing on one leg.

### *Soft-tissue Lesions*

#### Gluteal Tendinitis and Bursitis

Gluteal tendinitis and trochanteric bursitis is the most common soft-tissue lesion around hip: it may occur together or separately. The gluteus medius tendon is separated from greater trochanter and other hip muscles by a small and large bursa. When inflamed, the patient’s pain becomes well localized over outer aspect of greater trochanter, and may radiate down posterior or posterolateral aspect thigh. The pain is brought on by hip movements in walking and climbing stairs and can be reproduced by stretching or contracting gluteus medius muscle. In this case the tendon passively stretched with hip and knee both flexed 90° while leg is fully laterally rotated with patient supine. The muscle is contracted by resisted isometric test in abduction with patient lying on unaffected side.

### Adductor Tendinitis

This condition most often occurs in athletes but also happens in horse riders. It is characterized by pain well localized over origin of adductor longus from the pubis or a few centimeters distally at the musculotendinous junction. The pain is reproduced by stretching or contracting adductor longus tendon; which is stretched by moving patient's hip into full passive abduction while supine. The muscle then contracted by isometric resistance to patient moving hip in direction of adduction.

### Psoas Tendinitis and Bursitis

The iliopsoas muscle is powerful hip flexor that inserts into the lessor trochanter of femur. It is separated from anterior aspect of hip capsule proximal to its insertion by the psoas bursa which may communicate with hip joint. Tendinitis and bursitis may present with pain in the anterior thigh made worse by activity. The pain can be reproduced by contracting or stretching the tendon with patient supine. Here, the hip is flexed to 90° and examiner then isometrically resists any further flexion. Alternatively, with the patient prone with knee flexed to 90°, the examiner passively hyper-extends the hip to stretch the psoas tendon.

### Hamstring Tendinitis

Origin of hamstrings tendons is from ischial tuberosity and may be involved in tendinitis due to overuse syndrome, especially in runners and sprinters. The resulting tenderness well localized over ischial tuberosity. The pain can be reproduced by resisting hip extension or by stretching tendon origin by fully flexing hip. Avulsion of the hamstring origin from the ischial tuberosity can occur in young athletes by separation of part of the bony cortex.

### Rectus Femoris Tendinitis

This tendinitis may involve the origin of the rectus femoris muscle at the anterior inferior iliac spine. A traction injury to an adolescent may result in avulsion of the spine. This could follow sudden exertion in patient with previous tendinitis. Also, this can result from direct contusion to thigh muscles with subsequent loss in extensibility.

### Ischiogluteal Bursitis

The ischiogluteal bursa can be chronically inflamed by prolonged sitting while acute inflammation of this bursa is rare. This condition presents with pain at the ischial tuberosity, made worse by sitting, and relieved by standing. Resulting tenderness is localized over the ischial tuberosity and pain may be reproduced by straight leg raising test.

### Piriformis Syndrome

Part or all of the sciatic nerve passes through rather than below the piriformis muscle in about 15% of the population. These individuals are more likely to develop piriformis syndrome by compression of sciatic nerve. This condition presents with burning pain and hyperesthesia in sacral or gluteal area as well as along sciatic nerve distribution. In addition the patient may have pain and weakness on abduction and lateral rotation of hip. The pain reproduced from stretching the piriformis muscle by passive medial rotation of the extended hip. Medial rotation with hip flexion also accentuates the patient's condition.

#### Capsulitis of Hip

This condition is found in middle-aged and young people, but occurs much less frequently than capsulitis of the shoulder. The patient presents with pain and stiffness which came on over a short period for no apparent reason and is made worse by activity. There is a loss in hip flexion-adduction, rotation, and hyperextension which occurs early. The condition progresses to a loss in abduction and restriction of flexion to about 90°, with loss of accessory movements. The pain gradually resolves over several months while stiffness of the hip movements improve more slowly.

#### Snapping Hip

This condition involves a situation where a loud snapping sound emanates over the lateral aspect of the hip. It may occasionally be associated with pain as well. The sound is produced by the tensor fasciae latae sliding over the greater trochanter; usually brought on by hip flexion and rotation.

### *Entrapment Neuropathy of Hip*

Often occurs in middle-aged males presenting with burning pain, numbness or paresthesia, or itching in the anterior lateral aspects of the thigh down to just above the knee. This involves the lateral cutaneous nerve of the thigh derived mainly from L2 and L3 nerve roots; which supplies skin over the anterolateral aspect of thigh. The nerve emerges from the lateral border of the psoas muscle crossing the iliacus muscle to enter the thigh. Here it either passes through a tunnel in the inguinal ligament near its attachment to the anterior superior iliac spine, or passes under the ligament. Entrapment usually involves the tunnel as the nerve angulates to enter the thigh; degree of angulation and nerve compression is increased by hip extension. Compression of the nerve can also be the result of trauma, pregnancy, alteration in body weight, and activity after prolonged bed rest.

## Examination of the Hip

Prior to active testing of the hip it is observed for possible deformities, synovial swelling, muscle spasms, muscle wasting, abnormal gait, and perhaps the Trendelenburg test.

### Active Movements of Hip

Following the standard rule in orthopedic assessment of active, passive, and resistive movements, the painful movements are done last. Likewise, it is important to minimize moving the patient into various test positions. For example, all test performed in the supine position would be completed before conducting those that required the patient to lying in the prone or side lying positions. Hence, hip flexion, abduction, and adduction can be performed while the patient is supine before moving patient to the prone position to measure hip extension, medial rotation, and lateral rotation. These last to measurements can also be performed with the patient seated with legs over the end of the examination table.

Each of the active movements is conducted to measure range and characteristics of motion, including possible restrictions and pain. If the movement is pain free overpressure can be applied at the limit of motion to assess the characteristics of the end-feel. Otherwise, end-feel is measured during passive movements.

### *Hip Flexion*

Active flexion is conducted with the patient supine and flexing the hip by lifting the thigh up off the examination table with the knee allowed to flex to keep potentially tight hamstrings in limiting the motion. Hip is normally flcxed from 110° to 120° and the end-feel is typically soft due the muscular contact of the anterior thigh with the lower abdomen. Hip flexion can be measured with a goniometer that has sufficiently long arms or by using an inclinometer.

Flexion can be measured with a goniometer with the fulcrum centered on the lateral aspect of the hip joint. The greater trochanter of the femur is used as a reference. The proximal fixed arm is aligned with the lateral midline of the pelvis while the movable distal arm is aligned along the lateral midline of the femur using the lateral epicondyle as reference. Flexion is maintained at the end of movement while the examiner aligns the distal arm with the lateral aspect of the femur to note the angular movement value.

Hip flexion can also be measured with a bubble or gravity sensitive inclinometer. A bubble inclinometer is held vertically, proximal to the knee, with the long axis aligned with the femur. The inclinometer is adjusted zero as the horizontal reference. The patient flexes the leg as before allowing the knee to flex while the examiner holds the inclinometer on the thigh. Full extension angle can be read directly at the end of flexion movement.

If using a gravity sensitive inclinometer, it is strapped onto the lateral thigh just proximal to the knee with the dial on the midline of the femur. The dial is adjusted to zero. The examiner stabilizes the pelvis as the hip is moved to the limit of flexion and the measurement recorded.

### *Hip Extension*

Active extension is conducted with the patient prone with the feet over the end of the examination table. The hip is extended from 10° to 30° by the patient lifting the thigh up off the examination table. The end-feel is typically firm due to tension in the iliofemoral ligament and anterior joint capsule. Other contribution to the firm end-feel is possible tension in hip flexors including the iliopsoas, adductor longus, tensor fasciae latae, sartorius, and gracilis muscles.

Extension can be measured with a goniometer with the fulcrum centered on the lateral aspect of the hip joint. The greater trochanter of the femur is used as a reference. The proximal fixed arm is aligned with the lateral midline of the pelvis while the movable distal arm is aligned along the lateral midline of the femur using the lateral epicondyle as reference. Extension is maintained at the end of movement while the examiner aligns the distal arm with the lateral aspect of the femur to note the angular movement value.

Hip extension can also be measured with a bubble or gravity sensitive inclinometer. A bubble inclinometer is held vertically on the posterior surface of the thigh, proximal to the knee, with the long axis aligned with the femur. The inclinometer is adjusted zero as the horizontal reference. The patient extends the leg as before while the examiner holds the inclinometer on the thigh. Full extension angle can be read directly at the end of flexion movement.

A gravity sensitive inclinometer is strapped onto the lateral thigh just proximal to the knee with the dial on the midline of the femur. The dial is adjusted to zero. The examiner stabilizes the pelvis as the hip is moved to the limit of extension and the measurement recorded.

***Hip Abduction***

Active hip abduction of 30° to 50° is conducted with the patient supine initially with both knees extended legs and aligned straight on the table in 0° of flexion, extension, and rotation. Examiner stabilizes the hip by placing one hand on the pelvis. Abduction is accomplished by the patient sliding one foot laterally out across the table while avoiding rotation of the leg. Examiner may partially support the leg as it moves off the table in the horizontal plane. The normal end-feel is firm due to the inferior (medial) joint capsule, ischiofemoral ligament, inferior band of the iliofemoral ligament, and the pubofemoral ligament. Passive tension in the adductor longus, adductor magnus, adductor brevis, pectineus, and gracilis muscles may contribute to the firm end-feel.

Abduction can be measured with a goniometer with the fulcrum centered on the anterior superior iliac spine (ASIS) of the extremity being measured. The proximal fixed arm is aligned with an imaginary line connecting one ASIS to the other. The distal arm is aligned with the lateral midline of the femur using the midline of the patella for reference. The goniometer is then reading 90°. The patient then moves the leg into full abduction and the reading is obtained by subtracting 90° from the total angular abduction.

Abduction can also be measured with a compass device used in measuring rotation in the horizontal plane. The dial is strapped on the anterior aspect of the thigh proximal to the knee. The compass is set to zero degrees and the abduction angle is read at the full abduction range of motion.

Hip abduction can also be measured with a bubble or gravity sensitive inclinometer if the patient is lying on their side and are able to lift their upper leg off the lower leg into full abduction. A bubble inclinometer is held vertically on the lateral thigh, proximal to the knee, with the long axis aligned with the femur. The inclinometer is adjusted zero as the horizontal reference when the leg is supported by the examiner to be level with the table. The patient abducts the leg by lifting it up into full abduction. If using a gravity sensitive inclinometer, it is strapped onto the anterior or posterior thigh just proximal to the knee with the dial on the midline of the femur. The dial is adjusted to zero. The examiner stabilizes the pelvis as the leg is lifted off the upper leg as before into full abduction.

***Hip Adduction***

Active hip adduction of 20° to 30° is conducted with the patient supine initially with both knees extended legs and aligned straight on the table in 0° of flexion, extension, and rotation. Examiner stabilizes the hip by placing one hand on the pelvis. The contralateral leg is first moved in abduction to allow space to adduct the leg being assessed. The test leg is initially held in its straight aligned position. Adduction is then accomplished by sliding the foot medially across the table while avoiding rotation of the leg. The normal end-feel is soft/firm due to the superior (lateral) joint capsule and the superior band of the iliofemoral ligament. Passive tension in the tensor fasciae latae, gluteus medius, and gluteus minimus muscles may contribute to the firm end-feel.

Adduction can be measured with a goniometer with the fulcrum centered on the anterior superior iliac spine (ASIS) of the extremity being measured. The proximal fixed arm is aligned with an imaginary line connecting one ASIS to the other. The distal arm is aligned with the lateral midline of the femur using the midline of the patella for reference. The goniometer is then reading 90°. The patient then moves the leg into full adduction and the reading is obtained by subtracting the final value from 90°.

Adduction can also be measured with a compass device used in measuring rotation in the horizontal plane. The dial is strapped on the anterior aspect of the thigh proximal to the knee. The compass is set to zero degrees and the adduction angle is read at the full adduction range of motion.

Hip adduction can also be measured with a bubble or gravity sensitive inclinometer if the patient is lying on their side and are able to lift their lower leg off the examination table into full abduction. The upper leg is extended or flexed with the foot resting on the examination table to provide clearance for the lower leg to be raised into adduction. A bubble inclinometer is held vertically on the lateral thigh, proximal to the knee, with the long axis aligned with the femur. The inclinometer is adjusted zero as the horizontal reference. The patient abducts the lower leg by lifting it off the table into full abduction. If using a gravity sensitive inclinometer, it is strapped onto the anterior or posterior thigh just proximal to the knee with the dial on the midline of the femur. The dial is adjusted to zero. The examiner stabilizes the pelvis as the leg is lifted off the table into the full of adduction.

***Hip External (Lateral) Rotation***

Normal external (lateral) hip rotation of 40° to 60° can be measured with the patient prone, supine, or seated. Normal end-feel of this movement is firm/soft due to tension in the iliofemoral ligament, pubofemoral ligament, and inferior joint capsule. Passive tension in the anterior portion of the adductor magnus, adductor longus, gluteus medius, gluteus minimus, pectineus, and the piriformis muscles may also contribute to the firm end-feel.

While seated with legs over the edge of the examination table the examiner places one hand on the patient's distal femur to prevent hip flexion and abduction. The patient is instructed to shift their weight onto the hip being tested to assist in stabilizing the hip while flexing the other leg to allow clearance for lateral rotation of the test leg. A towel may be placed under the distal humerus to provide better horizontal alignment. This configuration is reversed to test the other leg in external rotation.

The fulcrum of the goniometer is placed on the anterior aspect of the patella with the fixed arm perpendicular to the floor and aligned with of the lower leg midline. The crest of the tibia and a point midway between the two malleoli are used as a reference. The leg is then moved into full external rotation with the movable arm of the goniometer held on the leg during movement.

If a gravity sensitive device is used to measure external rotation, it is strapped on the leg proximal to the ankle with the dial on the anterior of the leg. If using a bubble inclinometer, it is held on the medial aspect of the leg proximal to the ankle.

Measuring external rotation while prone, the knee of the test leg is flexed 90° with the leg standing straight up. A goniometer is placed on the anterior aspect of the patella and aligned in reverse of the seated position as previously noted. The leg is allowed to rotate toward the other leg. A gravity sensitive device or bubble inclinometer can be used as well as previously described.

In the supine test configuration, the test leg is held with the knee and hip both flexed 90°. Movement directions are similar to the seated position except the patient is lying on their back and supporting the weight of the lower leg. Examiner may help support lower leg during rotation. A goniometer or compass device can be used to measure hip external rotation in this configuration.

### *Hip Internal (Medial) Rotation*

Normal internal (medial) hip rotation of 30° to 40° can be measured with the patient prone, supine, or seated. Normal end-feel of this movement is firm due to tension in the ischiofemoral ligament and posterior joint capsule. Passive tension in the hip lateral rotators (piriformis, quadratus femoris, gemellus superior, gemellus inferior, obturator internus, and obturator externus) and gluteus maximus contribute to the firm end-feel.

While seated with legs over the edge of the examination table the examiner places one hand on the patient's distal femur to prevent hip flexion and abduction. The patient is instructed to shift their weight onto the hip being tested to assist in stabilizing the test hip. A towel may be placed under the distal humerus to provide better horizontal alignment. This configuration is reversed to test the other leg in internal rotation.

The fulcrum of the goniometer is placed on the anterior aspect of the patella with the fixed arm perpendicular to the floor and aligned with of the lower leg midline. The crest of the tibia and a point midway between the two malleoli are used as a reference. The leg is then moved into full internal rotation with the movable arm of the goniometer held on the leg during movement.

If a gravity sensitive device is used to measure internal rotation, it is strapped on the leg proximal to the ankle with the dial on the anterior of the leg. If using a bubble inclinometer, it is held on the lateral aspect of the leg proximal to the ankle.

Measuring internal rotation while prone, the knee of the test leg is flexed 90° with the leg standing straight up. A goniometer is placed on the anterior aspect of the patella and aligned in reverse of the seated position as previously noted. The leg is allowed to rotate away from the other leg. A gravity sensitive device or bubble inclinometer can be used as well as previously described.

In the supine test configuration, the test leg is held with the knee and hip both flexed 90°. Movement directions are similar to the seated position except the patient is lying on their back and supporting the weight of the lower leg. Examiner may help support lower leg during rotation. A goniometer or compass device can be used to measure hip internal rotation in this configuration.

## Passive Movements of Hip

If the end-feel was not measured during the active movements, passive movement would then be necessary to obtain this information. The movements are basically the same as those performed in the preceding active movements. With the exception of hip extension, all of these movements are performed in the supine position, with extension performed in the prone position. End-feel for all hip movements essentially involves tissue approximation or tissue stretch which is characterized from soft, firm, soft/firm to firm/soft.

The capsular pattern for the hip is flexion, abduction, and internal (medial) rotation usually being the motions that are most limited (Table 14.1). However, the order of restriction can vary such as internal rotation being more restricted followed by flexion and abduction.

#### *Hip Flexion*

With the patient supine, the examiner lifts the thigh by the knee while allowing the knee to flex through the complete range of passive movement as possible. Areas of pain, restriction, and end-feel are noted.

#### *Hip Extension*

Patient is prone while the examiner extends the thigh by lifting up just proximal to the knee and the knee is allowed to flex.

#### *Hip Abduction*

Patient is supine with both legs aligned straight with the body. The examiner slightly lifts and supports the leg by placing one hand under the ankle. The leg is then slowly moved into the complete range of passive abduction as possible.

#### *Hip Adduction*

Patient is supine with the test leg aligned straight with the body while the contralateral leg is moved into abduction to allow clearance for the other leg to be adducted. Examiner supports the test leg by slightly lifting with one hand placed under the ankle to assure leg can slide across the examination table surface to move it into the complete range of passive adduction as possible.

#### *Hip Internal and External Rotation*

Patient is supine while the examiner supports the thigh and lower leg with the hip and knee of the test leg flexed at 90°. While maintaining the lower leg parallel to the floor, the examiner slowly moves the leg outward from the midline into the complete range of passive internal (medial) rotation as possible. After possible restriction and end-feel are determined, the leg is return to 0° position of rotation. The leg is then slowly moved toward the midline into the complete range of passive external (lateral) rotation as possible. Leg is returned to original position and the other leg is tested.

### Resistive Movements of Hip

The isometric resistive movements of the hip can be performed while the patient is supine. Due to the strength of the hip muscles it is important that the patient's hips and body are positioned properly. If the knee is not going to be assessed following the hip, then it is essential to also perform an isometric resistive test for knee flexion and extension since the rectus femoris and hamstrings act over the knee and hip joint as well. To ensure that the examiner is applying a constant isometric resistive force, the patient is instructed to only supply sufficient resistance to keep the examiner from moving them. Hence, the patient is told: "Don't let me move you." For functional reasons not all of the muscle groups have the same strengths. Hip adductors may be 2.5 times stronger than the abductors, while hip flexors and extensors may be nearly equal in strength.

Resisted isometric movements can produce pain in affected or weak muscles or reproduce the patient's pain. Focus of the assessment is to determine if a particular muscle is involved in the presenting case. Some muscles participate in more than one movement of the hip (See Table 15.2). If a particular muscle is the only one involved in specific movements that result in pain being produced, then this might indicate a possible source of the problem. For example, the gluteus maximus (lower fibers) is the only muscle involved in the three movements of hip adduction, extension, and lateral rotation. If pain is experienced in all three of these movements, the gluteus maximus may be involved.

Examiner must be aware that some internal problems can manifest as muscular pain on resisted isometric testing. Some cases of intra-abdominal inflammation in the region of the psoas muscle may result in pain on resisted hip flexion. Other intra-abdominal conditions may manifest with rigidity of the abdominal wall.

### *Hip Flexion*

Resisted isometric movement in hip flexion mainly involves the psoas and iliacus muscles (iliopsoas) with accessory participation of the rectus femoris, sartorius, tensor fasciae latae, and pectineus muscles. Patient is supine with body and hip properly aligned and the test leg flexed about 45°. The examiner raises the lower leg off the table and maintains it also flexed about 45°. Isometric force is applied just proximal to the knee in the direction of hip extension.

### *Hip Extension*

Resisted isometric movement in hip extension mainly involves the gluteus maximus, biceps femoris, semitendinosus, and semimembranosus muscles. Accessory muscles include the adductor magnus, piriformis, and gluteus medius muscles. The patient is supine with the test leg aligned straight with the body while the contralateral leg is held in slight abduction on the table. Standing to the test side, the examiner grasps the patient's thigh with both hands on the underside of the leg just proximal to the knee. The leg, with the knee extended, is lifted off the examination table into several degrees of flexion and the patient is then asked to keep the examiner from moving the leg further into flexion. Other leg is similarly evaluated.

### *Hip Abduction*

Resisted isometric movement in hip abduction mainly involves the gluteus medius and gluteus minimus muscles, with accessory participation of the tensor fasciae latae and gluteus maximus muscles. The patient is supine with both legs slightly abducted. While standing to the test side, the examiner grasps the patient's leg with one hand proximal to the ankle to slightly lift it off the table. The other hand is placed on the lateral aspect of the leg just proximal to the knee to apply a resistive isometric force in the direction of hip adduction by pushing in the medial direction on the thigh.

### *Hip Adduction*

Resisted isometric movement in hip adduction mainly involves the adductors longus, brevis, and magnus, along with the pectineus and gracilis muscles. The patient is supine with both legs slightly abducted. While standing to the test side, the examiner grasps the patient's leg with one hand proximal to the ankle to slightly lift it off the table. The other hand is placed on the medial aspect of the leg just proximal to the knee to apply a resistive isometric force in the direction of hip abduction by pulling in the lateral on the thigh.

***Hip Internal (Medial) Rotation***

Resisted isometric movement in hip internal rotation mainly involves the gluteus medius, gluteus minimus, and tensor fascia latae muscles, with accessory involvement of the adductor longus. The patient is supine with both legs initially aligned straight with the body. The test leg hip and knee are both flexed 90° with the thigh straight up and the lower leg parallel to the floor. The examiner stands on test side while grasping the patient's leg with one hand proximal to the ankle. The other hand is placed just above the knee to stabilize the thigh. A resistive isometric force is applied by the hand above the ankle by pushing in the direction of hip external rotation.

***Hip External (Lateral) Rotation***

Resisted isometric movement in hip external rotation mainly involves the piriformis, obturator externus and internus, gemellus superior and inferior, and quadratus femoris muscles. The patient is supine with both legs initially aligned straight with the body. The test leg hip and knee are both flexed 90° with the thigh straight up and the lower leg parallel to the floor. The examiner stands on test side while grasping the patient's leg with one hand proximal to the ankle. The other hand is placed just above the knee to stabilize the thigh. A resistive isometric force is applied by the hand above the ankle by pulling in the direction of hip internal rotation.

***Hip Abduction and Hip Flexion***

This test specifically addresses the resistive isometric strength of the tensor fascia latae muscle with accessory participation of the gluteus medius and gluteus minimus muscles. The patient is lying on the non-test side with the leg held in maximum hip and knee flexion by drawing the knee up toward the chest with both hands. The test leg is extended at the knee and placed into 10 - 20° of hip flexion and internal rotation with the pelvis rolled backward. Examiner stands behind the patient and stabilizes the pelvis by placing one hand on the iliac crest. Patient then slowly abducts the hip through full ROM while the examiner palpates on the iliotibial band distal to the greater trochanter or lateral to the upper part of the sartorius muscle. The leg is returned to a position of slight hip abduction and a resistive isometric force is applied on the anterolateral aspect of the thigh just proximal to the knee. Resistive force is applied in the direction of hip adduction and extension.

***Hip Flexion, Abduction, and External Rotation with Knee Flexion***

This test specifically addresses the resistive isometric strength of the sartorius muscle with accessory participation of the iliopsoas, rectus femoris, and tensor fascia latae muscles. Patient is supine with legs aligned straight with the body. The patient flexes the hip to approximately 90° and then abducts and internally rotates the hip and flexes the knee to where the heel of the foot is almost over the opposite knee joint. The examiner grasps the medial posterior aspect of the lower leg just above the ankle while the other hand is placed over the anterolateral aspect of the thigh just proximal to the knee joint. Resistive isometric pressure is then applied to the anterolateral aspect of the thigh and also on the posterior aspect of the lower leg by pulling up. Resistance is applied in the direction of extension, adduction, and internal rotation of the hip with one hand and in knee extension with the other hand.

## Functional Assessment

Normal function of the hip is required for ambulation and gait, but more range of motion (ROM) is involved in normal daily activities including: sitting, tying a shoe, getting up from the seated position, stooping, squatting, going up stairs, and picking things up from the floor. Functional assessment of the hip can be accomplished by conducting tests that require normal ROM in the principal hip movements involving: going up and down stairs one or two steps at time; squatting; running sideways; touching the knee of one leg with the ankle of the other leg, etc. There are several functional assessment and grading methods in use for the hip.

## Accessory Movements of Hip

The accessory or joint play movements of the hip are first examined on the unaffected side to compare with the affected hip. Small differences in joint play may be difficult to determine due to the large bulky muscles associated with the hip.

### *Longitudinal Caudad*

Patient is supine and the examiner uses both hands to grasp the lower end of the femur of the test leg. The thigh is lifted into slight hip flexion and abduction. Lower leg may be allowed to flex with heel rested on table or it may be rested on examiner's flexed knee that is positioned on the table. The examiner then pulls longitudinally on the thigh is a direction aligned with the axis of the femur to evaluate accessory movement. An oscillatory application the traction force can be used for mobilization. Technique is effective as a test or mobilization treatment for any hypomobility problem or painful restriction.

If the patient does not have any problems with the knee, the caudal force can be applied by grasping the ankle and pulling longitudinally.

### *Longitudinal Cephalad*

Patient is supine and the examiner uses both hands to grasp the knee with one hand under the posterior aspect of the knee and the other on the anterior aspect. The thigh is lifted into slight hip flexion and abduction. Lower leg may be allowed to flex with heel rested on table or it may be rested on examiner's flexed knee that is positioned on the table. The examiner then pushes on knee in the cephalad direction aligned with the axis of the femur to evaluate accessory movement. An oscillatory application the longitudinal cephalad force can be used for mobilization. Technique is effective as a test or mobilization treatment for any hypomobility problem or painful restriction.

### *Posteroanterior*

Patient lies on side with hip and knees slightly flexed with a pillow between the legs to maintain the femur in 0° of abduction and adduction. A posteroanterior force is applied from behind the greater trochanter with one hand while the other hand stabilizes the anterior iliac crest. Accessory movement is evaluated. An oscillatory application of the posteroanterior force can be used for mobilization. Technique is effective as a test or mobilization treatment for any hypomobility problem or painful restriction, and for increasing extension.

### *Anteroposterior*

Patient lies on side with hip and knees slightly flexed with a pillow between the legs to maintain the femur in 0° of abduction and adduction. An anteroposterior force is applied to the anterior aspect of the greater trochanter with one hand while the other hand stabilizes the posterior iliac crest. Accessory movement is evaluated. An oscillatory application of the posteroanterior force can be used for mobilization. Technique is effective as a test or mobilization treatment for any hypomobility problem or painful restriction, and for increasing flexion.

#### *Lateral Femoral Glide*

Patient is supine with the hip of the test leg flexed 90°. The examiner gasps the upper end of the thigh with both hands wrapped around leg. Knee can be flexed as well in which case the examiner grasps both the thigh and flexed lower leg. A force is applied to the upper thigh region by pulling laterally from the body. An oscillatory application the lateral force can be used for mobilization. This technique is useful for testing accessory joint play and treating hypomobility and any painful restriction.

#### *Caudal Femoral Glide*

The same test configuration applied in the Lateral Femoral Glide can be used for accessory movement in the caudal direction. In this case the thigh is grasped in the upper anterior aspect and the patient can also rest the lower leg on the shoulder of the examiner. An oscillatory application in the caudal directed force can be used for mobilization. This technique is useful for testing accessory joint play and treating hypomobility and any painful restriction.

### Special Tests

There a number of auxilary orthopedic tests of the hip that can provide additional information to confirm the clinical impression derived by the standard assessment tests.

#### *90 - 90 Straight Leg Raise Hamstring Test*

Patient is supine and stabilizing both hips at 90° of flexion using both hands while the lower legs are relaxed. Patient is then instructed extend each lower leg one at a time. If the knee remains flexed 20° or greater after full extension possible, it indicates the hamstrings of that leg are tight.

This test is not considered to be a complete assessment of hamstring extensibility since the passive motion of the hamstring muscle group is limited by the strength of the patient's quadriceps muscle group.

#### *Thomas Test*

Patient is initially sitting with buttocks at the end of the table and then lying supine while simultaneously passively flexing both legs by drawing them up to the chest. The examiner stands to the side of the patient to place one hand on the lumbar spine or iliac crest to monitor lumbar lordosis or pelvic tilt respectively. Patient slowly lowers the leg on the affected side until the leg is fully relaxed or until either there is an increase in lumbar lordosis or anterior pelvic tilting. Increases in lumbar lordosis and pelvic tilt must be eliminated to prevent false negative findings.

A lack of hip extension with knee flexion greater than 45° is indicative of iliopsoas muscle tightness. Full hip extension with knee flexion less than 45° indicates possible tightness in the rectus femoris muscle. A lack of hip extension with knee flexion less than 45° indicates possible tightness in the rectus femoris and iliopsoas muscles. Hip external rotation of any of these situations indicates possible tightness in the tensor fasciae latae.

A variation of this test is performed with the patient is resting supine while the examiner places a goniometer fulcrum on the lateral aspect of the greater trochanter of the affected side with the fixed and moveable arms held aligned along the axis of the femur. The patient then stabilizes the hip by passive flexion of the uninvolved hip by drawing the leg up to the chest with the knee flexed. If the opposite leg moves into flexion the movable arm is allowed to move with the thigh to determine amount of possible flexion. Flexion of the thigh indicates a hip flexor contraction.

#### *Ober Test*

Patient is side lying on the uninvolved side with the lower leg hip and knee slightly flexed. The examiner passively moves the upper leg into abduction and extension by lifting the leg with one hand grasping just distal to the knee while stabilizing the pelvis with the other hand on the ilium. The examiner then releases the grip to allow the leg to drop. If the leg does not drop into adduction the test is positive for contracture of the iliotibial band.

#### *Patrick (FABER) Test*

Patient is supine and instructed move the affected hip into flexion and abduction so the leg can be externally rotated to place the lateral malleolus on the opposite knee. Examiner places one hand on the uninvolved hip to stabilize the pelvis while slowly pushing on the knee of the affected leg to push it into abduction. The test is considered positive indicating possible hip pathology if the patient cannot complete this maneuver; or if the lower leg of the involved side cannot be abducted to the same level as the uninvolved leg; or if inguinal pain is reproduced; or if it reproduces posterior sacral pain. These findings may be indicative of iliopsoas, sacroiliac, or hip joint abnormalities.

FABER is an acronym for the initials for positioning the patient, namely: F = flexion; AB = abduction; and ER = external rotation.

#### *Piriformis Test*

Patient lies on the unaffected or non-test side with the test leg in 60° of hip flexion with the lower leg in relaxed knee flexion. Examiner stands behind patient with one hand on the lateral aspect of the pelvis and the other on the lateral side of the knee. With the pelvis stabilized the examiner applies a downward force on the patient's knee in the direction of adduction. Pain or tightness in the hip or buttock area indicates possible tightness in the piriformis muscle. Pain in the buttock and posterior thigh may indicate sciatic nerve impingement secondary to piriformis tightness.

This test can also be performed with the patient supine by moving the uninvolved leg into slight abduction to allow room for moving the test leg into adduction. Examiner stands to affected side and places one hand on the patient's hip to stabilize the pelvis. The other hand is placed just proximal to the knee to lift the thigh off the table and slowly move it into adduction. Positive indications are the same as in the previous piriformis test configuration above.

### Neurological Evaluation

#### *Myotomes*

Generally the isometric screening tests (See Table 13.2) for the lumbar spine and lower extremities are conducted as part of the initial examination for problems affecting the hip and lower extremities. The only specific myotome test for the hip is that of L2 - iliopsoas, with strength graded 0 - 5.

## Diagnostic Imaging

### *Plain Film Radiography*

Anteroposterior View: This view is used to compare the two hips to examine: joint space and pelvis lines; presence of bone diseases; femur neck and shaft angles; femoral head shape; presence of osteophytes or arthritis; possible fracture or dislocation; and pelvic distortion.

**Lateral (Axial "Frog-Leg") View:** This view provides a true lateral image of the femoral head and neck by the patient in the supine position with hip in flexion, abduction, and lateral rotation. Examiner looks for slipping of the femoral head and any pelvic distortion.

### *Magnetic Resonance Imaging (MRI)*

Magnetic resonance imaging of the hip is useful to show soft-tissue problems such as bursitis and tendon lesions, as well as osseous tissue problems.

### *Computed Tomography*

Computed tomography (CT) scans used to show size and shape of acetabulum and femoral head, including relative position and congruity of the femoral head in relationship to the acetabulum.

### *Arthrography*

An arthrogram may be indicated in situation where a hip dislocation cannot be reduced.

# Management of Hip and Thigh Disorders

Needling therapy and mobilization techniques used to treat hip and thigh problems. Mobilization is employ to address pain, hypomobility, and restricted movement of the hip.

## Mobilization

The previously described accessory movements can be used for hip mobilization by applying oscillatory movements, depending on the specific signs and symptoms. This includes the following tests plus additional techniques discussed in the following:

- Longitudinal caudal
- Longitudinal cephalad
- Posteroanterior
- Anteroposterior
- Lateral femoral glide
- Caudal femoral glide

### *Dorsal Femoral Glide*

Patient is supine with the hip flexed 90° and slightly adducted. Examiner stands to the patient's opposite side with one hand behind the patient's hip to stabilize the pelvis. The other hand is placed on the flexed knee along with the chest to apply a dorsal-lateral force through the longitudinal axis of the femur. This maneuver has a similar effect as anteroposterior mobilization previously discussed. Technique is effective in increasing hip flexion.

### *Ventral Femoral Glide*

Patient is prone with a towel slightly raising and supporting the pelvis. Standing at the opposite of the patient the practitioner places their overlapping hands the dorsal proximal femur. With the arms somewhat parallel to the line of force, the practitioner applies body weight to direct a ventral force to the femoral head. This maneuver has a similar effect as posteroanterior mobilization previously discussed. Technique is effective in increasing hip extension.

### *Medial Femoral Rotation*

Patient is prone with the hip slightly abducted and medially rotated until the ASIS on the opposite side lifts off the table. Standing to the affected side of the patient, the practitioner stabilizes the lower leg with one hand and forearm with the other hand placed on the unaffected pelvis. Practitioner presses ventrally (rotates hip opposite to medial rotation) with gentle oscillatory movements. Generally, this technique is effective in increasing medial hip rotation; however, it is used with caution or modified if patient has knee instability problems.

### *Lateral Femoral Rotation*

Patient is prone with hip slightly abducted and laterally rotated until the ASIS is lifted from the table. Standing on the opposite side, the practitioner stabilizes the lower leg with one hand and forearm while the other hand is placed on the pelvis of involved side. Practitioner presses ventrally (rotates hip opposite to lateral rotation) with gentle oscillatory movements. Generally, this technique is effective in increasing lateral hip rotation; however, it is used with caution or modified if patient has knee instability problems.

## Needling Therapy for Hip and Thigh Problems

Pain and dysfunction of the hip may reflect in the joint itself or may be reflected to various regions of the thigh, including the buttocks and low back. There may be restricted motion in extension, flexion, abduction, adduction, medial rotation, or lateral rotation. Each of these areas involves one or more muscular distribution and so treatment approaches vary. Thus, different nodes may be considered depending on the specific area and nature of the problem.

### *Hip Joint Pain*

When pain and restricted motion problems are specifically reflected in the hip joint, candidate local and adjacent, proximal and distal nodes can be considered as summarized in Table 15.3.

Table 15.3. Regional nodes considered in treatment of hip joint pain and dysfunction

| Hip Joint Pain or Disorder | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Guanyuanshu (PLF 26)<br>Huantiao (LF 30)<br>Juliao (LF 29)<br>Fengshi (LF 31)<br>Xuanzhong (LF 39) | LF | Danshu (PLF 19) | Zulinqi (LF 41)/<br>Diwuhui (LF 42) |

### *Candidate Electroneedling (EN) Application for Hip Joint Pain*

**Frequency:** 2 Hz
**Mode:** continuous
**Duration:** 20-30 minutes
**Lead placement:**

- Danshu (PLF 19) + lead to Juliao (LF 29) – lead
- Guanyuanshu (PLF 26) + lead to Huantiao (LF 30) – lead

### *Pain and Dysfunction of Hip*

Candidate local and adjacent, proximal and distal nodes considered in treatment of hip joint pain and dysfunction, which reflects in three particular muscular distributions, are summarized in Table 15.4. Pain and weakness associated with specific muscles and related hip movements may require adding particular nodes related to those muscles, while restricted movements might involve tightness or contractures would require examination of muscles that oppose specific movements. Additional nodes may be added or deleted from those listed in Table 15.4 for particular disorders affecting specific muscle distributions moving the hip including:

- Flexion: mainly involves the iliopsoas belonging to the ALF distribution; may replace Yanglingquan (LF 34) with Zusanli (ALF 36), add Biguan (ALF 31) and Qihaishu (PLF 24), and delete Zhibian (PLF 54), Chengfu (PLF 36) and Huantiao (LF 30)
- Extension: mainly involve the gluteus maximus belong to the PLF distribution muscles; may add Shenshu (PLF 23), Guanyuanshu (PLF 26), Baiyuanshu (PLF 30) and Feiyang (PLF 48), and delete Zhibian (PLF 54), Yanglingquan (LF 34) and Liangqiu (ALF 34)
- Abduction: mainly involve the gluteus minimus, gluteus medius, and the tensor fasciae latae muscles belong to the LF distribution; add Qihaishu (PLF 24) and Fengshi (LF 31), and delete Zhibian (PLF 54), Chengfu (PLF 36), and Liangqiu (ALF 34)
- Adduction: mainly involve the adductor magnus, longus, and brevis belonging to the PMF muscle distribution; treat using PLF distribution but add Shenshu (PLF 23), Zhubin (PMF 9), and Jimen (AMF 11), and delete Zhibian (PLF 54), Chengfu (PLF 36), and Liangqiu (ALF 34)
- Medial rotation: mainly involve the adductor longus, adductor brevis belonging to the PMF muscle distribution and the gluteus minimus and tensor fasciae latae belonging to the LF distribution; treat using PLF and LF distributions but add Shenshu (PLF 23), Zhubin (PMF 9), and Jimen (SP 11), and delete Zhibian (PLF 54), Chengfu (PLF 36), and Liangqiu (ALF 34)
- Lateral rotation: mostly involve the hip lateral rotators including the piriformis, quadratus femoris, gemellus superior, gemellus inferior, obturator internus, and obturator externus muscles belonging to the PLF distribution; treat as PLF distribution and add Qihaishu (PLF 24), Ciliao (PLF 32), Baiyuanshu (PLF 30) and Feiyang (PLF 58), and delete Zhibian (PLF 54), Chengfu (PLF 36), and Liangqiu (ALF 34)

Table 15.4. Regional nodes in treatment of pain and dysfunction in moving the hip

| Thigh Pain or Disorder | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Zhibian (PLF 54)<br>Chengfu (PLF 36)<br>Huantiao (LF 30)<br>Yanglingquan (LF 34)<br>Liangqiu (ALF 34) | PLF | Pangguanshu (PLF 28) | Shugu (PLF 65) |
| | | LF | Danshu (PLF 19) | Zulinqi (LF 41) |
| | | ALF | Weishu (PLF 21) | Xiangu (ALF 43) |

### *Candidate Electroneedling (EN) Application for Thigh Problems*

**Frequency:** 2 Hz
**Mode:** continuous
**Duration:** 20-30 minutes
**Lead placement:**

Anterior lateral foot (ALF) distribution (flexion):

- Weishu (PLF 21) + lead to Biguan (ALF 31)
- Qihaishu (PLF 24) + lead to Liangqiu (ALF 34)/Zusanli (ALF 36) – lead

Posterior lateral foot (PLF) distribution (extension):

- Shenshu (PLF 23) + lead to Huantiao (LF 30) – lead
- Guanyuanshu (PLF 26) + lead to Baiyuanshu (PLF 30) – lead

Lateral foot (LF) distribution (abduction):

- Danshu (PLF 19)/Huantiao (LF 30) + lead to Fengshi (LF 31) – lead
- Qihaishu (PLF 24) + lead to Yanglingquan (LF 34) – lead

Posterior medial foot (PMF) distribution (adduction):

- Shenshu (PLF 23) + lead to Jimen (AMF 11)/Zhubin (PMF 9) – lead

Posterior lateral foot (PLF) distribution (lateral rotation):

- Qihaishu (PLF 24) + lead to Huantiao (LF 30) – lead
- Guanyuanshu (PLF 26) + lead to Baiyuanshu (PLF 30) – lead

Posterior medial foot (PMF) and lateral foot (LF) distributions (medial rotation):

- Shenshu (PLF 23) + lead to Jimen (AMF 11)/Zhubin (PMF 9) – lead
- Huantiao (LF 30) + lead to Yanglingquan (LF 34) – lead

## Remedial Exercise for Muscles Moving the Hip Joint

The pelvis and femur that comprise the hip joint have some similarities to the shoulder joint, and the hip muscles have similar movements in extension, flexion, abduction, adduction, and rotation (See Table 15.2). However, the pelvis is basically a fixed structure and is the major load bearing element that directs the upper body weight onto the legs and the ground. Hence, the function of the hip is dramatically different from the shoulder. Given that humans are bipedal, the task of the muscles moving the hip is critical to maintaining overall body function.

## Hip Flexor Stretches

The iliopsoas (psoas + iliacus) muscles can be stretched while lying supine or standing. In the supine position the subject lies down from a seated position at the end of a treatment table or other location that allows the upper legs extended without the feet touching the floor. One leg is drawn up to the chest to flex the lumbar spine and rotate the pelvis while the other leg is extended relaxed over the end of table to allow the dead weight to put a stretching load on the iliopsoas. The lower leg can also be relaxed and allowed to flex to not involve the rectus femoris muscle. This position is held for 10 - 15 seconds after which the leg drawn up to the chest is partially lowered to relieve the iliopsoas stretch, and then drawn up to the chest again. This cycle can be performed for 3 - 5 repetitions and then performed with the other leg being stretched. Both legs can also be extended over the end of the table at the same time to stretch both simultaneously. The lumbar spine needs to be flexed and the pelvis rotated back against the table.

The iliopsoas can also be stretched from the standing position. The subject is steadied with one hand against a wall or other strong support while partially flexing the knee on the other side. The free hand is used to pull up the lower leg by grasping at the ankle while allowing the thigh to move into extension but keeping the lower leg from moving into full flexion. This position is held for 10 - 15 seconds and repeated 3 - 5 times. Repeat procedure on other leg.

## Exercising Hip Flexors

The prime movers in hip flexion include the psoas major, iliacus, rectus femoris, and the pectineus muscles. Other muscles involved in flexion of the hip function as assistant movers include the sartorius, tensor fasciae latae, gluteus medius anterior fibers, gluteus minimus anterior fibers, adductor longus, adductor brevis, adductor magnus upper fibers, and the gracilis muscles.

### *Bent-Leg Raise*

Hip flexor strengthening exercises are performed with the subject supine with hands straight down along body with palms down. One leg is slowly raised while allowing the lower leg to flex about 90°. This provides a lighter load on the iliopsoas muscles and also reduces the contribution of rectus femoris in flexing the thigh. Leg is held at the end position for 2 - 3 seconds and the leg is slowly lowered to the floor. This exercise is repeated for up to 10 - 16 repetitions and eventually performed for 3 - 5 sets. Repeat exercise with other thigh.

### *Straight-Leg Raise*

This exercise is performed with the subject supine with hands straight down along body with palms down. One leg is slowly raised with the knee fully extended. This places a greater load on the iliopsoas muscles but also includes participation of rectus femoris in flexing the thigh. Leg is held at the end position for 2 - 3 seconds and the leg is slowly lowered to the floor. This exercise is repeated for up to 10 - 16 repetitions and eventually performed for 3 - 5 sets. Repeat exercise with other thigh.

At the end of each set, the leg is raised to the full range of hip flexion, with knee extended, while subject pulls lower leg into the extended position to stretch the hamstring muscles.

## Hip Lateral (External) Rotation

Lateral rotation of the hip is mainly accomplished by six small muscles lying deep to the gluteus muscles and includes the piriformis, quadratus femoris, obturator externus and internus, and the gemellus superior and inferior muscles. These are all prime movers in hip lateral rotation as is the gluteus maximus muscle. All lateral hip rotators are considered as a group and typically are exercised in opposition to the medial hip rotators.

### *Stretch-Contraction*

While lying prone with knees flexed 90° and the lower legs pointing straight up with feet in the neutral position, the hip is externally rotated by contracting the lateral rotators. This results in both feet moving inward to approach each other and eventual cross with one foot passing behind the other. Feet are moved to the maximum extent possible and held in the end position for 10-15 seconds stretching the medial rotators. By medially rotating the hip, with knees still flexed 90° the feet are then moved outward toward the floor to the maximum extent possible and held in the end position for 10 - 15 seconds. This causes the lateral rotators to be put into stretch. The exercise is repeated by contracting the lateral rotators and moving the feet toward each other again and then allowing them to cross each other. Reverse the order of what foot passes behind the other on each repetition of the exercise. Repeat for 3 - 5 repetitions for 1 - 3 sets. This exercise is identical to the stretch-contraction of the hip medial rotators.

### *Side-Lying Strength Exercises*

While side-lying with the below leg knee flexed 90° and the above leg pointing straight out along the axis of the body, the below foot is raised off the floor to the maximum extent possible. The foot is held for 2 - 3 seconds and then lowered to rest of the floor surface. This exercises the hip lateral rotators of the below leg against the gravity load of its lower leg. Repeat for up to 8 or more repetitions for 2 - 3 sets. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load. This exercise is usually performed in conjunction with medial rotation exercises of the above leg while still in the same side-lying position. Each set of below leg lateral and above leg medial rotator exercises is alternated, after which the subject then lies on the opposite side to exercise the other set of medial and lateral rotators.

## Hip Medial (Internal) Rotation

The gluteus minimus, anterior fibers are the prime mover for hip medial rotation. The tensor fascia latae, semitendinosus, semimembranosus, gluteus medius anterior fibers, and adductor magnus lower fibers muscles acting as assistant movers in medial rotation of the hip. These muscles are considered as a group when performing medial hip rotation and typically are exercised in opposition to the lateral hip rotators.

### *Stretch-Contraction*

While lying prone with knees flexed 90° and the lower legs pointing straight up with feet in the neutral position, the hip is internally rotated by contracting the medial rotators. This results in both feet moving outward toward the floor to the maximum extent possible. This end position is then held for 10 - 15 seconds. Feet are then moved in the opposite direction to approach each other and eventual cross with one foot passing behind the other to the maximum extent possible and held in the end position for 10 - 15 seconds. By laterally rotating the hip, with knees still flexed 90° the medial hip rotators are put into stretch. The exercise is repeated by contracting the medial rotators and moving the feet again toward the floor. When moving the feet back toward each other to stretch the medial rotators, reverse the order of what foot passes behind the other on each repetition of the exercise. Repeat 3 - 5 times for 1 - 3 sets. This exercise is identical to stretch-contraction of the hip lateral rotators.

***Side-Lying Strength Exercises***

While side-lying with the above leg knee flexed 90° and the below leg pointing straight out along the axis of the body, the above foot is lifted off the floor to the maximum extent possible. This exercises the hip medial rotators of the above leg against the gravity load of its lower leg and held for 2 - 3 seconds. The foot is then lowered to rest of the floor surface. Repeat for up to 8 or more repetitions for 2 - 3 sets. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load. This exercise is usually performed in conjunction with lateral rotation exercises of the below leg while still in the same side-lying position. Each set of below leg lateral and above leg medial rotator exercises is alternated; the subject then lies on the opposite side to exercise the other set of medial and lateral rotators.

## Hip Adduction

The adductors longus, brevis and magnus, along with the pectineus and gracilis muscles are the prime movers in hip adduction with the gluteus maximus lower fibers participating as assistant mover. Hip adduction exercise can easily be performed from the side-lying position with the above leg hip flexed 90° and its lower leg externally rotated so the foot rests on the floor. This forms a bridge-like configuration to provide stability and allow space to lift the below leg off the floor. The below leg remains on the floor aligned with the body axis until being lifted off the floor to the highest extent possible and held for 2 - 3 seconds and then slowly returned to the starting position.

Repeat for up to 8 or more repetitions for 2 - 3 sets. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load. This exercise is usually performed in conjunction with hip abductor exercises of the above leg while still in the same side-lying position. Each set of below leg adductors and above leg abductors exercises is alternated, after which the subject then lies on the opposite side to exercise the same muscles on other leg.

## Hip Abduction

The gluteus medius muscle is the prime mover for hip abduction while the gluteus minimus, gluteus maximus upper fibers, tensor fascia latae, iliopsoas, rectus femoris, and sartorius function as assistant movers. Hip abduction exercise can easily be performed from the side-lying position with the below leg knee flexed 90° to provide stability. The above leg is pointed straight out along the axis of the body, and is raised to the highest extent possible and held for 2 - 3 seconds. The above leg is then lowered to rest on the below leg. Repeat for up to 8 or more repetitions for 2 - 3 sets. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load. This exercise is usually performed in conjunction with hip adductor exercises of the below leg while still in the same side-lying position. Each set of below leg adductors and above leg abductors exercises is alternated, after which the subject then lies on the opposite side to exercise the other set of below leg adductors and above leg abductors.

### Hip Abduction/ Flexion

Hip abduction in slight flexion is performed to specifically address strengthening the tensor fascia latae, although the gluteus medius and gluteus minimus participate as well. Hip abduction exercise can easily be performed from the side-lying position with the below leg knee flexed 90° to provide stability. The hips are rotated backwards around the vertical axis approximately 15° to place the tensor fasciae latae in the best position. The above leg is pointed straight out along the axis of the body, and is raised to the highest extent possible and held for 2 - 3 seconds. The above leg is then lowered to rest on the below leg. Repeat for up to 8 or more repetitions for 2 - 3 sets. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load.

### Hip Abduction/ Extension

Hip abduction in extension is performed to specifically address strengthening the gluteus medius and gluteus minimus muscles although the tensor fascia latae participates as well. Hip abduction exercise can easily be performed from the side-lying position with the below leg knee flexed 90° to provide stability. The hips are rotated forwards around the vertical axis approximately 45° to place the gluteus medius and gluteus minimus muscles in the best position. The above leg is pointed straight out along the axis of the body, and is raised to the highest extent possible and held for 2 - 3 seconds. The above leg is then lowered to rest on the below leg. Repeat for up to 8 or more repetitions for 2 - 3 sets. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load.

### Hip Extension

The gluteus maximus, biceps femoris, semitendinosus, and semimembranosus muscles are the prime movers in hip extension with the gluteus medius posterior fibers, gluteus minimus posterior fibers, and adductor magnus lower fibers participating as assistant movers. Hip extension is performed with the subject in the prone position with arm along side of the body with head usually turned to one side. Hip extension is performed in two parts, first with the knee flexed to allow the gluteus maximus to fully contract and with the leg extended to include the hamstrings.

The subject slowly lifts the thigh of one leg off the floor while the knee is flexed 90° and moves it into the fullest extension possible and held for 2 - 3 seconds. The thigh is then slowly lowered to the floor. Repeat for up to 8 repetitions for 2 - 3 sets. Repeat exercise for the other leg.

The hip extension exercises are then repeated with the leg extended provided strength has improved to the point for the subject to perform to complete the routine. Hip extension will be less since the hamstrings will be involved. As in the previous hip extension exercise, the subject slowly lifts one leg off the floor while the knee is fully extended and moves the leg into the fullest extension possible and held for 2 - 3 seconds. The leg is then slowly lowered to the floor. Repeat for up to 8 repetitions for 2 - 3 sets. Repeat exercise for the other leg.

# 16

# Knee

The knee is the largest synovial joint in the body and combines considerable strength and mobility while providing the stability necessary to lock the knee in the upright position. The two active movements that take place in the knee joint include flexion-extension and axial rotation. Flexion and extension are about an axis that runs through the femoral condyles as the knee functions somewhat as a hinge joint. Spiral action is also possible to permit axial rotation of the lower leg. Axial rotation of the knee around the long axis of the leg only takes place when the knee is flexed, and is normally not possible while the knee is extended. The extensive synovium associated with the knee joint communicates with many bursae important to the knee. Cruciate ligaments within the knee joint have an important functional role and tibial menisci improve congruency between the tibia and femur. A summary of normal limiting factors and other characteristics of the knee joint structures involved in movement of the knee joint are provided in Table 16.1.

Table 16.1. Normal limiting factors and characteristics of joint structures involved in movement of the knee joint

| | Flexion | Extension | Internal Rotation | External Rotation |
|---|---|---|---|---|
| Articulation | Tibiofemoral Patellofemoral | Tibiofemoral Patellofemoral | Tibiofemoral | Tibiofemoral |
| Plane | Sagittal | Sagittal | Horizontal | Horizontal |
| Axis | Frontal | Frontal | Longitudinal | Longitudinal |
| Normal limiting factors | Tension in the rectus femoris; soft tissue apposition of the posterior aspects of the calf and thigh or the heel and buttocks | Tension in parts of both cruciate ligaments, the tibial and fibular collateral ligaments, the posterior aspect of the capsule, and the oblique posterior ligament | Tension in the cruciate ligaments | Tension in the collateral ligaments |
| Normal end-feel | Firm/soft | Firm | Firm | Firm |
| Normal active range of motion | 0 - 135° | 135° - 0° | 30° with 90° knee flexion | 40° with 90° knee flexion |
| Capsular pattern | Knee joint: flexion, extension<br>Tibiofibular joint: pain on joint stress | | | |

### *Tibiofemoral Joint*

The tibiofemoral joint is the largest joint in the body and functions as a modified hinge with three degrees of rotational freedom. The articular surfaces of the femur are convex from side to side and from front to back. The medial surfaces of the tibia are correspondingly concave from side to side and from front to back, while the lateral tibial surface is concave only side to side and is convex from front to back. The articular surfaces of the tibia and femur are not congruent which allows the two bones to move different amounts as controlled by the muscles and ligaments. The tibia and femur approach congruency in full extension, which is the close packed position for this joint.

### *Patellofemoral joint*

Excursion of the patella in its femoral groove is controlled by the quadriceps femoris muscle and tendon during flexion and extension of the knee. The patella is fixed in relationship to the tibia by means of the patellar ligament attached to the tibial tuberosity. As the knee is flexed, the tibia slides back along the surface of the femoral condyles and pull the patella downwards and backwards. During flexion the patella moves on the femoral trochlear surface, extending down to the articular surface of the medial and lateral femoral condyles. As flexion increases the patella moves into the deep groove between the condyles to lie within the intercondylar notch.

### *Capsular Ligaments*

The joint capsule of the knee consists of two tibiofemoral compartments that separately surround the medial femoral and tibial condyles, and the lateral femoral and tibial condyles.

#### Medial joint compartment

The medial compartment is bounded medially by the medial capsular ligament, and laterally by the posterior cruciate ligament. The medial capsular ligament is divided into anterior, middle and posterior thirds.

#### Lateral joint compartment

The lateral compartment is bounded laterally by the lateral capsular ligament, and medially by the anterior cruciate ligament. The lateral capsular ligament is also divided into anterior, middle and posterior thirds.

### *Cruciate Ligaments*

The two cruciate ligaments occupy the central intercondylar space of the knee. They are named because they cross each other and are further identified according to their tibial attachments. The posterior cruciate inserts on the tibia at the posterior aspect of the intercondylar area, while the anterior cruciate inserts more anteriorly in this space.

### *Menisci*

Space between the femur and tibia is partially occupied by a lateral and medial meniscus attached to the tibia by means of the coronary ligaments. The menisci are avascular in their cartilaginous inner two thirds and are partly fibrous and vascular in their outer one third. The menisci are also attached to joint capsule and capsular ligaments. The menisci move forward during knee extension and move backwards on knee flexion. They are compressed between the posterior aspect of the tibia and femur in maximum knee flexion.

## Physiology of the Knee

The principal muscles controlling flexion-extension of the leg include the medial hamstrings consisting of the semitendinosus (PLF) and semimembranosus (PMF) which rotate the tibia medially while flexing the knee, and the vastus medialis (AMF) which extends the knee. The popliteus (PLF) performs the key function of stabilizing the femur while flexing the knee. The rectus femoris, vastus intermedius muscles (ALF) and vastus lateralis (LF), play a major role in extension of the leg.

The biceps femoris, short head (LF) along with the biceps femoris, long head (PLF) serve as the principal lateral rotators of the tibia. The gracilis (MF), sartorius (AMF) and popliteus (PLF) serve as medial rotators of the tibia.

Many of the knee muscles also have a role in movement of the thigh. Summary of muscles moving the knee, along with their nerve roots and muscular distribution assignments are noted in Table 16.2.

Table 16.2. Function, nerve root, and muscular distribution (MD) assignment of prime mover (PM) and assistant/accessory mover (AM) muscles of knee, and moving the hip (H)

| Muscle | MD | Nerve Root | Flexion | Extension | Medial Rotation | Lateral Rotation |
|---|---|---|---|---|---|---|
| Biceps femoris, l. h. | PLF | L5, S1, 2 | PM | H | | PM & H |
| Biceps femoris, s. h. | LF | L5, S1, 2 | PM | | | PM |
| Semitendinosus | PLF | L5, S1, 2 | PM | H | PM & H | |
| Semimembranosus | PMF | L5, S1, 2 | PM | H | PM & H | |
| Sartorius | AMF | L2, 3, (4) | AM & H | | AM | |
| Gracilis | MF | L2, 3, (4) | AM & H | | AM | |
| Popliteus[1] | PLF | L4, 5, S1 | | | PM | |
| Gastrocnemius, lat. h. | PLF | S1, S2 | AM | | | |
| Gastrocnemius, med. h. | PMF | S1, S2 | AM | | | |
| Plantaris | PLF | L4, 5, S1 | AM | | | |
| Tensor fasciae latae | LF | L4, 5, S1 | H | AM | H | |
| Rectus femoris | ALF | L2, 3, 4 | H | PM | | |
| Vastus lateralis | LF | L2, 3, 4 | | PM | | |
| Vastus medialis | AMF | L2, 3, 4 | | PM | | |
| Vastus intermedius | ALF | L2, 3, 4 | | PM | | |

1. Unlocks knee at start of knee flexion; l.h. = long head; s.h. = short head; lat. h. = lateral head; med. h. = medial head

## Disorders of the Knee

Since the knee is the largest synovial joint in the body it is susceptible to traumatic, degenerative, and inflammatory disorders. Pain may be felt in the knee or reflected from hip disorders where it manifests as a dull aching pain in the knee or suprapatellar area. Problems affecting the knee also include pain and weakness in muscles moving the knee which may reflect in particular muscle distributions.

### Muscular Distribution Problems

Specific disorders of the six longitudinal muscular distributions of the knee include the following:

Posterior lateral foot (PLF) distribution:

- Contractions and pain in the back of the knee.

Lateral foot (LF) distribution:

- Stretched muscles and acute cramps in the lateral aspect of the knee.
- Knee is unable to bend or extend.
- Contractions in the back of the knee, with tight and stretched muscles in the anterior aspect of the thigh.

Anterior lateral foot (ALF) distribution:

- Acute cramps and spasms in the rectus femoris muscle.

Anterior medial foot (AMF) distribution:

- Acute cramps and pain in the medial knee with pain in the upper medial fibula.

Medial foot (MF) distribution:

- Pain and acute cramps of the inner thigh and medial aspect of knee.

Posterior medial foot (PMF) distribution:

- Acute cramps and pain in region of knee at major insertion sites of the PMF muscles (posteromedial aspect).

## Pathology Affecting the Knee

Problems affecting the knee cover a wide of symptoms with pain perhaps being the most common complaint. There may be instability of the knee as well as episodes of the joint locking. The knee is susceptible to soft-tissue injuries, inflammatory diseases, and joint lesions. As in all other areas of the musculoskeletal systems of the body, a detailed history is essential.

### *Knee Symptoms*

#### Knee Pain

Pain usually manifests within the knee joint but can also be the result of disease in the more proximal structures. Pain due to hip problems may radiate down the anterior aspect of the thigh and to the knee. Patients with an intervertebral prolapse that results in nerve root pressure at L3 or L4 may also complain of pain in the knee. Problems associate with the knee joint typically cause pain within the knee itself.

Pain associated with the tibiofemoral joint has certain characteristics. Pain is often worse when the patient first stands up and starts to walk, or after walking for some distance. Pain on the affected side is typically worse on load bearing or while going up and down stairs. Pain may be accompanied with or associated with stiffness after being seated for some time.

Pain produced by disorders of the patellofemoral joint often manifests as pain in the retropatellar aspect of the knee. This pain is made worse by going up stairs, riding a bicycle, walking, running, or after sitting for a long period such as riding in a vehicle or airliner, or sitting in a theater.

#### Locking

Locking of the knee refers to a sudden complete block to full extension of the knee while movement in full flexion is possible. Typically there is about a 15° to 45° loss in extension, along with some impairment in rotation. End-feel of a locked knee in extension may be "Muscle Spasm or Springy Block" due to protective muscle spasms. Locking may not be the best term since it conveys the idea of a complete block with no possible motion. Patients may use this term to denote an inability to move the knee due to stiffness or pain.

Patient may have a history of the joint unlocking which may occur spontaneously or after manipulation of the knee. Patient may report the feeling of something slipping or snapping back into place. Locking may result from a loose bony fragment, torn meniscus, torn cruciate ligament, dislocated patella, or avulsed tibial spine.

**Instability**

The giving way, buckling, or feeling of instability of the knee on use is a common complaint. The knee can suddenly give way without any pain or prior indication but with the feeling that one bone has slipped or moved over the other. This may occur when walking or running over uneven ground, or walking down stairs. Instability may be the result of many disorders including arthritis, a loose bony foreign body, or torn meniscus. It can also result from damage to ligaments causing rotatory instability.

***Ligament Injuries***

Integrity of the ligaments is essential to prevent abnormal movements of the knee joint. Sprain of the knee ligaments is perhaps one of the most common of all soft-tissue injuries. The knee is normally stable in extension where the ligaments function as static stabilizers of the knee. While flexed the knee is less stable and able to rotate so abnormal stresses in this situation are more likely to result ligamentous injury.

Ligamentous injuries are classified in terms of various degrees of sprain. A first degree sprain involves the tear or damage of only a few ligament fibers. Assessment and diagnosis is straight forward with the patient's pain being reproduced by stressing the ligament. A valgus directed force is used to evaluate sprains of the medial ligament, whereas a varus directed force is used to evaluate sprains of the lateral ligament. Possible tenderness is usually localized over the site of injury, which may be at the upper or lower attachments or over the joint line. There may be some swelling over the site of injury without synovial effusion, and the knee is stable.

In a second degree sprain synovial effusion may be present and it may be difficult to determine if there is any damage to intra-articular structures. A diagnosis is a little more difficult than with a first degree sprain. The magnitude of pain and disability is greater than a first degree sprain and a slight instability of the knee joint may be present.

A third degree sprain involves a complete rupture of the ligament. In the case of the lateral ligament, it is usually torn from its lower fibular attachment while the medial ligament is torn from its upper femoral attachment. A fragment of bone may also be avulsed in either case, which may be visible on x-ray. Severe pain and disability is instantly obvious and diagnosis may be straight forward if the patient is seen immediately. Later the pain may decrease and the diagnosis may not be obvious since a synovial effusion may not develop since blood and fluid can escape from the synovial cavity through the capsular tear. A ruptured ligament requires surgical intervention.

Rupture of the anterior cruciate ligament may occur but it is more likely for this ligament to be damaged along with other ligaments of the knee. A tear in the anterior cruciate ligament can progressively become worse and finally give way when additional stress is placed on other supporting soft-tissues. Injury to the anterior cruciate ligament is usually the result of hyperextension of the knee. This occurs by a direct blow to the anterior femur when the tibia and foot are fixed to the ground, or by a rotational injury to the knee when changing direction while running. Patient is usually aware that something seemed to give way in the knee and they were not able to continuing their activity. A tense effusion develops within 24 hours and arthroscopy or arthrography may be needed to confirm the diagnosis.

### *Musculotendinous Lesions at Knee*

These lesions involve muscles that articulate the knee or whose insertion or origin is at the knee and their tendons often manifesting with tendinitis.

#### Quadriceps Tendon

A partial tear or complete rupture can occur where the quadriceps tendon inserts into the upper border of the patella. This is a significant injury since the quadriceps is essential in maintaining the stability and function of the knee. The injury can occur during an unexpected slip and fall accident while the quadriceps are held in flexion with maximum contraction. This problem is more likely to be seen in elderly male patients and possibly associated with degenerative tendon changes. If not treated there may be some amount of repair but patient will probably not be able to climb stairs or walk up hills without the knee giving way. Condition is confirmed when patient cannot sustain an isometric contraction of the quadriceps.

#### Quadriceps Injury

The quadriceps can quickly lose strength and bulk following any injury affecting its function or following any knee joint disorder. This is especially true for the vastus medialis which is essential in maintaining balance in the quadriceps group. These late effects can lead to self-perpetuating painful knee conditions which may be confused with intrinsic disorders. It is important that any injuries to the quadriceps be properly treated and rehabilitated through proper exercises.

#### Bicipital Tendinitis

The biceps tendon inserts into the fibular head and is susceptible to tendinitis usually following overuse injury from running and can be associated with bursitis. Tenderness is well localized over the tendon insertion as confirmed by palpation. The patient's pain can be reproduced by isometric resistive flexion of the knee.

#### Popliteal Tendinitis

The popliteal muscle runs from the posterior aspect of the tibia and is attached by its tendon into the lateral surface of the lower end of the femur. Patient's pain is located at the posterolateral corner of the knee joint and may be intense for the first 24 hours after running, or other activities that aggravate the condition, and then often improves. In some cases the tendon may produce a painful click as its slips out of its groove on femur condyle. Patient's pain may be reproduced on contraction of the popliteal muscle which is tested in the supine position with the hip flexed, abducted, and laterally rotated with the knee flexed 90°. Examiner applies resistive flexion with one hand while palpating the tendon just posterior to the lateral collateral ligament. Popliteal tendinitis is further confirmed by tenderness in the posterolateral corner of the knee just above the joint line.

#### Gastrocnemius Tendinitis

This lesion is due to overuse and more often manifests in the origin of the gastrocnemius medial head (PMF) and can also involve inflammation of the underlying bursa. Usually involves distance runners that have changed their program by running up and down hills, or running at a faster rate, and is also common at the beginning of an athletic season. Patient's pain well localized above the joint line and if severe, pain can radiate down lower leg. Pain can be reproduced by fully resisting knee flexion while patient is prone. Tenderness is localized over the head of the gastrocnemius muscle.

**Iliotibial Tract**

Patient presents with pain over the lateral compartment of the knee where the iliotibial tract passes over the lateral femoral epicondyle. Pain is usually brought on by running a few miles along a flat surface or on running downhill, but may occur at the end of a run and then becomes worse. Pain can radiate distally or proximally, and patient may even complain of clicking in the hip. With the patient side lying, the pain may be reproduced by applying compression on the iliotibial band just proximal to the lateral epicondyle while flexing and extending the knee. Patient's knee is initially flexed 90° and then slowly moved into extension and pain is reproduced at about 30° of flexion. Condition is confirmed by palpating about 3 cm proximal to the joint line.

***Bursitis***

There are numerous bursae related to the patella, ligaments, and muscle tendons inserting or originating at the knee. Some of these may be inflamed resulting in bursitis or also related to tendinitis of the affected muscle.

***Tibiofemoral Joint Lesions***

Include damage to the menisci, traumatic synovitis, osteoarthritis of the bone, other bony lesions, and loose body formation.

***Patellofemoral Joint Lesions***

Include patellofemoral pain, recurrent subluxation of the patella, infrapatellar pain, and patellar tendinitis

## Assessment of Knee

Generally, the lumbar spine, hip, and lower leg are evaluated before the knee is examined. The trunk and pelvis function as a supporting pedestal that transmits body forces through to the lower legs, feet, and the ground. The knee is the intermediate joint in this linkage and problems in the lower limbs can produce alterations in the biomechanical loads on the knee joint resulting in pathology. Lumbar spine and hip movements are tested for any limitations in movement or weakness, tightness, or wasting in thigh muscles that result in knee pain.

### Observation

Standing: patient is viewed head-on to note the alignment of the femur on the tibia which in the adult straight leg is normally offset by 6° to 7° of valgus. It is necessary to be able to see the medial aspect of the knees and the medial malleoli to observe upper and lower leg alignment. Patient is instructed to put the limbs to together as close as possible. If the knees touch and the ankles do not, the patient has genu valgum. A distance of 9 to 10 cm between the ankles is considered excessive. If the patient's malleoli touch but the knees do not, the patient has a genu varum. The normal tibiofemoral shaft angle difference as measured on X-ray studies is about 6°

Patella position: at 45° knee flexion the patella articular surface is directly against the anterior femur; when ratio of patellar length to length of patellar ligament (measured from patella inferior pole and the tibial tuberosity with knee extended) is greater than 1 it indicates patella baja, when less than 1 it indicates patella alta

Q Angle: This is the acute angle between a line which bisects the patella and the anterior superior iliac spine (ASIS) and a line which bisects the patella and the tibial tuberosity. This angle represents the frontal plane alignment of the knee extensor mechanism which is normally about 10° when the quadriceps muscles are contracted. A Q angle greater than 20° may indicate excessive lateral forces on the patella

- Deformities
- Swellings
- Muscle wasting

## Active Movements of Knee

The knee joint functions somewhat as a complex hinge joint which primarily moves in flexion and extension. The lower leg can also rotate when the knee is flexed at 90°. The range of active movements in flexion, extension, and axial rotation are measured as follow:

### *Knee Flexion-Extension*

Extension of the knee is usually not measured and recorded since it is the return to the starting position in measuring flexion ROM. However, hyperextension is measured. Restriction in flexion indicates possible tightness in the quadriceps muscles. Of these the rectus femoris can be specifically tested for possible involvement (See Ely Rectus Femoris Test).

Active knee flexion ranges from 0° to 135° with 0° representing a straight leg. This can be measured in the supine or prone position. With the patient supine the knee is simultaneously flexed with the hip where the hip is held perpendicular to the examining table at 90° flexion while the knee is fully flexed. Initially, the patient is supine with the leg fully extended; the fulcrum of a goniometer is placed on the lateral aspect of the knee joint with the center on the axis of knee joint movement in flexion/extension. A towel may be placed under the ankle to make certain the knee is fully extended. The fixed arm of the goniometer is aligned with the femur and pointing at the greater trochanter. The movable arm is aligned with the tibia and pointing at the lateral malleolus. Examiner holds the goniometer on the thigh and lower leg as the patient flexes the thigh 90° while fully flexing the knee.

In the prone position, the patient's feet should be off the end of the examination table. The fulcrum of a goniometer is placed on the lateral aspect of the knee joint with the center on the axis of knee joint movement in flexion/extension. The fixed arm of the goniometer is aligned with the femur and pointing at the greater trochanter. The movable arm is aligned with the tibia and pointing at the lateral malleolus. Examiner holds the goniometer on the thigh and lower leg as the patient fully flexes the knee.

A gravity sensitive goniometer can be employed to measure knee flexion with the patient prone. The gravity sensitive goniometer is strapped on the lower leg just proximal to the ankle with the dial on the lateral aspect of the leg. The device is zeroed out before flexing the knee through the full range flexion that is possible.

### *Knee Hyperextension*

Active knee extension is close to 0° but may be hyperextended up to 15° in some people, especially women. Restrictions in knee extension may be due to tightness in the hamstring muscles (See Hamstring Tightness Test).

Hyperextension is passively measured with patient supine while the examiner lifts the foot with one while stabilizing the thigh by placing the other hand just proximal to the knee. This procedure is then repeated by placing one hand on the tibial condyle and lifting the foot with the other.

### *Ely Test (Rectus Femoris)*

Purpose of this test is to determine possible tightness in the rectus femoris muscle in limiting knee flexion. The rectus femoris flexes the hip and extends the knee (See Table 15.2). Hence, any shortness in the rectus femoris can restrict knee flexion. The knee flexion ROM value obtained in this test is compared with the knee flexion ROM measured with the patient supine and hip flexed to 90° as noted above. The rectus femoris test configuration is the same as used in measuring knee flexion in the prone position as previously described. The difference here is that thigh is stabilized so that it can not flex. Tightness in the rectus femoris will cause the hip to move in the direction of flexion when the knee is fully flexed.

If the rectus femoris is short there will be a limitation in knee flexion when the hip is maintained in a neutral position. When knee flexion is limited while the hip is flexed to 90°, the restriction is possibly due to joint structure abnormalities or shortness in a one-point knee extensor muscles (See Table 16.2).

### *Hamstring Tightness*

The three hamstring muscles (semitendinosus, semimembranosus, and biceps femoris long head) that attach to the ischial tuberosity function to extend the hip. All four hamstrings (including the biceps femoris short head) flex the knee. Shortness or tightness in the hamstrings can result in knee flexion restriction. This can be evaluated using a variation of the test in measuring knee flexion in the supine position. This measurement could actually be performed immediately after measuring full knee flexion as previously described.

The patient is supine with the test leg hip flexed at 90° while held in 0° of hip abduction, adduction, and rotation, with the knee allowed to relax in flexion. The other leg rests on the examination table with the hip in 0° of flexion, extension, abduction, adduction, and rotation, with the knee fully extended. The examiner stabilizes the femur to prevent hip rotation, abduction, and adduction while maintaining the hip in 90° of flexion.

Examiner passively extends the patient's knee to the full range of extension until resistance is felt as tension in the posterior thigh and further extension causes the hip to move toward extension. Normal end-feel is firm due to tension in the hamstrings. The ROM is measured by placing the fulcrum of a goniometer on the lateral aspect of the knee joint with the center on the axis of knee joint movement in flexion/extension. The fixed arm of the goniometer is aligned with the femur and pointing at the greater trochanter. The movable arm is aligned with the fibular head and pointing at the lateral malleolus. The ROM measured from the zero point provides the amount of flexion deficit. Value may range from 15° to 45° with an average of about 30°.

### *Lateral-Medial Tibial Rotation*

The tibia can be laterally rotated on the femur from 30° to 40° and medially rotated 20° to 30°. Axial rotation of the tibia is conducted with the patient seated with knees flexed 90° and lower legs dangling over edge of the examination table. The hip is flexed in the seated position with 0° abduction, adduction, medial rotation, and lateral rotation. Patient actively rotates tibia from the neutral position in 0° of knee rotation, with the foot in the neutral position, while maintaining the tibial axis perpendicular to the floor. Care is taken to make certain that the hip is not rotated or the foot is not dorsiflexed, plantar flexed, everted, or inverted during tibial rotation.

Rotation can be measured with a compass device with a 90° platform strapped to the lower leg proximal to the ankle. Compass needle moves in the horizontal plane and set to zero degrees in the neutral position. Tibia is first rotated either medially or laterally with the angular measurement read at the end of each axial rotation ROM. Tibia is returned to the neutral zero degree position before rotating in the other direction.

Rotation can also be measured with a goniometer placed on the knee with the fulcrum over axis of the tibia with the fixed arm aligned with the femur and the movable arm aligned with the space between the first and second toe with the foot in the neutral position. Movable arm is moved along with tibial rotation to record the full ROM.

## Passive Movements of Knee

The knee is passively moved in flexion, extension, medial rotation, and lateral rotation. Distal, medial, and lateral passive movement of the patella is also performed. Main purpose is to assess possible hypomobility, hypermobility, and end-feel for the movements for the knee. If the above active movement can be performed without restrictions due to pain, the end-feels can be assessed at the end of ROM.

### *Flexion*

Passive flexion of the knee can be accomplished with the patient supine or prone. In the supine position the examiner grasps the knee with one hand and holds the ankle with the other. The patient's knee is gently lifted up to 90° of hip flexion while ankle is moved into full degree of flexion possible. The end-feel is tissue approximation.

In measuring passive flexion with the patient in the prone position, the examiner lifts the lower leg and gently moves it into full flexion. While moving the lower leg into full knee flexion, the examiner looks for possible flexion of the hip that would suggest possible tightness in the rectus femoris muscle.

### *Extension*

Patient is supine while the lifts up on the ankle with one hand while stabilizing the thigh with one hand placed just proximal to the knee joint. The end-feel is tissue stretch. The hip can also be passively moved into 90° of flexion with lower leg moved into extension until the hip starts to extend due to hamstrings. If the flexion deficit is large this may indicate tightness in the hamstrings.

### *Lateral-Medial Tibial Rotation*

Passive rotation of the tibia is conducted with the patient seated with knees flexed 90° and lower legs dangling over edge of the examination table. The hip is flexed in the seated position with 0° abduction, adduction, medial rotation, and lateral rotation. The examiner grasps the lower tibial area with one hand while stabilizing the knee with the other hand. While maintaining the tibia perpendicular to the floor, the examiner rotates the tibia on its axis to the full range of lateral and then medial rotation. The end-feel of tibial rotation on the femur is tissue stretch.

During knee rotation the menisci move with the femur which can be easily felt by palpating the joint line while the flexed knee is laterally (externally) and medially (internally) rotated. On lateral rotation the lateral meniscus moves anteriorly in its tibiofemoral compartment while the medial meniscus moves posteriorly in its compartment. These menisci movements are reversed during medial rotation.

## Resistive Movements of Knee

Resisted isometric movements are tested for knee flexion and extension. If the lower leg and ankle are not going to be evaluated then it is advisable to conduct resisted isometric movement testing in dorsiflexion and plantar flexion.

### *Knee Flexion*

Resisted isometric movement in knee flexion mainly involves the biceps femoris, semitendinosus, and semimembranosus muscles with accessory participation the gastrocnemius, popliteus, gracilis, and sartorius muscles. Patient is supine with the examiner standing to the test side and holding the thigh in about 75° of hip flexion with the knee flexed 90°. The examiner stabilizes the thigh with one hand just proximal to the knee joint while the other hand applies a resistive force to the posterior aspect of the lower leg just above the ankle. Resistive force is applied in the direction of knee extension.

### *Knee Extension*

Resisted isometric movement in knee extension mainly involves the rectus femoris and vastus intermedius, lateralis and medialis muscles. Patient is supine with the examiner standing to the test side. The examiner places on hand under test leg thigh to place a hand on the opposite thigh. This places the patient's thigh into slight flexion and the patient moves the test into knee extension to lift leg off the table. The examiner then uses the other hand placed proximal to the ankle to apply an isometric force in the direction of knee flexion while the patient counteracts the force so the leg is not moved.

### *Ankle Dorsiflexion*

This test mainly assesses the isometric strength of the tibialis anterior muscle. This is described in the following section on the Lower Leg and Ankle and would be conducted while assessing the knee if it was not required to test the lower leg and ankle.

### *Ankle Plantar Flexion*

This test mainly assesses the isometric strength of the gastrocnemius and soleus muscles. This is described in the following section on the Lower Leg and Ankle and would be conducted while assessing the knee if it was not required to test the lower leg and ankle.

## Accessory Movements of the Knee

Accessory joint play movements for the knee are conducted with the patient in the supine position. As is all cases of movement assessment of uninvolved side is tested first to compare with the affected side. The passive movements of the patella consisting of the distal, medial, and lateral glides are also used to evaluate accessory movements of the patella. Accessory movements can also be used in mobilization methods in those cases of hypomobility where the force is applied in an oscillatory manner. Accessory movements for the knee include:

### *Anteroposterior and Posteroanterior Movement of Tibia on Femur*

Both anterior to posterior and posterior to anterior movement of the tibia on the femur are conducted to feel the quality of movement, which is normally tissue stretch. These two tests are similar to anterior and posterior drawer test for ligamentous instability.

With the patient supine and knee flexed 90° and the hip flexed 45° the examiner places the heel of one hand over the tibial tuberosity while stabilizing the limb with the other hand. The examiner may partially set on the patient's foot to stabilize the lower leg. The examiner applies an anteroposterior directed force to move the tibia backward on the femur.

To perform the posteroanterior accessory movement, the examiner then places both hands around the posterior aspect of the tibia. The examiner needs make sure that the hamstrings and gastrocnemius muscles are relaxed. The examiner then moves the tibia forward on the femur.

### *Lateral and Medial Movement of Tibia*

The patient is supine and knee flexed 90° and the hip flexed 45° while the examiner holds the patient's leg between examiner's trunk and arm. For lateral movement of the tibia on the femur, the examiner places one hand on the medial side of the tibia and the other hand on the lateral femur. The tibia is then pushed laterally on the femur and the normal end-feel is tissue stretch. Excessive moment may indicate a torn posterior cruciate ligament.

To test medial translation of the tibia on the femur, the examiner places one hand on the medial aspect of the femur while the other hand is placed on the lateral side of the tibia. The tibia is then pushed medially on the femur and the normal end-feel is tissue stretch. Excessive movement in the medial direction may indicate a torn anterior cruciate ligament.

### *Medial and Lateral Rotation of Tibia*

Medial rotation of the tibia on the femur is produced by the examiner with the patient supine with the knee and hip flexed 90°. In the case of the right leg, the examiner while standing to the side of the patient and facing toward the end of the table holds the patient's heel with the right hand while using the left hand to reach around the top of the foot to grasp the lateral edge of the foot over the fifth metatarsal and little toe. The left hand is used to medially rotate the tibia on the femur while the right hand stabilizes the foot and holds the axis of the tibia parallel to the floor and longitudinally aligned.

Lateral rotation is performed in the same test configuration and conducted immediately following the medial rotation test, but here the hands are reversed. The left hand now supports the heel while the right hand is placed over the anterior foot to grasp the medial edge of the foot over the first metatarsal and big toe. The right hand is then used to laterally rotate the tibia on the femur.

Testing the left leg in medial and lateral tibial rotation requires standing on the other side of the table and reversing the hand placements used for the right leg.

### *Patellar Mobility*

Passive movement of the patella is also conducted to determine its mobility and to compare it with the unaffected side. Passive movements include distal, medial, and lateral glides. These are conducted with the patient supine and supported under the knee to provide some degree of flexion (about 30°). Medial and lateral patellar mobility is greatest at 45° of flexion and should be tested at position as well. Caution is to be applied when assessing the lateral movement especially in patients with a history of patellar dislocation. The end-feel in all three movements is tissue stretch

#### Distal Glide

This passive motion is performed by placing the heel of one hand on the base of the patella with the forearm lying aligned along the thigh. The other hand is placed on top of the first hand and both are used to move the patella in the distal direction.

#### Medial-Lateral Glide

For this movement the palmar aspect of the examiner's thumbs is placed on the lateral border of the patella. The pads of the index fingers are placed on the medial border of the patella. The thumbs are used to apply a medially directed force to move the patella in that direction while the index fingers are used to move the patella laterally in a side-to-side motion. Typically, the patella should move about half of its width medially and laterally. Full or restricted ROM is noted.

### *Posteroanterior Movement of Fibula on Tibia*

Patient is supine with hip flexed 45° and knee flexed 90° while examiner partially sets on patient's foot. Examiner places one hand around the patient's knee to stabilize leg while the other hand grasps the head of the fibula. The fibula is drawn forward on the tibia and the accessory movement and end-feel are tested. The fibula will return to its original position when examiner releases grip. This movement is then repeated several times and compared with the unaffected side.

➔ This test must be performed with care since the common peroneal nerve winds around the fibular head and may be easily compressed resulting in pain. If the superior tibiofibular joint is hypomobile this test can cause discomfort.

## Functional Assessment

There are several functional and numerical rating approaches that have been developed for the knee. Some of these are specialized for specific populations, such as athletes or individual recovering from knee surgery. If the active, passive, and resisted isometric tests are uneventful, the patient can be subjected to a series of functional tests to determine if sequential activities produce pain or other symptoms. These activities can be given a numerical score based on the time required to complete each test. A sequence of candidate functional activities can be selected consistent with the patient's normal ability and interest, such as being work related, recreational, or sports that could include:

- Walking
- Ascending and descending stairs (can include both normal pace and running)
- Squatting (observe for symmetrical flexion of both knees)
- Running straight ahead (possibly stopping on command)
- Running and twisting (over a figure 8 course about 4 by 20 meters)
- Vertical jump
- Jumping and then going into a full squat

- Hopping, twists, hard cuts, pivots

## Special Tests

There numerous special tests for the knee to knee instabilities due to damage to the main ligaments and other problems, as well as those that detect possible menisci damage

### *Anterior Lachman's Test*

Patient is supine with the test knee flexed 20° to 30° while the examiner stands to next to the examination table with one hand on the lateral aspect of the distal thigh immediately proximal to the patella. The other hand is placed on the posteromedial aspect of the proximal tibia immediately distal to the tibial tuberosity.

An alternative test position involves the examiner placing their flexed knee under the patient's test knee, with one hand on the anterior aspect of the distal thigh with the other hand on the medial aspect of the proximal tibia just distal to the tibial tuberosity.

Starting from a neutral anterior-posterior position an anterior directed force is applied to the tibia while the other hand stabilizes the femur. The same approach applies to the alternate test position. Excessive anterior movement of the tibia on the femur (as compared to the unaffected side) from the neutral position with a diminished or absent endpoint indicates a possible partial or complete rupture of the anterior cruciate ligament.

Increased proximal tibial translation by itself is not totally indicative of anterior cruciate ligament pathology. A torn posterior cruciate ligament can allow the proximal tibia to translate posteriorly thereby allowing increased anterior translation of the tibia on the femur when the anterior Lachman's test is performed. A meniscal tear involving the posterior horn may also contribute to anterior translation. It is essential to determine the presence and quality of the endpoint before the integrity of the anterior cruciate ligament can be accurately assessed. Some individuals may use their dominant hand for translation assessment, but it is important to stabilize the tibia on the medial side for this test to prevent increased lateral rotation that can contribute to increased anterior translation.

### *Anterior Drawer Test*

The patient is supine with the hip flexed 45° and knee flexed 90° and the foot is in the neutral position. The examiner partially sets on the patient's foot while grasping the patient's tibia with both hands behind the proximal tibia with thumbs of the tibial plateau. An anterior force is then applied to the tibia while assessing anterior displacement of the tibia on the femur. Increased anterior tibial translation on the femur as compared to the unaffected side possible indicates a partial of complete tear of the anterior cruciate ligament.

Assessment of the endpoint during this test is less reliable than the anterior Lachman's test and hence there is a greater chance for false negative findings, secondary to the increased possibility for hamstring guarding.

### *Pivot Shift Test*

Patient is supine with the leg fully extended while the examiner stands with one hand on the anterolateral tibiofemoral joint and thumb on the posterior fibular head. The other hand grasps the patient's heel and midfoot.

An alternate position involves placing the patient's foot between the examiner's arm and body while the other hand remains on the anterolateral tibiofemoral joint and thumb on the posterior fibular head.

Slowly flex the knee while internally rotating the tibia with the hand on the foot and apply a valgus force with the hand on the tibiofemoral joint. This same procedure also applies to the alternate test position, except a slight axial load first applied to the case starting with the extended knee.

A palpable pivot shift or "clunk" occurring between 20° and 30° of flexion indicates a possible anterolateral rotary instability that is secondary to tearing the posterolateral capsule and anterior cruciate ligament.

It is essential to apply the axial load in the test configuration that starts with the leg fully extended before flexing the knee in order to accentuate the shift or clunk that facilitates detecting the trace pivot shift.

- ➔ This test may create apprehension and anxiety since it often reproduces the injury mechanisms, which can contribute to false negative findings.
- ➔ This test may be the most sensitive in detecting anterior tibiofemoral instability; however, this test is difficult to perform and potential patient apprehension and anxiety make it difficult to allow the practitioner to gain experience as compared to other tests.

### *Posterior Drawer Test*

The patient is supine with the hip flexed 45° and knee flexed 90° and the foot is in the neutral position. The examiner partially sets on the patient's foot while grasping the patient's tibia with both hands behind the proximal tibia with thumbs of the tibial plateau. A posterior force is then applied to the tibia while assessing posterior displacement of the tibia on the femur. Increased posterior tibial translation on the femur as compared to the unaffected side possible indicates a partial of complete tear of the posterior cruciate ligament.

It is essential that the quadriceps and hamstring muscles are completely relaxed during this test. In addition, the examiner should carefully assess and posterior step-off of the tibia on the femur while applying the posteriorly directed force.

### *Posterior Lachman's Test*

Patient is supine with the test knee flexed 20° to 30° while the examiner stands to next to the examination table with one hand on the lateral aspect of the distal thigh immediately proximal to the patella. The other hand is placed on the medial aspect of the proximal tibia immediately distal to the tibial tuberosity. Starting from a neutral anterior-posterior position a posterior directed force is applied to the tibia while the other hand stabilizes the femur. Excessive posterior movement of the tibia on the femur (as compared to the unaffected side) from the neutral position with a diminished or absent endpoint indicates a possible partial or complete rupture of the posterior cruciate ligament.

If this test is not conducted from the neutral position the test knee may appear to present with decreased posterior tibial translation when compared to the unaffected knee. This apparent discrepancy is most likely due to posterior cruciate ligament pathology allowing the proximal tibia to posteriorly translate, thereby producing a false negative result. It is essential to determine the presence and quality of the endpoint before the integrity of the posterior cruciate ligament can be accurately assessed.

***Posterior Sag Test (Gravity Drawer Test)***

Patient is supine with the affected hip flexed 45° and knee flexed 90° and the foot is in the neutral position. Examiner notes the position of the tibia relative to the femur in the sagittal plane. The patient is then instructed to actively contract the quadriceps muscle group in an attempt to extend the knee while retaining the hip flexion. The foot of the test leg is to remain fixated on the table during the attempted knee extension.

Posterior displacement of the tibia on the femur while the patient's quadriceps remain silent shows a possible posterior instability. This situation may indicate possible injury to any of the following structures: posterior cruciate ligament, arcuate ligament complex, and posterior oblique ligament.

It is essential for the examiner to identify a neutral tibiofemoral joint position since this test can be misinterpreted as an anterior instability when one observes an anterior translation of the tibia on the femur

***Lateral Rotation-Recurvatum Test***

Patient is supine while the examiner stands at the foot end of the examination table and grasps a big toe with each hand. Examiner then lifts both relaxed legs off the table by pulling up on the big toes. An increase in tibial lateral rotation and hyperextension as compared to the unaffected knee is indicative of posterolateral rotary stability secondarily due to damage mainly of the posterior cruciate ligament, lateral collateral ligament, posterolateral capsule, and arcuate complex.

It is essential for the examiner to be aware that the test results are possibly due to the patient's normal joint extensibility, and hence a positive finding may be a false positive.

***Valgus Stress Test (0° - 30°)***

Examiner holds the patient's fully extended leg slightly up off the table with one hand grasping the lower leg proximal to the ankle. With the ankle stabilized with the first hand, the other hand is placed on the lateral aspect of knee to apply a valgus directed force. This test is repeated with the knee in 20° to 30° of flexion.

An increase in medial knee pain and/or valgus movement with an absence or diminished endpoint indicates possible damage mainly to the medial collateral ligament, posterior cruciate ligament, and posteromedial capsule when found in full knee extension. When these symptoms are found in 20° to 30° of flexion it indicates possible involvement of the medial collateral ligament.

- ➔ Examiner must ensure that the femur is not allowed to internal or externally rotate during this test since it may give a false impression of increased valgus movement. This can be prevented by having the patient lying with their lower legs off the end of the table which stabilizes the thigh on the table.

***Varus Stress Test (0° - 30°)***

Examiner holds the patient's fully extended leg slightly up off the table with one hand grasping the lower leg proximal to the ankle. With the ankle stabilized with the first hand, the other hand is placed on the medial aspect of knee to apply a varus directed force. This test is repeated with the knee in 20° to 30° of flexion.

An increase in lateral knee pain and/or varus movement with an absence or diminished endpoint indicates possible damage mainly to the lateral collateral ligament, posterior cruciate ligament, and arcuate complex when found in full knee extension. When these symptoms are found in 20° to 30° of flexion it indicates possible involvement of the lateral collateral ligament.

➔ Examiner must ensure that the femur is not allowed to internal or externally rotate during this test since it may give a false impression of increased varus movement. This can be prevented by having the patient lying with their lower legs off the end of the table which stabilizes the thigh on the table.

***McMurray Test***

This test is used to evaluate the knee for meniscal injury. The patient is supine with the hip flexed 45° and knee flexed 90°. The examiner stabilizes the leg by one hand grasping the patient's ankle or distal leg while the other hand grasps the knee with the fingers able to palpate the medial and lateral joint lines.

For medial meniscus assessment the medial joint line is carefully palpated for pain and tenderness with knee flexed. The tibia is then externally rotated (toes pointing outward) at which time a valgus force is applied to the medial aspect of the lower leg. A "click" felt along the medial joint line may be indicative of a medial meniscus tear.

For lateral meniscus assessment the lateral joint line is carefully palpated for pain and tenderness with knee flexed. The tibia is then internally rotated (toes pointing inward) at which time a varus force is applied to the lateral aspect of the lower leg. A "click" felt along the lateral joint line may be indicative of a lateral meniscus tear.

A patellar "click" or "pop" should not be confused with meniscus pathology. If there is excessive joint swelling that limits ROM, or a flap tear of the meniscus, it may be difficult to accurately perform this test. Also, the examiner needs to be aware that palpation along the joint line can result in significant pain especially if there is a meniscus tear associated with collateral ligament injury.

***Apley Compression-Distraction Tests***

This test is used to evaluate the knee for meniscal injury. Patient is prone with both legs initially straight on the table and the examiner standing to the affected side. Examiner stabilizes the thigh by placing one hand just proximal to the knee while the other hand lifts knee into 90° flexion with the other hand placed on the patient's heel and plantar region over the longitudinal axis of the tibia.

For the longitudinal cephalad movement direction the tibia is medially and laterally rotated while the examiner pushes straight down on the foot toward the knee to compress the tibia on the femur. Any restriction in movement and/or pain and clicking, is indicative of either a medial or lateral meniscus tear, depending on the location of the symptoms.

This test may be repeated with the patient in the same position by applying a longitudinal distraction force along the axis of the tibia. In this case the examiner stabilizes the thigh by placing one hand just proximal to the knee joint while the other hand grasps the distal aspect of the lower leg. The examiner then pulls longitudinal upward to distract the tibia from the femur while rotating the tibia medially and laterally. If pain and/or clicking found on the compression test is followed by an absence of these symptoms on distraction of the tibia, this is most likely indicates meniscal pathology. On the other hand, an increase and/or change in location of the pain on tibial distraction is more indicative of ligamentous pathology.

***Steinman's Displacement Test***

Patient is supine with both legs in full extension while examiner stands to the side with one hand under the affected knee while the other hand grasps the ankle and heel. The leg is lifted into various degrees of knee flexion. The examiner then dynamically moves the tibia into internal rotation and external rotation while using the other hand to palpate along the lateral and medial knee joint line. If the patient complaints of pain during the tibial rotation or lacks full flexion, this may be indicative of a meniscal tear.

It is essential to maintain relaxation of the quadriceps and hamstrings muscles during this test. If the patient has restricted flexion the examiner may choose to conduct passive internal and external tibial rotation with the knee in maximum possibly flexion to determine if pain and other symptoms are reproduced.

***Medial-Lateral Grind***

Patient is supine with the examiner standing to the affected side with one hand holding the patient's foot while the other hand is placed over the joint line of the knee. Examiner then fully flexes the patient's hip and knee after which the tibia is moved in a circular clockwise and counterclockwise manner. Any pain, grinding, or clicking is indicates a possible meniscal tear.

A varus and valgus stress may also be applied simultaneously by the hand over the knee joint line as the knee is passively extended.

## Neurological Evaluation

***Myotomes (strength graded 0 - 5)***

In assessment of problems associated with the hip, knee, and lower extremities, all the myotomes of the lower body are routinely performed. If any of these tests indicate possible upper motor neuron involvement, all the myotomes of the upper body are performed as well. Key myotomes associate with the knee include:

**L3: Quadriceps Femoris**

The L3 myotome is evaluated by performing a resistive isometric test involving knee extension. See preceding discussion.

**S1 - S2: Gastrocnemius-Soleus**

The S1 - S2 myotome is evaluated by performing a resistive isometric test involving foot plantar flexion. See preceding discussion.

***Key Reflexes***

After completion of movement, muscular, and ligamentous testing of the knee it is important to check relevant reflexes, especially if myotome testing and other signs indicate possible neurological involvement. Reflexes are first tested on the unaffected side for comparison to the affected side. Two key reflexes at the knee include the patellar and medial hamstring tests. Reflexes are graded from 0 to 4 with 0 being absent, 2 normal and 4 indicating clonus or very brisk.

### Patellar Reflex

This is the well know knee jerk reflex which provides information on motor control function served by the L3 - L4 spinal cord root level. This test is typically performed with the patient sitting on the examination table with the leg dangling over the edge of the table. The examiner strikes the patient's patellar ligament between the tibial tuberosity and the patella. This reflex test can also be performed with the subject seated in a chair with the test leg crossed over the opposite knee. In addition, it can be tested with the patient supine. In this case the examiner places one hand under the test leg thigh to grasp the thigh of the opposite leg. This causes the hip and knee to be slightly flexed. Examiner then strikes the patellar ligament midway between the tibial tuberosity and the patella.

### Medial Hamstring Reflex

The medial hamstring reflex provides information on motor control function served by the L5 - S1 spinal cord root level. The patient is prone and the examiner lifts the lower leg and cradles it with the arm while placing the examiner's thumb on the medial hamstring tendon. The other hand is used to strike the reflex hammer onto the examiner thumb held on the medial hamstring tendon.

## Diagnostic Imaging

### *Plain Film Radiography*

**Anteroposterior View:** This view is used to examine the knee for possible fractures, diminished joint space, osteoarthritis, epiphyseal damage, lipping, osteophytes, loose bodies, abnormal calcification, and ossification.

**Lateral View:** Delineates the same structures as observed in the anteroposterior view.

**Intercondylar Notch (Tunnel View X-ray):** This view is taken with the patient prone and knees flexed from 45° to 90° to show the tibia and intercondylar attachments of the cruciate ligaments, as well as the intercondylar notch.

Axial (Skyline) View: This involves a 30° tangential view mainly when patellar problems are suspected such as patellar subluxation and dysplasia.

### *Magnetic Resonance Imaging (MRI)*

Magnetic resonance images are useful in diagnosing lesions of the menisci and cruciate ligaments, but should be used only to confirm clinical findings.

### *Computed Tomography*

Computed tomography (CT) scans to view soft tissue and bony tissue of the knee.

### *Arthrography*

Arthrograms of the knee have been commonly used to diagnose menisci tears, but their use is being replaced by arthroscopy.

### *Arthroscopy*

Use of the arthroscope has increased in diagnosis of knee lesions, and to repair them surgically.

# Management of Knee Disorders

Management of knee problems relies on mobilization techniques to address hypomobility and restricted movements. Needling therapy including electroneedling (EN) is also essential as is remedial exercises for rehabilitation.

## Mobilization

Knee mobilization involves the use of the accessory movements as previously described.

### *Accessory Movements*

Accessory movements involve application of small amplitude forces to address hypomobility of the knee joint including the following:

- Anteroposterior and posteroanterior movement of tibia on femur
- Lateral and medial movement of tibia
- Medial and lateral rotation of tibia
- Patellar mobility
- Posteroanterior movement of fibula on tibia

### *Passive Movements*

Knee passive movements are used to passively move the knee joint in its major directions of flexion, extension, lateral tibial rotation, and medial tibial rotation. Oscillations may be move the knee up to the point of pain and restriction, or at the end of motion range to increase ROM. Active movements in these same directions can be employed to actively move the knee repetitively into the area of pain and restriction to regain full movement.

## Needling Therapy Knee Problems

Candidate local and adjacent, proximal and distal nodes considered in treatment of knee joint pain and dysfunction, with respect to the muscular distributions are summarized in Table 16.3.

- Several of the candidate local and adjacent nodes are selected to cover the affected area of the knee, such as the medial, lateral, anterior, and posterior aspect depending where the main problem is situated
- Proximal nodes are selected for the related lateral muscular distribution, however, if problems lie within the PMF muscles, the node Shenshu (PLF 23) may be considered
- The same concept applies to the distal nodes which are selected for the PLF, ALF, and LF related muscle distributions on the leg, if the knee problem mainly affects the PMF distribution then the node Zhubin (PMF 9) can be considered.

Table 16.3. Regional, proximal and distal nodes for knee pain and dysfunction

| Knee Joint Pain or Disorder | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Dubi (ALF 35)<br>Xiyan (Extra)<br>Heding (Extra)<br>Xiyangguan (LF 33)<br>Yanglingquan (LF 34)<br>Xuehai (AMF 10)<br>Yinlingquan (AMF 9) | PLF | Shenshu (PLF 23) | Shugu (PLF 65) |
| | | ALF | Weishu (PLF 21) | Xiangu (ALF 43) |
| | | LF | Danshu (PLF 19) | Zulinqi (LF 41) |

### *Candidate Electroneedling (EN) for Knee Pain and Other Problems*

In uncomplicated cases affecting the knee one or two circuits are employed that basically distribute over the knee joint. In the situation where the problem affects to whole knee joint, both of the circuits listed below can be used.

**Frequency:** 2 Hz

**Mode:** Continuous

**Duration:** 20-30 minutes

**Lead Placement:**

- Xiyangguan (LF 33) + lead to Yanglingquan (LF 34) – lead
- Xuehai (AMF 10) + lead to Yinlingquan (AMF 9) – lead

In complicated cases or those that reflect in PLF and PMF aspect of the knee the following two additional circuits could be considered using the same frequency and mode as noted above:

- Fuxi (PLF 38) + lead to Feiyang (PLF 58) – lead
- Yingu (PMF 10) + lead to Zhubin (PMF 9) – lead

## Remedial Exercises for Muscle Moving the Knee Joint

The main function of the knee is to flex and extend the lower leg which involves several muscles that muscles that move the hip joint as well such as the rectus femoris, tensor fasciae latae, bicep femoris, semitendinosus, semimembranosus, sartorius, and gracilis muscles which are also responsible for hip motions (See Table 16.2). The knee can also be internally and externally rotated when it is flexed 90°.

### Hamstring Stretches

The hamstrings play a major role in flexing the knee and are often affected by tightness. There are several approaches to stretching these muscles in the supine, floor seated, and standing positions.

#### *Supine*

This procedure stretches the hamstrings of one leg at a time. While lying supine and keeping one leg straight, it is lifted off the floor to the maximum extent of hip flexion. The subject then grasps the knee, while keeping the leg straight with back flat on the floor, and gently pulls the leg into slightly further extension and holds that position for 10

- 15 seconds. Do not pull leg into region of pain. Leg is then slowly lowered, while still maintaining the straight leg configuration and the stretch is repeated. Repeat this procedure with other leg.

### *Floor Seated*

This procedure isolates the stretching of the hamstrings of one leg at a time. While seated on the floor both legs are abducted to form approximately a 45 - 60° angle between the two, the knee of one leg is flexed in order to rest the bottom of one foot on the inner thigh surface of the leg to be stretched. A slight downward pressure can be exerted on the knee of the flexed leg by the hand of the same side to hold the knee down to the floor. The upper body is then flexed while the other hand is slowly extended out in an attempt to touch the toes of the leg being stretched. The end position is held for up to 10 - 15 seconds after which the subject returns to the start position to repeat the process 3 - 5 times. The other leg is then straightened and the stretched in the same manner with the other leg flexed to place its foot on the inner surface of the opposite thigh. Hamstrings of the un-stretched leg are then stretched in the same manner.

### *Hamstring Stretch with Abdominal Oblique Movement Exercise*

This procedure isolates the stretching of the hamstrings of one leg at a time. While seated on the floor both legs are abducted to form approximately a 45 - 60° angle between the two. The subject then rotates and flexes the upper body while stretching out one hand to touch the toes of the opposite foot. The right hand touches the left foot alternated by the left hand touching the right foot. Each stretch is held for up to 10 - 15 seconds. Routine is repeated for up to 8 cycles for each set and performed for 3 - 5 sets.

The abdominal oblique muscles should be contracted while rotating the body during this routine. Muscles of the arm can also be contracted to obtain exercise benefit as the arm is being drawn back after touching the toes. The wrist should be supinated (turning the wrist upward) immediately after touching the toes to obtain optimum benefit from contracting the arm muscles during the retraction movement.

### *Standing*

This procedure stretches the hamstrings of both legs at the same time. This is the simplest means of stretching the hamstrings and is often best performed after any of the other hamstring stretches. It is performed from the erect standing position by slowly bending forward to flex the body and extend the hands down the front of legs, moving them lower toward an effort to touch one's toes. The end position is held for up to 10 - 15 seconds, after which the subject slowly moves back to the erect standing position. Exercise can be repeated 3 - 5 times. This exercise is similar to the standing back flexion stretch.

## Knee Flexion

The biceps femoris, semitendinosus, and semimembranosus muscles are the prime movers for knee flexion while the sartorius, gracilis, gastrocnemius, and plantaris muscles function as assistant movers. Knee flexion can be performed in prone or the standing position. Advantage of the standing position is the knee can be flexed through its full range of flexion.

In the prone position, the subject is lying with both arms to the side and both legs extended straight aligned with the body axis. The lower leg of one leg is slowly lifted off the floor and flexed to the fullest extent possible up to 90° and then slowly lowered to the floor. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other leg. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load.

Knee flexion in the standing position involves placing one hand on the wall or other structure to steady the body. The lower leg on the same side that is being supported by the hand is slowly lifted off the floor and moved into flexion to the greatest extent possible and held for 2 - 3 seconds. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other leg. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load.

## Quadriceps Stretch

The quadriceps (rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius) are the prime movers that extend the knee and are often develop or experience tightness. This muscle group can be stretched while side lying or standing. In the side lying position, the knee of the above leg is flexed while the hand of the same side is used to grasp the foot. The foot is pulled up extending the leg and stretching the quadriceps for 10 - 15 seconds and then releasing the stretch. This routine is repeated for 3 - 5 cycles for each set and performed for 3 - 5 sets.

In stretching the quadriceps the subject is steadied with one hand against a wall or other strong support while partially flexing the knee on the other side. The free hand is used to grasp and to pull up the moving the thigh into extension and stretching the quadriceps. This position is held for 10 - 15 seconds and repeated 3 - 5 times and performed for 3 - 5 sets. Repeat procedure on other leg.

## Knee Extension

The rectus femoris and vastus intermedius, lateralis and medialis muscles are the prime movers for knee extension, with the tensor fasciae latae having an assistant mover role. Knee extension can be exercised in the seated and supine positions.

### *Seated Knee Extension*

The subject is seated at the end or side of treatment table with lower legs hanging down toward the floor. One knee is slowly extended to the maximum extent possible and held for 2 - 3. The lower leg is then lowered to the start position. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other leg. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load.

### *Supine Knee Extension*

Subject is supine with one thigh flexed to 90° perpendicular to the floor. One knee is slowly and fully extended to the maximum extent possible and held for 2 - 3. The lower leg is then lowered to the start position. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other leg. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be employed to increase the resistive load.

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# 17

# Lower Leg, Ankle, and Foot

The tibia and fibula are joined proximately at the superior tibiofibular joint and distally at the inferior tibiofibular joint. These two joints form a functional structure that is essential to movement of the ankle joint. The movement of the ankle joint permits extension (plantar flexion) or flexion (dorsiflexion) of the foot while the subtalar joint provides for eversion and inversion of the foot. Normal limiting factors to these movements and other characteristics of ankle and subtalar joint structures are summarized in Table 17.1.

Table 17.1. Normal limiting factors and characteristics of joint structures involved in movement of the ankle joint.

| | Plantar Flexion | Dorsiflexion | Inversion | Eversion |
|---|---|---|---|---|
| Articulation | Talocrural | Talocrural | Subtalar | Subtalar |
| Plane | Oblique sagittal | Oblique sagittal | Oblique frontal | Oblique frontal |
| Axis | Oblique frontal | Oblique frontal | Oblique sagittal | Oblique sagittal |
| Normal limiting factors | Tension in the anterior joint capsule, anterior portion of the deltoid and anterior talofibular ligaments, and the ankle dorsiflexors; contact between the talus and the tibia | Tension in posterior joint capsule, the deltoid, calcaneofibular and posterior talofibular ligaments, and the ankle plantar flexors; contact between the talus and the tibia | Tension in the lateral collateral ligament, ankle evertors | Contact between the talus and calcaneous; tension in the medial joint capsule and medial collateral ligaments |
| Normal end-feel | Firm/hard | Firm/hard | Firm/hard | Hard/firm |
| Normal active range of motion | 0 - 50° | 0 - 20° | 0 - 5° (forefoot at 0 - 35°) | 0 - 5° (forefoot at 0 - 20°) |
| Capsular pattern | Knee joint: flexion, extension<br>Tibiofibular joint: pain on joint stress | | | |

Principal joints of the foot and toes provide for extension, flexion, abduction and adduction of the toes. The subtalar joint also permits inversion and eversion of the foot. The normal limiting factors involved in movement of the toes, and other characteristics of joint structures of the foot and toes are summarized in Table 17.2.

## Physiology of Lower Leg, Ankle, and Foot

### Muscles Moving the Foot

The principal muscles of the lower leg are involved in moving the foot in either extension (plantar flexion) or flexion (dorsiflexion). These motions are essential for bipedal locomotion and for climbing up or down inclines or stairs. Several of these muscles also act to either evert or invert the foot and some act on the toes as well. The main muscles in plantar flexion include the soleus, lateral (PLF) and medial (PMF) parts, gastrocnemius, lateral (PLF) and medial (PMF) heads, tibialis posterior (AMF), and the flexor digitorum longus (AMF). The plantaris (PLF) also participates in plantar flexion and in addition to the gastrocnemius, can assist in flexion of the knee as well. Principal muscles providing dorsiflexion include the tibialis anterior (ALF), extensor digitorum longus (ALF) and the peroneus tertius (LF). These latter two muscles along with the peroneus longus (PLF) and brevis (PLF) are foot evertors. Muscle that function as foot invertors include the flexor hallucis longus (AMF), extensor hallucis longus (MF) and the extensor digitorum longus (ALF) (See Table 17.3.).

Table 17.2. Normal limiting factors and characteristics of joint structures involved in movement of the toes.

| | Flexion | Extension | Abduction | Adduction |
|---|---|---|---|---|
| Articulation | Metatarsophalangeal (MTP), Proximal interphalangeal (PIP), Distal interphalangeal (DIP) (second to fifth toes) | MTP | MTP | MTP |
| Plane | Sagittal | Sagittal | Horizontal | Horizontal |
| Axis | Frontal | Frontal | Vertical | Vertical |
| Normal limiting factors | MTP: tension in the dorsal joint capsule, extensor muscles, collateral ligaments<br>PIP: soft tissue apposition between the plantar aspects of the phalanges; tension in the dorsal joint capsule, collateral ligaments<br>DIP: tension in the dorsal joint capsule, collateral ligaments | MTP: tension in the plantar joint capsule, flexor muscles, plantar ligament PIP: tension in the plantar joint capsule, plantar ligament DIP: tension in the plantar joint capsule, plantar ligament | Tension in the medial joint capsule, collateral ligaments, adductor muscles, fascia and skin between the web spaces | Contact between the toes |
| Normal end-feel | MTP firm<br>PIP soft/ firm<br>DIP firm | MTP firm<br>PIP firm<br>DIP firm | Firm | |
| Normal active range of motion | Big toe:<br>MTP: 0 - 45°<br>IP: 0 - 95°<br>Toes 2-5:<br>MTP: 0 - 40°<br>PIP: 0 - 35°<br>DIP: 0 - 60° | Big toe:<br>MTP: 0 - 70°<br>IP: 0°<br>Toes 2-5:<br>MTP: 0 - 40°<br>PIP: 0°<br>DIP: 0° | | |
| Capsular pattern | First metatarsophalangeal joint: extension, flexion<br>Second to fifth metatarsophalangeal joints: tend to fix in extension with the interphalangeal joints in flexion | | | |

## Fascial Compartments of Lower Leg

The bones and muscles of the lower leg are invested by a layer of deep fascia in addition to the opposed interosseous surfaces of the tibia and fibula being joined by the interosseous membrane. This arrangement encloses the lower leg muscles within four fascial compartments, three of which pass to the tibia and fibula. These are known as the anterior, medial, lateral and posterior compartments. Certain pathologies of the lower leg are viewed in terms of these compartments.

## Muscles Moving Toes

The foot provides a strong, but slightly flexible, structure to distribute the weight of the body on the surface of the ground. The joints and muscles of the toes permit an efficient and smooth transfer of weight from the heel to the toes during the process of walking. The foot can accommodate uneven surfaces to some degree as well as slanted surfaces. Muscle acting on the toes results in movements of extension, flexion, abduction and adduction. The specific function of the muscles moving the toes and their nerve roots and traditional distribution assignment are summarized in Table 17.4.

Table 17.3. Function, nerve root, and muscular distribution (MD) assignment of primary mover (PM) and accessory/assistant mover (AM) extrinsic muscles of the ankle, foot, and toes

| Extrinsic Muscles | MD | Nerve Root | Ankle and Foot | | | | Toes | |
|---|---|---|---|---|---|---|---|---|
| | | | Plantar Flexion | Dorsi-flexion | Inver-sion | Ever-sion | Flexion | Exten-sion |
| Soleus, lateral part | PLF | L5, S1, 2 | PM | | | | | |
| Soleus, medial part | PMF | L5, S1, 2 | PM | | | | | |
| Gastrocnemius, l. h. | PLF | S1, 2 | PM | K | | | | |
| Gastrocnemius, m. h. | PMF | S1, 2 | PM | K | | | | |
| Plantaris | PLF | L4, 5, S1 | AM | K | | | | |
| Tibialis posterior | AMF | L5, S1 | AM | | PM | | | |
| Tibialis anterior | ALF | L4, 5, S1 | | PM | PM | | | |
| Peroneus tertius | ALF | L4, 5, S1 | | PM | | PM | | |
| Extensor digitorum longus | ALF | L4, 5, S1 | | PM | | PM | | PM1 |
| Extensor hallucis longus | MF | L4, 5, S1 | | AM | AM | | | PM2 |
| Peroneus longus | LF | L4, 5, S1 | AM | | | PM | | |
| Peroneus brevis | LF | L4, 5, S1 | AM | | | PM | | |
| Flexor digitorum longus | AMF | L4, 5, S1 | AM | | AM | | PM1 | |
| Flexor hallucis longus | AMF | L5, S1, 2 | AM | | AM | | PM2 | |

1. 2nd through 5th toes only; 2. Great toe only; K: participates in knee flexion

The primary extensors of the toes include the extensor digitorum longus (ALF) and brevis (LF), extensor hallucis longus (MF) and brevis (ALF) muscles. The main flexors of the toes include the flexor digitorum longus (AMF) and brevis (PMF), flexor hallucis longus (AMF) and brevis (PMF), and the flexor digiti minimi brevis (PLF) muscles. Muscles abducting and adducting the great toe respectively include the abductor hallucis (AMF) and adductor hallucis (PMF) muscles. Abductors and adductors of the other toes include the abductor digiti minimi (PLF), 1st - 4th dorsal interossei (MF, ALF, LF) and the plantar interossei (PMF) muscles. Muscles acting on the toes also participate in eversion and inversion of the foot. The extensor digitorum longus assists in eversion while the flexor digitorum longus, flexor hallucis longus and extensor hallucis longus all assists in foot inversion.

## Disorders of the Leg, Ankle, and Foot

### Muscular Distribution Problems

Specific disorders of the six longitudinal muscular distributions of the lower leg, ankle, and toes include the following:

Anterior medial foot (AMF) distribution:

- Pain in the big toe and medial ankle

Medial foot (MF) distribution:

- Pain in the medial aspect of the fibula
- Pain in the big toe and the anterior region of the medial malleolus

Anterior lateral foot (ALF) distribution:

- Acute cramps and spasms in the middle toe and along the tibia
- Foot tremors

Lateral foot (LF) distribution:

- Acute cramps and spasms in the fourth and fifth toes
- Pain along anterior aspect of lateral ankle and anterior lateral region of lower leg

Posterior lateral foot (PLF) distribution:

- Pain and swelling in the small toe and the region of the lateral heel
- Pain along tendo calcaneous and lateral region of calf

Posterior medial foot (PMF) distribution:

- Pain along tendo calcaneous and medial region of calf
- Acute cramps in the bottom of the feet as well as pain and cramps in the medial ankle and heel

Table 17.4. Function, nerve root, and muscular distribution assignment of intrinsic muscles of the foot and toes

| Intrinsic Muscles | MD* | Nerve Root | Function |
|---|---|---|---|
| Abductor hallucis | AMF | L5, S1, 2 | Spreads big toe away from 2nd toe |
| Adductor hallucis | PMF | S1, 2 | Draws big toe toward 2nd toe |
| Flexor hallucis brevis | PMF | L4, 5, S1 | Flexes proximal phalanx of big toe |
| Flexor digitorum brevis | PMF | L4, 5, S1 | Flexes 2nd through 5th toes |
| Quadratus plantae | PMF | S1, 2 | Flexes 2nd through 5th toes |
| Extensor digitorum brevis | LF | L4, 5, S1 | Extends proximal phalanx of 1st to 4th toes |
| Extensor hallucis brevis | ALF | L4, 5, S1 | Extends big toe |
| Flexor digiti minimi brevis | PLF | S1, 2 | Flexes proximal phalanx of 5th toe |
| Abductor digiti minimi | PLF | S1, 2 | Spreads 5th toe away from 4th toe |
| Lumbricals I, II, III, IV | PMF | L4, 5 (1st), S1, 2 (2nd-4th) | Flex proximal phalanx and extends distal phalanx of 2nd to 5th toes |
| Interosseous[1] | | | |
| 1st dorsal interossei | MF | S1, 2 | Draws second toe toward big toe |
| 2nd & 3rd dorsal interossei | ALF | S1, 2 | Draw 2nd, and 3rd away from big toe |
| 4th dorsal interossei | LF | S1, 2 | Draw 4th toe away from big toe |
| Plantar interossei | PMF | S1, 2 | Draw 3rd, 4th, and 5th toes away from 2nd toe |
| | | | 1. Also flex proximal phalanx and extends distal phalanx of 2nd through 4th toes |

## Pathology of Leg and Ankle

### *Anterior Compartment*

The anterior compartment of the lower leg contains the tibialis anterior muscle and toe extensors, the anterior tibial artery, and the deep peroneal nerve which supplies the muscles. Problems affecting the anterior compartment include:

### Acute Anterior Tibial Syndrome

This condition usually follows sudden, intense or unusual running type activities but can occur after moderate effort in those who recently started exercising. The patient presents with history of pain in anterior compartment that quickly becomes worse. The pain is made worse by passive plantar flexion of ankle or by isometric contraction of the ankle dorsiflexors. In addition, the overlying skin may be reddened, warm, and edematous. Possible muscle necrosis and nerve damage can result if compression is not relieved; can lead to foot drop and sensory changes.

### Chronic Anterior Tibial Syndrome

In this condition, pain is provoked by exercise, becoming worse so the patient is not able to continue physical activity. Resulting symptoms are similar to arterial insufficiency and may include swelling and tenderness over the anterior compartment of the lower leg. The patient's pain can be reproduced on passive dorsiflexion of foot or toes. If the patient continues to exercise, there risk of developing muscle necrosis and nerve compression.

### Tendinitis of Tibialis Anterior

This is an overuse condition involving the musculotendinous junction of tibialis anterior in lower third of the leg. This muscle is the principle decelerator of foot at heel strike when running and patient may not be aware of the problem in early stages of training. Patient complains of pain made worse by ankle movements. In addition, marked crepitus may be palpable or even audible over the involved area of the muscle.

## *Medial Compartment*

The medial compartment contains the tibialis posterior, flexor hallucis longus, and flexor digitorum longus muscles, along with the posterior tibial artery and nerve.

### Medial Tibial Compartment Syndrome

This condition is similar to anterior compartment problems where exercise produces muscular swelling in a tight medial compartment. This is the most common of the compartment problems usually due to overuse injury which may manifest bilaterally. The patient presents with pain over the lower third medial border of the tibia. Initially, pain may be dull and aching and come on with running and is relieved by rest. The pain gradually increases to point where patient has to alter their activities, such as shortening running stride, or running flatfooted. The patient's pain can be reproduced by passive plantar flexion, active dorsiflexion, or isometric contraction of the tibialis posterior muscle. Marked tenderness may also be found along lower third of posteromedial border of the tibia. X-ray examination may be required to differentiate this condition from a tibial stress fracture.

## *Lateral Compartment*

This compartment contains the peroneus longus and brevis muscles (LF) along with the lateral popliteal nerve. Acute swelling the peroneal compartment is uncommon but can develop several hours after strenuous exercise. The resulting pain is made worse by active and passive inversion of the foot. The swelling may compress the lateral popliteal nerve resulting in sensory changes followed by a foot drop with inversion of the foot.

### *Posterior Compartment*

The posterior compartment contains the gastrocnemius, soleus, and plantaris muscles that form the Achilles tendon. Pathology associated with this compartment includes:

#### Tear of Gastrocnemius

This is a common injury occurring in middle-aged males, often while jogging or playing tennis (sometimes called "tennis leg"). Minor degrees of this problem can also occur in the elderly while walking, especially on uneven surfaces. History of the problem often indicates that pain occurred suddenly, as if someone had hit them in the leg from behind with a rock. Site of injury is usually the medial belly of the gastrocnemius or at the medial musculotendinous junction. The pain in the calf can be reproduced by stretching the gastrocnemius muscle by passive dorsiflexion of the ankle. The pain can also be reproduced by active contraction of this muscle by having the patient to attempt standing on their toes, or by resisted plantar flexion of the ankle.

#### Acute Posterior Compartment Syndrome

Problems in the posterior compartment are rare; however, exercise can produce acute ischemia of the soleus muscle in the tight confines of the posterior compartment. Surgical treatment may be required to relieve the pressure by splitting the fascia over the medial side of the soleus muscle.

#### Chronic Posterior Compartment Syndrome

This condition may follow an overuse injury of the soleus or be the result of a previous fracture of the tibia and fibula. The problem is characterized by calf pain on activity and may be associated with an altered sensation on the plantar surface of the foot along with weakness in ankle flexion. The patient's pain is reproduced on passive dorsiflexion of the foot which stretches the structures in the posterior compartment.

### *Lesions of the Achilles' Tendon*

The Achilles tendon is the strongest tendon in the body and curves around the concave posterior surface of the calcaneous, from which it is separated by a bursa, to insert into the lower part of the posterior surface of the calcaneous. The tendon does not have a tenosynovial layer but is invested by a relatively rigid fibrous paratenon that contains the major part of the blood supply to the tendon. The Achilles tendon is susceptible to degenerative changes as commonly found in other tendons, including:

- Achilles tendinitis: occurs as a combination of degenerative and/or inflammatory changes due to overuse involving the tendon and its paratenon
- Chronic thickening of paratenon: produced by chronic inflammatory changes in the paratenon possibly as a complication of acute peritendinitis due to overuse
- Bursitis: can involve the deep and superficial bursae associated with the Achilles tendon
- Rupture of tendon: complete rupture is uncommon in young people and occurs more commonly with increasing age especially over 40 years of age
- Partial rupture of tendon: is becoming increasingly recognized where patient suffers a sudden sharp pain in the tendon, often while running, and then is noticed while stepping off the affected leg; rupture usually occurs a few centimeters above the tendon insertion

- Avulsion of Achilles tendon: is serious but rare condition occurring in the elderly patient when a portion of the calcaneous bone is avulsed along with the Achilles tendon attachment
- Ossification: this may occur in the tendon as a complication of Achilles tendinitis but rarely does this fracture which would result in severe pain with the tendon rupturing at the same time
- Pathological conditions: spondyloarthritis may present with tendinitis or bursitis and rheumatoid involvement of the bursa can produce erosive changes in the calcaneus bone
- Osteochondritis of calcaneus: this condition occurs in young males and is due the traction by the Achilles tendon on an un-united calcaneal apohysis; the child is usually involved in sports

### *Disorders Involving Ankle Joint*

#### Lateral Collateral Ligament Sprains

Three bands of lateral collateral ligament injuries are consistent with its function and direction in which the fibers run.

The anterior band (anterior talofibular ligament) runs from the anterior border of lateral malleolus passing medially to neck of talus fusing with anterior capsule of ankle joint. It is taut during plantar flexion and therefore damaged by sudden forced or excess degree of plantar flexion.

The middle band (fibulocalcaneal ligament) runs vertically downward from tip of lateral malleolus to lateral surface of calcaneus. It is taut with the ankle at a right angle and tends to be injured by inversion strain.

The posterior band (posterior talofibular ligament): runs medially from the posterior aspect of the lateral malleolus to the talus, strengthening the posterior aspect of ankle capsule. It is rarely injured but mechanics involving sports like long jumpers landing on feet with their body weight thrusting forward forcibly dorsiflexing ankle can result in sprains.

#### Anterior Tibiofibular Ligament Sprain

This is a relatively common ankle injury possibly resulting from an unusual type of inversion strain. The sprain may also follow either a dorsiflexion or eversion injury. In eversion injury the talus is forced against medial malleolus straining ligament fibers. A rupture of this ligament widens inferior tibiofibular joint with disruption of normal ankle-joint mortise.

#### Medial Ligament Sprain

Sprains to this ligament do not occur frequently because eversion injuries are relatively uncommon and the medial ligament is strong. It is also called the “deltoid ligament” consisting of following bands:

- Anterior tibiotalar ligament
- Posterior tibiotalar ligament
- Tibiocalcanean ligament
- Tibionavicular ligament

#### Recurrent Instability of Ankle

- Functional instability: common after ligamentous injury resulting in mechanical derangement of joint
- Complete ligamentous rupture: may involve anterior talofibular or calcaneofibular ligament or both causing talus to be loose in its mortise
- Inadequately treated sprains: may lead to pain and sudden giving way of ankle involving sprains of lateral ligament
- Foot deformities: due to valgus deformity of forefoot altering peroneus function resulting in recurring pain and disability in lateral ankle compartment
- Undiagnosed causes: possibly due to improper footwear, including high heels, and may require active exercises and proprioceptive retraining

#### Tenosynovitis of Ankle Tendons

Tenosynovitis of the peroneal tendons may occur along tendon course from behind fibular malleolus to outer side of foot. The patient's pain can be reproduced by fully resisting foot eversion or by stretching peroneal tendon by full passive inversion of foot. Tenosynovitis of the tibialis posterior involves the tendon behind or just below medial malleolus. The patient's pain can be reproduced by resisting active foot inversion or stretching tendon by full passive eversion of foot.

#### Talotibial Exostoses

This condition involves bony growths or spurs on surface of talus and tibia at ankle joint. They develop on the anterior margins of ankle joint on upper surface of talus and lower surface of tibia. They can also develop on the posterior margins of talotibial joint. This condition may result from talotibial impingement on dorsiflexion or plantar flexion of ankle.

#### Osteochondritis Dissecans

This is a type of fracture that occurs in adolescents often involving the superior surface of talus, usually on the fibular side. It often follows an inversion strain of the ankle when in dorsiflexion. The patient presents with ankle pain with possible swelling with a limp and there may be a history of injury.

## Pathology the Foot and Toes

### *General Conditions*

#### Pes Planus Deformity

This condition involves lowering of medial longitudinal arch of the foot. It may be an intrinsic disorder in how body weight is distributed and affects the joints and ligaments of the feet. It can be associated with genu valgum, external rotation of limb, shortening of Achilles tendon with valgus deformity of hindfoot, and hypermobility. It can be a functional condition or result of congenital lesions and classed as:

- Static deformity: depression of medial longitudinal arch associated with a valgus deformity of hindfoot and abduction of forefoot
- Rigid deformity: degenerative changes in late stages with painful and stiff foot fixed in valgus; condition helped by strong mobilization techniques

- Spastic flat foot: associated with marked spasm of peroneal muscles and long extensors of toes

**Pes Cavus Deformity**

This is a foot deformity involving increased elevation of medial longitudinal arch where the forefoot lies at lower level than hindfoot. The foot is foreshortened and eventually dorsal ligaments become contracted with toes clawed. Primarily this involves either a posterior or anterior bony compartments of medial arch.

**Ankle Equinus**

Indicates decreased range of dorsiflexion of ankle joint usually produced by tightness or shortening of gastrocnemius-soleus and Achilles tendon complex or restricted ankle joint movements. This condition may be congenital or acquired due to pes cavus, high heeled shoes, or after prolonged be rest. The congenital form involves an ankle flexion deformity and in a serve case the calcaneus is unable to touch floor.

**Hindfoot Varus Deformity**

This is a common problem in which calcaneus posterior surface is inverted relative to Achilles tendon. It may not be considered functionally significant unless deformity is greater than 5° in adults or 8° in children. This problem may be produced by varus deformity of tibia or by acquired or congenital lesions of subtalar joint. The foot may become inverted with patient walking on lateral surface of foot.

**Forefoot Varus Deformity**

This is a common deformity where forefoot is inverted relative to hindfoot. This is a basic abnormality resulting from a failure in normal degree of valgus rotation in talus head to develop. A varus deformity of 5° is common up to age of 2 years, but later this will result in foot pain and dysfunction.

**Forefoot Valgus Deformity**

This deformity occurs when plane of forefoot is everted relative to hindfoot. It is caused by an increase in the degree of valgus torsion taking place in talus head and neck during development. The patient may present with forefoot pain below the second or fifth metatarsal heads with callus formation.

**Sudeck's Atrophy**

This condition causes severe pain, swelling, and disability in the foot, but may also occur in other joints. It also known as reflex sympathetic dystrophy now referred to as regional pain syndrome. The etiology unknown but probably represents a sympathetic neurovascular disorder. The condition leads to hyperemia and osteoporosis of bone, similar to the shoulder hand syndrome. The condition may be idiopathic or follow prolonged immobilization but commonly follows trauma, which may even be trivial.

**Entrapment Neuropathies**

Several possible nerve entrapment problems are associated with the feet including the following conditions:

- Tarsal-tunnel syndrome: involves posterior tibial nerve as it passes behind and below medial malleolus

- Medial plantar nerve: involves branch of posterior tibial nerve where it runs through an opening in abductor hallucis longus muscle
- Digital nerves: occurs in course of nerve between metatarsal heads, most commonly involving third plantar digital nerve
- Deep peroneal nerve: may be entrapped in front of ankle where it lies beneath extensor retinaculum

### *Localized Regional Conditions*

#### Pain in Toes

Several conditions of the toes have been identified that cause pain as follow:

- Hallux valgus: lateral deviation of proximal phalanx of great toe on first metatarsal
- Hallux rigidus: result of osteoarthritis of first MTP joint but rarely produces complete rigidity
- Hammer toe: common toe deformity due to fixed flexion PIP joint contraction
- Mallet toe: flexion deformity of the DIP/TIP joint of one or more toes
- Varus deformity of fifth toe: congenital deformity where little toe comes to lie across base of $4^{th}$ toe
- Bunion of fifth metatarsal head: produced by inflammation bursa overlying lateral aspect of fifth metatarsal head
- Arthritis: spondyloarthritis, inflammatory changes in IP joints and tendons of dorsum of toes are common

#### Anterior Metatarsalgia

Several conditions involve pain that is common in the metatarsals of the forefoot. Most foot deformities may be the underlying cause of pain resulting from traumatic conditions including stress fractures, synovitis of MTP joint, and sesamoiditis. One condition called "Freiberg's disease" involves the head of second and rarely the third metatarsal bone during adolescence. Morton's syndrome is another condition that involves congenital shortening of first metatarsal with hypermobility of first tarsometatarsal joint.

#### Midtarsal Pain

Patients with pes planus or pes cavus foot deformities may present with midtarsal pain. Hypomobility lesions of transverse tarsal joints may follow trauma with strain of midtarsal joints. Stress fracture of navicular is another but rare condition that occurs in sprinters. Other conditions of the midtarsals include rare osteochondritis of navicular and dorsal exostosis which is an osteocartilaginous swelling over first tarsometatarsal joint. Midtarsal pain also results by soft tissue lesions involving overuse tendinitis of the peroneal brevis tendon.

#### Heel Pain

Heel pain can be due to soft-tissue lesion including plantar fasciitis, bruised heel, and lesions of Achilles tendon. It is also due direct trauma and fractures to the bones including stress fractures. Paget's disease can cause heel pain as result in joint disorders involving synovitis of the subtalar joint and hypomobility of subtalar joint.

### Plantar Pain

Plantar pain can be the result of soft-tissue lesions involving tendinitis of flexor hallucis longus muscle. It can also be the result of fibromatous swelling occurring usually in medial aspect of plantar fascia (Ledderhose's disease). Plantar pain may present in patients with pes planus or pes cavus. Plantar pain is also found in patients with inflammatory arthritis, hypomobility lesion of transverse tarsal joint or acute strain of medial longitudinal arch.

## Assessment of the Leg, Ankle, and Toes

### Observation

The weight-bearing (WB) and non-weight-bearing (NWB) posture of the foot as well as forefoot and hindfoot deformities, including the toes, is observed by viewing the patient's foot from the back, front, and side. Alignment of the leg and calcaneus bone are observed for supination or pronation of the subtalar joint as noted by an angular deviation of the heel with respect to the tibial axis. The foot is then observed for other deviations and deformities.

### Active Movements of Ankle and Toes

These movements can be performed on both feet at the same time if there are no painful restrictions; otherwise the non-painful side is tested last.

#### *Weight-Bearing*

These movements performed in the weight-bearing standing position with the patient standing on a solid surface to determine the weight-bearing alignments. This series of tests to be performed in the following sequence:

1. Dorsiflexion: standing on the heels
2. Plantar flexion: standing on the toes
3. Supination: standing on the lateral edge of the foot
4. Pronation: standing on the medial edge of the foot
5. Toe extension
6. Toe flexion

#### *Non-Weight-Bearing*

The non-weight-bearing tests are conducted with the patient lying supine with both legs extended with feet over the end of the examination table for some of the measurements. This series of tests to be performed in the following sequence:

### Dorsiflexion

Dorsiflexion of the ankle is about 20° past the anatomical position with the foot at 90° to the bones of the leg. The dorsiflexion ROM is measured by placing the fulcrum of a goniometer about 1.5 cm below the lateral malleolus with the fixed arm aligned with the fibula. The moveable arm is held aligned parallel to the axis of the fifth metatarsal.

The ROM can also be measured with a gravity sensitive device strapped around the foot with the dial on the lateral side and zeroed out with the foot the anatomical position.

### Plantar Flexion

Plantar flexion of the ankle is about 50° past the anatomical position with the foot at 90° to the bones of the leg. The plantar flexion ROM is measured by placing the fulcrum of a goniometer about 1.5 cm below the lateral malleolus with the fixed arm aligned with the fibula. The moveable arm is held aligned parallel to the axis of the fifth metatarsal.

The ROM can also be measured with a gravity sensitive device strapped around the foot with the dial on the lateral side and zeroed out with the foot the anatomical position.

### Inversion and Eversion

Inversion (0 - 5°) (forefoot at 0 - 35°) involves the combined movements of supination, adduction, and plantar flexion; eversion (0 - 5°) (forefoot at 0 - 20°) involves the combined movements of pronation, abduction, and dorsiflexion. Inversion involves turning the sole of the foot inward elevating the medial border; eversion involves elevating the lateral border turning the foot outward. Patient is supine with a roll placed under the knee to provide a slight flexion of the knee. The foot is held in the anatomical position in neutral dorsiflexion, plantar flexion, inversion, and eversion, with a piece of paper placed under the foot, and perhaps temporarily taped to the table.

A flat broad surface object, such as piece of plexiglass or clipboard supported vertically on the paper, is placed against the plantar surface of the foot. A base line is drawn on the paper using the edge of the device as the guide. The patient moves the foot into inversion (25 - 35°) while the flat object moves with the foot. A second line is then drawn on the paper using the flat object held against the plantar surface. The foot is then returned to the neutral position lined up with the first line on the paper. The foot is then moved into eversion (15 - 20°) and a third line is drawn. A protractor or goniometer is then used to measure the angular ROM for both inversion and eversion.

Inversion and eversion can also be measured with gravity sensitive goniometer with the patient seated with the leg hanging down over the edge of the table. The device needs to have a 90° platform to hold it vertical in the gravity field. The device is strapped on the forefoot with the dial zeroed out and the foot moved into inversion and eversion while the examiner stabilizes the lower leg.

## *Movements of Great Toe*

Active movements and ROM of the great toe in flexion and extension can be measured with a universal goniometer positioned on the medial aspect of the foot or with a small baseline 180° digit goniometer placed on the dorsal or plantar aspect of the big toe. Range of motion in flexion (45°) and extension (70°) is measured for metatarsophalangeal (MTP) joint, and flexion (90°) is measured for the interphalangeal (IP) joint. Extension for the IP is normally 0°. Abduction and adduction are also measured for the MTP.

In following movements the patient is supine with the knee slightly flexed with the ankle and toes in the neutral position. Alternatively, the patient can be seated with legs dangling over edge of table.

### Metatarsophalangeal (MTP) Flexion

Examiner stabilizes the first metatarsal while the axis of the goniometer is placed over the dorsum of the MTP joint with the fixed arm parallel to the longitudinal axis of the first metatarsal. The movable arm is parallel to the longitudinal axis of the proximal phalanx. The MTP joint is flexed to the limit of motion (MTP 45°). Alternatively, flexion of the first toe can be measured by placing the goniometer on the lateral aspect of MTP with the fixed arm parallel to the longitudinal axis of the first metatarsal and the movable arm parallel to the longitudinal axis of the proximal phalanx.

### Interphalangeal (IP) Flexion

Examiner stabilizes the proximal phalanx while the axis of the goniometer is placed over the dorsum of the IP joint with the fixed arm parallel to the longitudinal axis of the proximal phalanx. The movable arm is parallel to the longitudinal axis of the distal phalanx. The IP joint is flexed to the limit of motion (IP 90°).

### Metatarsophalangeal Extension

Examiner stabilizes the first metatarsal while the axis of the goniometer is placed over the plantar aspect of the MTP joint with the fixed arm parallel to the longitudinal axis of the first metatarsal. The movable arm is parallel to the longitudinal axis of the proximal phalanx. The MTP joint is extended to the limit of motion (MTP 70°). Alternatively, extension of the first toe can be measured by placing the goniometer on the lateral aspect of the MTP with the fixed arm parallel to the longitudinal axis of the first metatarsal and the movable arm parallel to the longitudinal axis of the proximal phalanx.

### Metatarsophalangeal Abduction and Adduction

Patient is supine with the ankle and toes in the neutral position. The examiner stands to the foot of the examination table and stabilizes the foot proximal to the MTP joint with one hand grasping the lateral edge of the foot in web of the thumb. The fingers are placed across the dorsal aspect of the foot with the thumb below the foot. The axis of the goniometer is held the dorsum of the first MTP by the examiner's stabilizing hand. The goniometer fixed arm is parallel to longitudinal axis of the first metatarsal with the movable arm parallel to the longitudinal axis of the proximal phalanx. The MTP joint is abducted to the limit of motion, with the ROM recorded. The MTP joint is then adducted to the limit of motion, with the ROM recorded.

## *Movements of Lateral Four Toes*

Active movements and ROM of the lateral four toes metatarsophalangeal (MTP) joints can be measured in flexion (40°) of each toe with a small baseline 180° digit goniometer or short universal goniometer placed on the dorsal aspect or the toe. Extension (40°) of the MTP joint is measured by placing the goniometer on the plantar aspect of the foot. Flexion and extension of the proximal interphalangeal and distal interphalangeal joints of the lateral four toes is observed and the ROM recorded as either "full" or "decreased."

In following movements the patient is supine with the knee slightly flexed with the ankle and toes in the neutral position. Alternatively, the patient can be seated with legs dangling over edge of table.

### Metatarsophalangeal (MTP) Flexion

Examiner stabilizes the metatarsals while the axis of the goniometer is sequentially placed over the dorsum of each MTP joint with the fixed arm parallel to the longitudinal axis of the metatarsal of each toe being tested. The movable arm is parallel to the longitudinal axis of the proximal phalanx. The MTP joint is flexed to the limit of motion (lateral four toes: MTP 40°). Alternatively, flexion of the fifth toe can be measured by placing the goniometer on the lateral aspect of MTP with the fixed arm parallel to the longitudinal axis of the fifth metatarsal and the movable arm parallel to the longitudinal axis of the proximal phalanx.

### Metatarsophalangeal Extension

Examiner stabilizes the metatarsals while the axis of the goniometer is sequentially placed over the plantar aspect of each MTP joint with the fixed arm parallel to the longitudinal axis of the metatarsal of each toe being tested. The movable arm is parallel to the longitudinal axis of the proximal phalanx. The MTP joint is extended to the limit of motion (lateral four toes: MTP 40°). Alternatively, extension of the fifth toe can be measured by placing the goniometer on the lateral aspect of the MTP with the fixed arm parallel to the longitudinal axis of the fifth metatarsal and the movable arm is parallel to the longitudinal axis of the proximal phalanx.

## Passive Movements of the Foot and Toes

The passive movements of the ankle and toes are performed in a non-weight bearing posture usually with the patient supine with feet slightly off the end of the examination table. If patient is able to achieve full active ROM, overpressure can be applied at the end range of active movements to assess the end-feel characteristics, there by eliminating the need for separate passive movement tests. The end-feel for all passive movements of the lower leg, ankle, and foot is tissue stretch. Passive movements of the ankle and toe include:

### *Plantar Flexion*

Patient is supine with legs extended with the feet over the end of the examination table. The Examiner stabilizes the lower leg by grasping the distal tibia and fibula with one hand while grasping the forefoot with the other hand. The lower leg and foot need to be relaxed as the examiner pushes downward to rotate the foot at the talocrural joint into plantar flexion to note the end-feel and other characteristics of the movement.

### *Dorsiflexion*

Patient is supine with legs extended with the feet over the end of the examination table. The Examiner stabilizes the lower leg by grasping the distal tibia and fibula with one hand while grasping the ankle below the calcaneus with the other hand. The lower leg and foot need to be relaxed as the examiner pulls up on the calcaneus to rotate the foot at the talocrural joint into dorsiflexion to note the end-feel and other characteristics of the movement.

### *Inversion*

Patient is supine with legs extended with the feet over the end of the examination table. The Examiner stabilizes the lower leg by grasping the distal tibia and fibula with one hand while grasping the foot with the other hand under midtarsal region with fingers on medial aspect of the foot. The lower leg and foot need to be relaxed as the examiner inverts the foot by rotation at the subtalar joint by flexing the examiner's hand. The end-feel and other characteristics of the movement are assessed.

***Eversion***

Patient is supine with legs extended with the feet over the end of the examination table. The Examiner stabilizes the lower leg by grasping the distal tibia and fibula with one hand while grasping the foot with the other hand under midtarsal and calcaneus region with fingers on medial aspect of the calcaneus. The lower leg and foot need to be relaxed as the examiner everts the foot by rotation at the subtalar joint by extending the examiner's hand to pull on the lower medial border of the calcaneus. The end-feel and other characteristics of the movement are assessed.

***Adduction and Abduction***

Patient is supine with the knee slightly flexed and ankle just off the table. The examiner stabilizes the navicular, talus, and calcaneus by grasping these bones in the web space, thumb, and fingers of one hand on the dorsum while the mobilizing hand grasps the distal row of tarsal bones (cuneiforms and cuboid). The hands should nearly touch each other if they are properly placed. A torsional force is applied in the medial direction to the distal row of tarsal bones in adduction while the proximal tarsal bones are stabilized. The torsional force on the distal row of tarsal bones is then moved in the lateral direction to the distal row of tarsal bones in abduction. The end-feel and other characteristics of the movement are assessed for both adduction and abduction.

***Flexion and Extension of Toes***

Passive movements for flexion and extension of the toes are applied individually for each of the metatarsophalangeal and interphalangeal joints. Initially the examiner stabilizes the distal metatarsals by grasping these bones in the web space, thumb, and fingers of one hand on the dorsum while fingers and thumb of the mobilizing hand grasps the distal phalanx of interest which is moved into flexion and extension. Moving distally to the next joint, the examiner stabilizes the proximal phalanx bone of interest with one hand while the fingers and thumb of the mobilizing hand grasps the distal phalanx of interest. The distal bone is then moved into flexion and then extension to assess the characteristics of movement and the end-feel.

***Adduction and Abduction of Toes***

Passive movements for adduction and abduction of the toes are applied individually for each of the metatarsophalangeal and interphalangeal joints. Initially the examiner stabilizes the distal metatarsals by grasping these bones in the web space, thumb, and fingers of one hand on the dorsum while fingers and thumb of the mobilizing hand grasps the distal phalanx of interest which is moved into adduction and abduction. Moving distally to the next joint, the examiner stabilizes the proximal phalanx of interest with one hand while the fingers and thumb of the mobilizing hand grasps the distal phalanx of interest. The distal bone is then moved into adduction and then abduction to assess the characteristics of movement and the end-feel.

## Resistive Movements of Foot and Toes

Resisted isometric movements of the lower leg, ankle, and toes are conducted to test the contractile tissue moving these structures. Some of these tests can be performed with the patient seated or lying supine. The following tests are described with the patient supine although the hip and knee may be flexed in order to conduct the test. The foot is maintained in the anatomical position for those tests involving the foot.

***Knee Flexion***

Patient is supine while the examiner lifts the test leg into about 60° of hip flexion and 90° of knee flexion. The other leg is relaxed in full extension. The examiner supports the test lower leg above the table surface with one hand under the distal aspect of the lower leg while the other hand is placed on the anterior thigh just proximal to the knee. The patient is instructed to not let the examiner move them as an isometric force is applied to the lower leg in the direction of leg extension.

***Dorsiflexion***

Patient is supine with heel of the test leg touching the examination table with the hip flexed 45°, knee flexed 90°, and the foot in the anatomical position. The other leg is relaxed in full extension. Standing to the test side, the patient's knee is held between examiner arm and body while the hand reaches over the thigh and under the lower leg to hold the calf to stabilize the leg. The other hand grasps the dorsal surface of patient's foot to apply an isometric force in the direction of plantar flexion. Patient is instructed to not let the examiner move them.

***Plantar flexion***

Patient is supine with heel of the test leg touching the examination table with the hip flexed 45°, knee flexed 90°, and the foot in the anatomical position. The other leg is relaxed in full extension. Standing to the test side, the patient's knee is held between examiner arm and body while the hand reaches over the thigh and under the lower leg to hold the calf to stabilize the leg. The other hand is placed on the plantar surface over ball of the patient's foot to apply an isometric force in the direction of dorsiflexion. Patient is instructed to not let the examiner move them.

***Foot Supination***

Patient is supine with both leg fully extended and relaxed. Standing to the test side the examiner stabilizes the test leg by placing one hand on the mid tibial area while the other hand is used to grasp the under the forefoot from the lateral side with fingers reaching under the foot to hold the medial edge of the foot. Patient is instructed to not let the examiner move them as the examiner applies an isometric torsional movement in the direction of foot pronation.

***Foot Pronation***

Patient is supine with both leg fully extended and relaxed. Standing to the test side the examiner stabilizes the test leg by placing one hand on the mid tibial area while the other hand is used to grasp the lateral edge of the foot with the thumb on the top of the foot and the finger under the foot. Patient is instructed to not let the examiner move them as the examiner applies an isometric torsional movement in the direction of foot supination.

***Flexion and Extension of Great Toe***

Patient is supine with both legs fully extended and relaxed to stabilize the legs with the examiner standing to the foot of the examination table. For flexion of the great toe the examiner applies an isometric force to the great toe nail in the direction of great toe extension while the patient is instructed to not let the examiner move them.

For extension of the great toe the examiner applies an isometric force to the pad of the great toe in the direction of great toe flexion while the patient is instructed to not let the examiner move them.

***Flexion of Lateral Four Toes***

Patient is supine with both legs fully extended and relaxed to stabilize the legs with the examiner standing to the foot of the examination table. The examiner grasps all four lateral toes by placing the base of the examiner's hand just distal to the ball of the patient's foot while examiner's fingers hold all four lateral toes. Patient is instructed to not let the examiner move them as the examiner applies an isometric force on all four lateral toes in the direction of toe extension.

***Extension of Lateral Four Toes***

Patient is supine with both legs fully extended and relaxed to stabilize the legs with the examiner standing to the foot of the examination table. The base examiner's palm is placed on the dorsal surface of the distal foot and all four lateral toes. Patient is instructed to not let the examiner move them as the examiner applies an isometric force on all four lateral toes in the direction of toe flexion.

## Joint Play Movements

Joint play or accessory movements of the lower leg, ankle, and foot can be performed with the patient supine or side lying depending on the specific movement. Comparison of normal movement on the unaffected side is always compared to the affected or injured side. Certain types of movements can be applied to several different joints so each case has to be specifically considered using the following guidelines:

***Talocrural (ankle joint)***

### Long-Axis Extension

This test involves applying a distraction force on a particular joint while stabilizing the proximal segment and providing traction to the distal segment. For the ankle the examiner stabilizes the tibia and fibula by having the patient lying supine with the test leg relaxed. A strap could also be employed to stabilize the leg. The examiner grasps the ankle with both hands distal to the malleoli and applies a longitudinal distractive force that is in line with the axis of the ankle and leg.

### Anteroposterior Glide

Patient is supine with the foot slightly off the table while the examiner stabilizes the tibia and fibula with one hand on the distal leg while the other hand grasps the forefoot to draw the talus and foot forward toward the anterior direction. The direction of force is then reversed to push the talus and foot backward to provide the posterior movement.

***Subtalar Joint***

### Talar Rock

This joint play test is performed with the patient side lying with the hip and knee flexed and test foot on the table side, with the examiner sitting behind the patient. The examiner places both hands around the ankle just distal to the malleoli. A mild distractive force is applied to the ankle while a forward (dorsiflexion) and backward (plantar flexion) rocking movement is applied to the ankle. The examiner should usually feel a "clunk" at the extreme end of each movement.

#### Medial and Lateral Side Tilt

Patient is supine with legs extended slightly over the end of the table while examiner standing at the foot end of the table grasps the heel with both hands around the calcaneus. The examiner's wrists are alternately flexed and extended thereby tilting the calcaneus medially and laterally on the talus. Examiner maintains the foot in the anatomical position during this movement. This particular movement is identical to that in the talar tilt (inversion and eversion) tests respectively for the calcaneofibular and deltoid ligaments.

### *Midtarsal Joints*

#### Anteroposterior Glide

Patient is supine with the knee slightly flexed and ankle just off the table. The examiner stabilizes the navicular, talus, and calcaneus by grasping these bones in the web space, thumb, and fingers of one hand on the dorsum while the other hand grasps the distal row of tarsal bones (cuneiforms and cuboid). The hands should touch each other if they are properly placed. An anteroposterior gliding movement of the distal row of tarsal bones is applied while the proximal tarsal bones are stabilized.

#### Rotation

This joint play movement should be performed immediately following the midtarsal joint anteroposterior glide. Patient is supine with the knee slightly flexed and ankle just off the table as before. Examiner stabilizes the navicular, talus, and calcaneus by grasping these bones in the web space, thumb, and fingers of one hand on the dorsum while the other hand grasps the distal row of tarsal bones (cuneiforms and cuboid). The hands should touch each other if they are properly placed. The examiner then rotates the distal row of tarsal bone with respect to the proximal row of bones. Rotation movement is to be performed in both directions.

### *Tarsometatarsal Joints*

#### Anteroposterior glide

The examiner's hands are shifted distally from the Anteroposterior Glide position for the midtarsal joints so the stabilizing hand is over the distal row of tarsal bones and the mobilizing hand rests on the proximal aspect of the metatarsal bones. The hands are still positioned so they touch each other. An anteroposterior gliding movement is applied to the proximal metatarsal bones while the distal row of tarsal bones is stabilized.

#### Rotation

This joint play movement should be performed immediately following the tarsometatarsal joint anteroposterior glide. Patient is supine with the knee slightly flexed and ankle just off the table as before. Examiner's stabilizing hand is over the distal row of tarsal bones and the mobilizing hand rests on the proximal aspect of the metatarsal bones. The hands are still positioned so they touch each other. The examiner then rotates the proximal metatarsal bones while the distal row of tarsal bones is stabilized. Rotation movement is to be performed in both directions.

### *Metatarsophalangeal and Interphalangeal Joints*

The joint play movements are applied individually for each of the metatarsophalangeal and interphalangeal joints. In the following four tests the patient is supine with the knee slightly flexed and ankle just off the table. The following four movements are applied to each joint in question before testing the next joint.

The procedure involves the examiner stabilizing the proximal bone of interest (metatarsal or phalanx) with one hand while the fingers and thumb of the mobilizing hand grasps the distal bone of interest (phalanx). The distal bone is then moved into long-axis extension, anteroposterior glide, rotation, and lateral or side glide.

#### Long-Axis Extension

Examiner applies a traction force by pulling longitudinally on the distal phalanx of interest with respect to the stabilized proximal bone (metatarsal or phalanx).

#### Anteroposterior Glide

Examiner moves the distal phalanx of interest in an anteroposterior and then posteroanterior direction with respect to the stabilized proximal bone (metatarsal or phalanx).

#### Rotation

Examiner moves the distal phalanx of interest in rotation about the long axis of the bone in both directions with respect to the stabilized proximal bone (metatarsal or phalanx).

#### Lateral or Side Glide

The side glide movement at the metatarsophalangeal and interphalangeal joints is conducted by first stabilizing the proximal bone (metatarsal or phalanx) of interest with one hand. Examiner then uses the fingers and thumb of the other hand to apply a slight traction force to the distal bone and moving the distal bone sideways right and left with respect to the stabilized proximal bone (metatarsal or phalanx).

## Functional Assessment

If the patient can adequately perform the foregoing movements, functional tests may be considered to determine if pain and dysfunction results in performing routine activities. Many conditions involving pain and dysfunction may not have any functional impact on the patient in carrying out activities of daily living and even performing their occupational activities. A series of tests can be considered to determine to what extent that problems of the lower leg, ankle, and foot compromise normal activities. Examiner must consider expected differences in individuals in being able to carry out certain tests. Differences to consider include age, gender, health status, body weight, and other parameters. The following type tests may be considered:

- Squatting: observe that both ankles dorsiflex symmetrically
- Standing on toes: observe that both ankles plantar flex symmetrically
- Standing on one foot at a time: observe that balance is stable
- Standing on toes, one foot at a time: observe that balance is stable
- Walking up and down stair
- Walking on toes

- Running straight ahead
- Running, twisting, and turning: run on a short (4 x 20 meters) figure 8 course
- Jumping: only for younger people
- Jumping and going into a full squat: only for the very fit

## Special Tests

Several special tests can be performed on the lower leg, ankle, and foot to provide additional information, including possible ligamentous damage, fractures, and other problems.

### *Homan Test*

Patient is supine with the affected leg fully extended on the examination table. The examiner stands to side of foot of the table and passively dorsiflexes the patient's foot. If this produces pain in the calf it is possible positive finding for deep vein thrombophlebitis (DVT).

Pain may also be provoked on palpation of the calf with the examiner's hand placed under the calf to grasp the gastrocnemius muscle and then passively dorsiflexing the patient's foot. A positive finding in this situation may indicate a potential life threatening condition that needs immediate medical attention.

### *Anterior Drawer Test*

Patient is seated at the end of the examination table with knees flexed 90° and hanging over edge of table with the affected foot relaxed and in slight plantar flexion. The examiner grasps the leg just proximal to the ankle joint with one hand to stabilize the tibia and fibula while using the other hand to grasps the calcaneus. This test can also be performed with the patient in the prone position with both feet hanging over the end of the examination table.

While maintaining stability of the distal tibia and fibula, the examiner applies an anterior directed force to the calcaneus and talus. Anterior translation of the talus away from the ankle mortise that is greater than the uninvolved ankle indicates a positive sign for a possible sprain of the anterior talofibular ligament. The uninvolved ankle should be tested first.

Flexion of the knee to 90° reduces the tension on the gastrocnemius muscle. Possible ankle swelling may restrict the amount of anterior translation of the talus.

### *Talar Tilt Test (Eversion)*

Patient is side lying on the involved side with the involved foot relaxed and the knee flexed 90° and the foot over the edge of the table. Examiner stabilizes the leg by grasping the distal tibia and fibula with one hand and grasping the talus with the other hand holding the medial aspect of the foot.

The foot is moved into the anatomical position of neutral dorsiflexion and plantar flexion. The examiner then tilts the talus into an abducted position. If the range of motion in abduction of the involved foot is greater than the uninvolved foot, this is a positive sign. This may indicate a tear in the deltoid ligament of the ankle. The uninvolved ankle should be tested first.

Flexion of the knee to 90° reduces the tension on the gastrocnemius muscle. Conducting this test with the ankle plantar flexed to various amount may assess different aspects of the deltoid ligament. Possible ankle swelling may restrict translation of the talus.

### *Talar Tilt Test (Inversion)*

Patient is side lying on the uninvolved side with the involved foot relaxed and the knee flexed 90° and the foot over the edge of the table. Examiner stabilizes the leg by grasping the distal tibia and fibula with one hand and grasping the talus with the other hand.

The foot is moved into the anatomical position of neutral dorsiflexion and plantar flexion. The examiner then tilts the talus into an adducted position. If the range of motion in adduction of the involved foot is greater than the uninvolved foot, this is a positive sign. This may indicate a tear in the calcaneofibular ligament of the ankle. The uninvolved ankle should be tested first.

Flexion of the knee to 90° reduces the tension on the gastrocnemius muscle. Conducting this test with the ankle more plantar flexed places less stress on the calcaneofibular ligament and instead may stress the anterior talofibular ligament. Possible ankle swelling may restrict translation of the talus.

### *Thompson Test*

Patient is prone with feet extending over the end of the examination table with the gastrocnemius-soleus muscle complex fully relaxed. Examiner stands to the side at the table end and squeezes the belly of these muscles.

A normal response to squeezing the patient's calf would be to plantar flex the foot. Lack of a plantar flexion response would be a positive indication for a possible rupture of the Achilles' tendon.

### *Tap or Percussion Test*

Patient is supine with the foot of the affected leg extended with the heel just over the end of the examination table. The examiner stands at the table to grasp the patient's foot over the dorsum to passively move it into maximal dorsiflexion while two flexed fingers of the other hand are used to strike a firm tap to the bottom of the patient's heel.

If the tap produces pain at the site of injury it is indicative of possible fracture. Tapping along the long axis of the bones will exaggerate pain at the fracture site.

➔ This test should not be conducted if there is an obvious deformity

### *Feiss Line*

The patient sits on the examination table with the affected leg extended on the table surface. Examiner places a mark on the apex (tip) of the patient's medial malleolus and another on the base (plantar aspect) of the first metatarsophalangeal (MTP) joint. A line is then drawn between the two marks and the examiner notes the position of the navicular tuberosity. Alternatively, the edge of a small transparent ruler can used to place on the two locations to check the position of the navicular tuberosity.

The patient is then asked to stand on the floor with the feet 3 to 6 inches apart. Examiner determines that the original two marks are still located over the apex of the medial malleolus and the base of the first MTP joint, and notes the position of the navicular tuberosity.

The navicular tuberosity should be in line with the two points. If the navicular tuberosity is below the line while the patient is seated, this is indicative of possible congenital pes planus. If the navicular tuberosity is in line with the other two points while seated, but falls below the line when the patient is standing, this is indicative of functional pes planus.

Varying degrees of pes planus may be indicate by this test based on how far the navicular tuberosity drops toward the floor. Pes planus may also be indicative of hyperpronation.

### *Interdigital Neuroma Test*

The patient is seated on the examination table with the affected leg fully extended. While standing at the next the affected foot, the examiner grasps the patient's foot with one hand over the plantar aspect of the metatarsal heads while the other hand stabilizes the lower leg by holding the tibia and fibula on the mid tibia. Examiner then squeezes the patient's metatarsal heads together and holds this for 1 to 2 minutes.

Production of pain, tingling, or numbness in the ankle, foot, or toes is indicative of a possible neuroma. A positive sign of a neuroma is indicated if the pain is relieved when the pressure is released. Pain can also indicate a stress fracture.

Pain between the metatarsal heads is indicative of Morton's neuroma. The most common site of occurrence is between the third and forth metatarsal heads.

### *Compression Test*

Patient is supine with the affected leg extended with the ankle/foot just off the end of the examination table. The examiner stands next to the patient's leg and notes the origin of the patient's pain. Examiner places one hand on either side of the lower leg with the hands on the medial and lateral aspect aligned with the leg.

Examiner squeezes the tibia and fibular bones together at a location that is away from the painful area. Reproducing or exaggerating the pain may be indicative of a facture. It should be noted that a positive test is not exclusive of a fracture. An X-ray is recommended when a fracture is suspected.

- ➔ This test should not be conducted if there is an obvious deformity

### *Long Bone Compression Test*

Patient is seated on the examination table with the affected leg extended with the heel just off the end of the table. Examiner stands at the end of the table and grasps the patient's ankle to stabilize the foot while the fingers and thumb of the other hand apply a compression along the long axis of the toe bones or metatarsals of interest.

Reproduction or exaggeration of pain at the injury site is indicative of a possible fracture.

- ➔ This test should not be conducted if there is an obvious deformity

### *Swing Test*

Patient is seated on edge of table with knees flexed 90° and legs hanging over end of the examination table. Examiner is seated at end of table with hands over the dorsum of the patient's feet to keep the feet parallel with the floor.

The examiner palpates the anterior aspect of the patient's talus with the thumb while passively dorsiflexing and plantar flexing the ankle and observing the level of movement, especially in dorsiflexion. Resistance to dorsiflexion is a positive indication for possible posterior tibiotalar subluxation.

### *Kleiger's Test*

Patient is seated on examination table with knee flexed 90° and leg hanging over end of the examination table. Examiner is seated at the end of the table and grasps the patient's distal tibia and fibula with one hand to stabilize the lower leg while the other hand is under the plantar surface to clasp the medial and inferior aspect of the calcaneus. Examiner then applies an externally rotated force on the calcaneus. The test is repeated with the ankle moved into dorsiflexion.

Production of pain or reproduced pain along the medial aspect of the ankle when the externally rotated force is applied in neutral dorsiflexion indicates possible deltoid ligament injury. Pain that presents medially and slightly more proximally when the ankle is dorsiflexed and externally rotated indicates distal tibiofibular syndesmotic involvement.

The syndesmosis may be injured when the foot is fixated and subjected to a significant rotational force. This is sometimes referred to as a "high ankle sprain" which may be very painful to the patient when a rotational torque is applied.

### *Tinel's Sign at the Ankle*

Patient is supine with the affected leg straight with the foot extended over the end of the table. While holding and stabilizing the patient's foot in the anatomical position the index finger of the other hand is used to tap over the medial aspect of the ankle just posterior to the medial malleolus where the posterior tibial nerve is most superficial. Production of pain or tingling that radiates along the route of the tibial nerve is indicative of a possible tarsal tunnel syndrome. Posterior tibial nerve compression in the tarsal tunnel will result in referred symptoms to the medial and plantar regions of the foot.

A positive indicates that the posterior tibial nerve had been compromised. The nerve could be undergoing compression as might be seen in inflammation within the tarsal tunnel, or it could be subjected to traction as is found with a hyperpronated foot.

## Neurological Evaluation

### *Myotomes (strength graded 0-5)*

- L4: tibialis anterior
- L5: extensor hallucis longus
- S1 - S2: gastrocnemius-soleus

### *Key Reflexes*

- Achilles tendon reflex- ankle jerk
- Babinski reflex

## Diagnostic Imaging

### *Plain Film Radiography*

**Anteroposterior View of Ankle:** This view shows the shape, position, and texture of the bones of the ankle to delineate possible fractures or new subperiosteal bone.

**Mortise View of Ankle:** The ankle mortise and distal tibiofibular can be visualized.

**Lateral View of Leg, Ankle, and Foot:** This view delineates the shape, position, and texture of the bones, including the tibial tubercle, and allows detection of fractures, new subperiosteal bone, and bone spurs.

**Dorsoplanar View of Foot:** This view mainly projects the forefoot to show the shape, position, and texture of the foot bones.

**Medial Oblique View of Foot:** This view is useful in providing a clear image of the tarsal bones and joints, and the metatarsal shafts and bases.

### *Magnetic Resonance Imaging (MRI)*

Magnetic resonance images are useful in delineating bony and soft tissues around the ankle and foot, and to diagnose ruptured tendons and fractures.

### *Computed Tomography*

Computed tomography (CT) scans for delineating bony and soft tissues and viewing the relationship of these structures in the ankle and foot.

### *Arthrography*

Arthrograms of the ankle are indicated whenever there is acute ligament injury, chronic ligament laxity, or indications of loose bodies.

# Management of Leg, Ankle, and Foot Disorders

## Mobilization

Mobilization of the lower leg, ankle, and foot may be valuable for the relief of foot pain, including pain due to either hypomobility syndrome or entrapment neuropathies. All accessory and passive movement of the leg, ankle, and foot can be applied.

### *Joint Play Movements*

Joint play or accessory movements of the leg, ankle, and foot are intended to assess joint play characteristics and can be used as small amplitude oscillatory movements to improve joint space to address hypomobility, restricted movement, and pain. Each particular accessory movement has a specific purpose to affect the joint for which it is applied.

### *Passive movements*

Passive movements involving mobilizing the lower leg, ankle, and foot are used when a wider range of motion needs to be applied to reduce pain and increase mobility. Mobilization by use passive movements are applied over a range of small and large amplitudes are graded from I to V as noted in Table 4.1.

## Needling Therapy for Leg, Ankle, and Foot

### *Lower leg*

Candidate local and adjacent, proximal and distal nodes considered in treatment of leg pain and numbness are summarized in Table 17.5. Nodes are listed with respect to addressing problem within the medial, posterior, anterior or lateral muscular compartments, consistent with the muscular distributions. Electroneedling (EN)

Table 17.5. Regional, proximal and distal nodes for treatment of lower leg pain and numbness

| Leg Pain and Numbness | Candidate Local & Adjacent Nodes | MD* | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| Medial | Zhubin (PMF 9)<br>Chengshan (PLF 57) | | Shenshu (PLF 23) | Taichong (MF 3) |
| Posterior | Chengshan (PLF 57)<br>Feiyang (PLF 58) | PLF | Pangguanshu (PLF 28) | Shugu (PLF 65) |
| Anterior | Zusanli (ALF 36) | ALF | Weishu (PLF 21) | Xiangu (ALF 43)<br>Taichong (MF 3) |
| Lateral | Yanglingquan (LF 34) | LF | Danshu (PLF 19) | Zulinqi (LF 41) |

*MD = Muscular Distribution

### *Candidate Electroneedling (EN) for Leg Pain*

**Frequency:** 2 Hz

**Mode:** Continuous

**Duration:** 20-30 minutes

**Lead Placement:**

Medial:

- Zhubin (PMF 9) + lead to Taichong (MF 3) – lead

Posterior:

- Feiyang (PLF 58) + lead to Shugu (PLF 65) – lead

Anterior:

- Zusanli (ALF 36) + lead to Xiangu (ALF 43) – lead

Lateral:

- Yanglingquan (LF 34) + lead to Zulinqi (LF 41) – lead

### *Ankle*

Candidate local and adjacent, proximal and distal nodes considered in treatment of ankle pain and dysfunction, with respect to the muscular distributions are summarized in Table 17.6.

Table 17.6. Regional, proximal and distal nodes for ankle pain and dysfunction

| Ankle Pain or Disorder | Candidate Local & Adjacent Nodes | MD* | Proximal Nodes | Distal Nodes |
|---|---|---|---|---|
| | Jiexi (ALF 41)<br>Shangqiu (AMF 5)<br>Qiuxu (LF 40)<br>Kunlun (PLF 60)<br>Taixi (PMF 3) | PLF | Feiyang (PLF 58)/<br>Pangguanshu (PLF 28) | Jinmen (PLF 63) |
| | | ALF | Fenglong (ALF 40)/<br>Weishu (PLF 21) | Xiangu (ALF 43) |
| | | LF | Xuanzhong (LF 39)/<br>Danshu (PLF 19) | Zulinqi (LF 41) |
| | | PMF | Zhubin (PMF 9)/<br>Shenshu (PLF 23) | Rangu (PMF 2) |

*MD = Muscular Distribution

***Candidate Electroneedling (EN) for Ankle Pain***

**Frequency:** 2 Hz

**Mode:** Continuous

**Duration:** 20-30 minutes

**Lead Placement:**

Posterior lateral foot (PLF) distribution:

- Feiyang (PLF 58) + lead to Jinmen (PLF 63) – lead

Anterior lateral foot (ALF) distribution:

- Fenglong (ALF 40) + lead to Xiangu (ALF 43) – lead

Lateral foot (LF) distribution:

- Xuanzhong (LF 39) + lead to Zulinqi (LF 41) – lead

Posterior medial foot (PMF) distribution:

- Zhubin (PMF 9) + lead to Rangu (PMF 2) – lead

***Foot and Toe Problems***

Possible local and adjacent, proximal and intermediate nodes to be considered for treatment of pain and numbness of the foot and toes are summarized in Table 17.7.

Table 17.7. Regional, proximal and intermediate nodes for pain and numbness of the foot and toes

| Toe Pain and Numbness | Candidate Local & Adjacent Nodes | MD | Proximal Nodes | Intermediate Nodes |
|---|---|---|---|---|
| | Shugu (PLF 65) | PLF | Pangguanshu (PLF 28) | Feiyang (PLF 58) |
| | Neiting (ALF 44) | ALF | Weishu (PLF 21) | Fenglong (ALF 40) |
| | Xiaxi (LF 43) | LF | Danshu (PLF 19) | Xuanzhong (LF 39) |
| | Gongsun (AMF 4)<br><br>Bafeng (Extra) | PMF | Shenshu (PLF 23) | Zhubin (PMF 9) |

***Candidate Electroneedling (EN) for Toe Pain and Numbness***

**Frequency:** 2 Hz

**Mode:** Continuous; may also consider 2Hz - 25Hz mixed mode for numbness

**Duration:** 20 - 30 minutes,

**Lead Placement:**

Posterior lateral foot (PLF) distribution

- Feiyang (PLF 58) + lead to Shugu (PLF 65) – lead

Anterior lateral foot (ALF) distribution

- Fenglong (ALF 40) + lead to Neiting (ALF 44) – lead

Lateral foot (LF) distribution

- Xuanzhong (LF 39) + lead to Xiaxi (LF 43) – lead

Posterior medial foot (PMF) distribution

- Zhubin (PMF 9) + lead to Gongsun (AMF 4)/Rangu (PMF2) – lead

## Remedial Exercises for Muscles Moving the Foot and Ankle Joint

The principal movements of the foot involve dorsiflexion and plantar flexion for walking and other activities (See Table 17.3). Muscles of the foot also provide movements of inversion and eversion to allow the foot to adapt to non-level surfaces. Extension and flexion of the toes are also critical to the function of the foot and ankle.

### Ankle Dorsiflexion

The tibialis anterior, extensor digitorum longus, and peroneus tertius muscles are the prime movers in dorsiflexion, with extensor hallucis longus muscle having an assistant role. Dorsiflexion is exercised with the subject seated and feet on the floor. Foot is dorsiflexed to the fullest extent possible and held in this position for 2 - 3 seconds with the ankle remaining on the floor. The lower leg is then lowered to the start position. Foot is then returned to the floor. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other foot. As strength increases, and no pain is present as result of this exercise, light strap-on ankle weights can be placed on the foot dorsum to increase the resistive load.

The dorsiflexors can also be exercised by negative stretch contraction with the subject placing their toes on the edge of a step or flat object that is about 2 inches thick. The plantar flexors are contracted to lift the ankles up and putting the dorsiflexors into a stretch contraction. This approach actually is directed at strengthening plantar flexion as described below.

### Ankle Plantar Flexion

The gastrocnemius and soleus muscles are the prime movers for plantar flexion with the tibialis posterior, peroneus longus, peroneus brevis assisting this movement. Plantar flexion is an essential function for walking and running served mainly by the strong and large soleus and gastrocnemius muscles, while dorsiflexion is mainly to lift the foot up while the leg is being forward in dorsiflexion to start the next step. Plantar flexion can be exercised in the seated or standing position.

With the subject seated and feet flat on the floor, one heel is lifted up off the floor thereby lifting the leg by plantar flexion to the maximum extent possible and held for 2 - 3 seconds. Heel is then lowered to the floor. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other foot. As strength increases, and no pain is present as result of this exercise, a resistance load can be applied to the top of the flexed knee to increase the resistive load. This added load can be applied by subject pushing down on the target knee.

In the standing position with both feet on the floor the subject lifts both heels off the floor by plantar flexion to the maximum possible and held for 2 - 3 seconds. Heels are then lowered to the floor. This exercise can be repeated 5 - 10 times for 3 - 5 sets. Repeat exercise with other foot. Subject may have to steady body by placing one hand on a wall or other structure.

As strength increases and no pain is present as result of this exercise, the subject alter the setup by placing their toes on the edge of a step or flat object that is about 2 inches thick. The plantar flexors are contracted to lift the ankles up and putting the dorsiflexors into a stretch contraction. Subject may still have to steady body by placing one hand on a wall or other structure.

As a further modification of this routine the subject can be performed the standing dorsiflexion by standing on a single foot at a time. This can be performed starting with the feet flat on the floor or with toes on a step or flat 2 inches thick solid object.

### Foot Inversion

The tibialis anterior and posterior muscles are the prime movers in foot inversion with the extensor hallucis longus, flexor hallucis longus, and flexor digitorum longus serving as assistant movers. Foot inversion can be exercised from a seated or standing position.

With the subject seated and feet flat on the floor, the medial aspect of the foot is lifted up off the floor thereby inverting the foot to the maximum extent possible and held for 2 - 3 seconds. Foot is then lowered to the floor. This exercise can be repeated 8-16 times for 3 - 5 sets. Repeat exercise with other foot. As strength increases, and no pain is present as result of this exercise, a resistance load can be applied to the top of the flexed knee to increase the resistive load against foot inversion. This added load can be applied by subject pushing down on the target knee.

### Foot Eversion

The extensor digitorum longus, peroneus tertius, peroneus longus, and peroneus brevis are the prime movers in foot eversion. Foot eversion can be exercised from a seated position. With the subject seated and feet flat on the floor, the lateral aspect of the foot is lifted up off the floor thereby everting the foot to the maximum extent possible and held for 2 - 3 seconds. Foot is then lowered to the floor. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other foot. As strength increases, and no pain is present as result of this exercise, a resistance load can be applied to the top of the flexed knee to increase the resistive load against foot eversion. This added load can be applied by subject pushing down on the target knee.

### Remedial Exercises for Muscles Moving the Toes

The toes much like the case for the finger are small and light weight and not particularly affected by gravity. Also, unlike the fingers, it is difficult to exercise individual toes. The toes are exercised in flexion and extension together. It is even more difficult to exercise the intrinsic muscles of the foot. Functions of the intrinsic muscles of the foot are noted in Table 17.4. Deficits in extension, flexion, abduction, and adduction of the toes can be determined by comparing the intrinsic muscle function.

### Toe Extension

The prime movers for extension of the great toe and second through fifth toes are the extensor hallucis longus and extensor digitorum longus muscles (See Table 17.4). Toe extension exercises can be performed with the foot flat on the floor and then extending all toes to the maximum extent possible and hold for 2 - 3 seconds. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other foot.

### Toe Flexion

The prime movers for flexion of the great toe and second through fifth toes are the flexor digitorum longus and flexor hallucis longus muscles (See Table 17.4). Toe flexion exercises can be performed with the heel on the floor with the ball of the foot slightly lifted off the floor and then flexing all toes to the maximum extent possible and hold for 2 - 3 seconds. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other foot.

Toes can also be exercised where flexion of all toes is immediately followed by toe extension and held the end position for both directions for 2 - 3 seconds. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other foot.

### Abduction and Adduction

The intrinsic muscles that abduct and adduct the toes are noted in Table 17.4 including the dorsal interossei and plantar interossei muscles. Abduction and adduction of the toes is performed with one heel on the floor with the ball of the foot slightly lifted up (slight dorsiflexion). All the toes are then abducted and held for 2 - 3 seconds and then adducted and held for 2 - 3 seconds. This exercise can be repeated 8 - 16 times for 3 - 5 sets. Repeat exercise with other foot.

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# Appendix A. Application of Electrostimulation

Use of electrostimulation in treating orthopedic and other conditions with needling therapy (acupuncture) involves the application of electrical stimulation to conductive needles inserted into various locations of the superficial body. This is a form of percutaneous electrical nerve stimulation (PENS) which is also referred to as electroneedling (EN). Therapeutic use of EN started being popularized around 1958 when China started using small electrical devices attached to needles inserted through the skin (percutaneous) to treat a wide range of medical conditions, and even using it to induce surgical analgesia. Small amounts of adjuvant drugs that enhance the effect of needling were often required to produce acceptable levels of analgesia for surgery.

Since Chinese needling therapy is based on a physiological understanding on how the human body functions in health and disease, and a keen insight into how the bodily systems are organized, including the importance of somatovisceral relationships, it seems natural to rely on the superficial location of neurovascular nodes (acupoints) that are a hall mark feature of Chinese medicine. Having thousands of years experience in treating every known disease affecting the human population by their understanding of the neurovascular nodes of the superficial body, the Chinese simply added electrical stimulation to a few key nodes used in particular treatment protocols to enhance the effect of needling therapy. Chinese percutaneous stimulation is called acupuncture by the West, which is of itself another Latin term (acus-needle + punctura-puncture) that means percutaneous needle insertion.

## Early use of Electrical Stimulation

The ancient Egyptians and Greeks may have been the first to use electrical stimulation for therapeutic purposes, by the application of electric fish. A depiction of malopterurus electricus (Nile catfish) is prominently displayed in an Egyptian tomb relief dated to the Fifth Dynasty, ca.2750 BCE. Both gnathonerus petersi and torpedo ray were depicted on ancient green pottery (Greek pinax) which were honored and feared for their unusual ability to numb the senses.

### Therapeutic Use

In Hippocrates times electric fish could be stepped on or placed on a particular body location, such as the low back or forehead, to treat particular pain conditions. The Greeks provided the earliest known written records of using electric fish for pain relief. Aristotle noted:

> "The torpedo ray is known to cause numbness, even in humans."

Both Pliny (*Natural History*) and Plutarch (*Morales*) refer to the numbing effects of the ray. Seribonius Largus (ca. 46 CE) advocated electrotherapy for pain relief and preventative measures:

> "For any type of gout, a live black torpedo ray should, when pain begins, be placed under the feet. The patient must stand on a moist shore washed by the sea, and he should stay like this until his whole foot and leg, up to the knee, is

> numb. This takes away present pain and prevents pain from coming on if it has not already arisen.
>
> Headache, even if it is chronic and unbearable is taken away and remedied forever by a live torpedo ray placed on the spot which is in pain, until the pain ceases. As soon as numbness has been felt the remedy should be removed lest the ability to feel to be taken away from the part."

### Features of Electric Fish

The electrical characteristics of electric fish are for defensive purposes against human, animals, and other fish. Typical output properties consist of pulse trains with voltage amplitude levels ranging from 1-350 volts (40-50v for the torpedo ray). Pulse characteristics show a low frequency component of 200 Hz and a higher frequency at 1000 Hz. Pulse trains can range from 100 to several thousand. These outputs are specifically directed at producing significant pain and dysfunction for any unfortunate critter or human that comes in contact with an electric fish.

### Defining Electricity

The term "electric" was coined by the English physician William Gilbert in 1600 to describe some static electrical effects, distinguishing them for the first time from magnetism. This term was derived from the Greek word *eleckrom* for amber since it had been known from Roman times that rubbing amber with a dry cloth could produce a static electric discharge. Otto Von Guericke built the first electrical machine in 1660. Luigi Galvani (1737-1798), an Italian physician and physiologist, caused a skinned frog leg to twitch when touched by two bars of dissimilar metal, when held together at their ends. The therapeutic use of a unidirectional direct current supplied by a chemical battery became known as Galvanism. Alessandro Volta (1745-1827) developed the voltaic pile and voltaic battery. However, the discovery of 2000 year old batteries in Baghdad in 1936 indicates a very early discovery of electrical devices in human history. These batteries may have been used for electroplating instead of therapeutic use, but then again, no one really knows what they were used for.

### Early Western Interest in Electrotherapeutics

Interest in applying electrical devices to treat human ailments in Europe and the United States evolved simultaneously with the exploration and understanding of electrical phenomena from 1600 to the late 1800s. Machines of various types were developed. These involved direct current (Galvanism), alternating current (Faradism), devices which employed static electricity (Franklinism, after Benjamin Franklin, 1706-1790), and capacity storage techniques. A wide range of disorders were treated including paralysis, defibrillation, nerve stimulation, resuscitation, and pain conditions, up to the early 1800s. Then a few French practitioners, including Sarlandiere le Chevalier (1825), started experimenting with Chinese needling therapy based on the 1683 treatise of Willem ten Rhijne on acupuncture.

Sarlandiere le Chevalier was perhaps the first to hook up an electrical device to inserted needles. This is the first known application of PENS. Transcutaneous electrical nerve stimulation (TENS) with conductive pads was also applied during this time. Use of PENS was investigated in Italy shortly thereafter by da Camino (1834, 1837). However, by the year 1900 PENS induced electroanalgesia promoted by Sarlandiere and da Camino was already in disrepute. In 1958 the Chinese reintroduced EN and used it to treat many common ailments, dental disorders, nerve dysfunction, paralysis, substance withdrawal, musculoskeletal conditions, and to induce surgical analgesia. Many practitioners of Chinese needling therapy in the United States and Europe presently use EN in their normal clinical routines.

### Discovery of Neuromuscular Attachments

One interesting outcome from the early use of electrostimulation was the observation of Guillaume Benjamin Amand Duchenne de Boulogne (1806-1875) that stimulation of specific small areas on the body could elicit muscular contractions. These locations became known as "points of election." Both Hugo Wilhelm Von Ziemssen (1829-1902) and Wilhelm Heinrich Erb (1840-1921) continued these studies and began to plot the location of these points. These sites were mapped out on agonal patients (those about to die) for dissection immediately after death. These locations were found to correspond to the entrance of nerves supplying muscles (motor points).

## Features of Typical Unit

Electrostimulation is usually applied by percutaneous means with leads of a simple, battery powered, pulse waveform output device connected to inserted needles. Positive and negative wire leads are attached by suitable clips to inserted needles. Output frequency and amplitude of electroneedling (EN) units are adjustable and they have several operational modes with respect to output pulse patterns. Many devices are similar to transcutaneous electrical nerve stimulation (TENS) units, although output characteristics may vary. Application of TENS uses conductive pads applied to the skin, in lieu of needles. Needles are generally inserted at known neurovascular nodes that address the segmental and axial relationships of the body as described by the Chinese. Selection of nodes follows the same principles of application as normal needling therapy, but often fewer needles need to be employed. There are other approaches to the application of EN, but most still rely on the segmental and axial relationships of the peripheral and central nervous system.

### Output Leads and Clips

Output leads of an EN device usually have a clip on the terminal end which is capable of grasping the metal shaft of the inserted needle, or needle handle if it is made of metal. These clips sometimes have opposing metal jaws with serrated edges and are referred to as "alligator clips." Other clips have opposing smooth surfaces (duck bill clips) and some are simply constructed from spring steel wire.

### On-Off Switch Control and Mode Selections

Most EN devices have a master on/off switch and two or four outputs, with a positive and negative lead associated for each output. Most units also have a mode select function to provide a range of different output pulse patterns usually consisting of:

- Continuous Output
- Discontinuous (Intermittent) Output

- Mixed Frequencies (Dense Disperse)

## Waveform Characteristics

Units are battery powered (6-9 v.) and use a pulse transformer design to increase output voltage. This type of circuit produces a pulse which has both a positive and negative voltage component (See Figure A.1). The pulse wave output can be adjusted in amplitude from zero volts to a level necessary to activate EN induced processes.

### *Biphasic Pulse*

Output of typical circuit produces a biphasic waveform consisting of a near square wave positive portion followed by a negative attenuated spike.

### *Pulse Width*

Width of the positive pulse is usually a fixed value of 0.2-0.4 ms. Pulse widths greater than 0.6 ms. have a greater potential to induce pain by stimulating nociceptive C fibers. Areas under the positive and negative portions of the waveform are equal and no net electrical energy is imparted to the body. Purpose of the biphasic pulse is to depolarize and repolarize tissue during each pulse cycle and therefore produces no deleterious effects at local site of needle insertion.

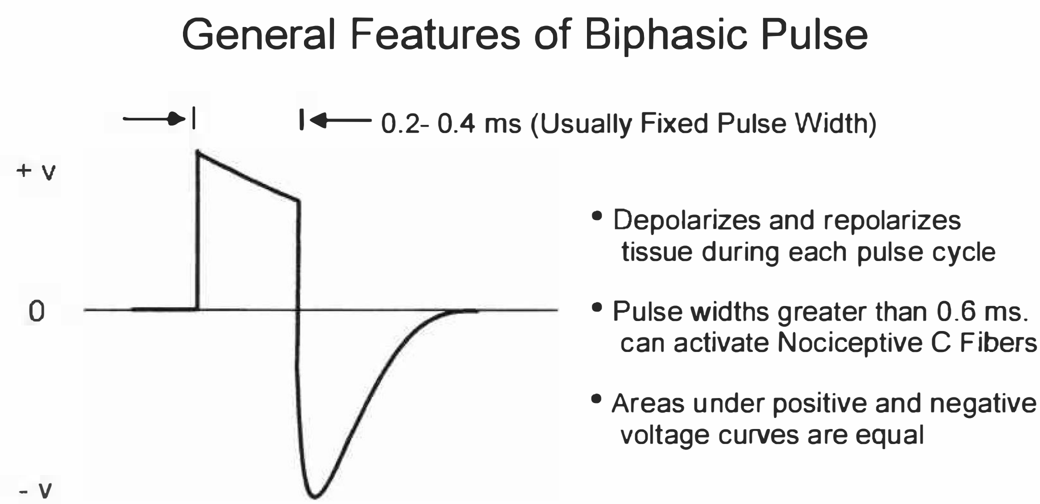


Figure A.1. Characteristics of positive and negative voltage portion of output waveform

## Amplitude Control

Output circuits should have an individual amplitude control capability (potentiometer) to manipulate the output voltage and some have on/off switches on each circuit. Output can be controlled from zero volts to maximum (See Figure A.2). Units can typically produce pulses with positive and negative amplitudes of 60 volts, while the current is limited to a negligible value. Some devices, especially when used for TENS application, produce pulses up to +80 v. and negative spikes of -130 v. Both positive and negative amplitudes increase and decrease together proportionately as the output is adjusted.

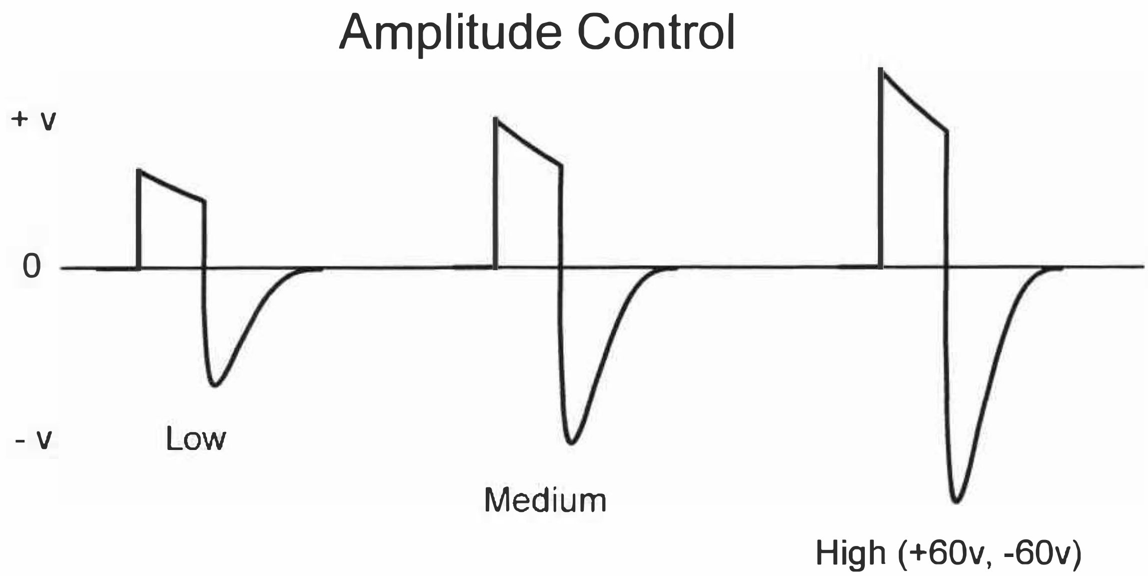


Figure A.2. Change in output signal as result of increasing or decreasing amplitude

**PRECAUTIONS** in controlling **Amplitude** include:

- It is necessary to make certain that all amplitude settings are at zero volts and unit is turned off before connecting leads to needles
- It is important to zero out (turn down) the amplitude before disconnecting the leads from needles or turning the unit off
- During initial application the amplitude is only adjusted to the level that the patient can just feel the sensation or the practitioner observes slight movement of the needle
- Be aware that in some cases of pain and also paralysis the patient may have impaired ability to feel the stimulating signal
- Patient needs to be checked on every few minutes after initiating treatment, and practitioner must be aware of recruitment phenomena of motor fibers

Recruitment is the phenomena where electrostimulation of a few muscle fibers eventually causes some of the adjacent fibers in the same muscle to start contracting in unison. More and more fibers can also be recruited until the entire muscle is contracting.

### Frequency Control

Devices usually have a frequency control capability that is common to all outputs in order to select appropriate stimulation in terms of number of pulses\second (See Figure A.3). Most biological and neural processes that beneficially respond to needling therapy and EN involve low frequency responses. Most EN devices provide either a range of selectable fixed frequencies or have an adjustable frequency capability. Useful selected fixed frequencies by means of a rotary switch range from 0.1, 1, 2, 10, 25, and 100 Hz, with some units providing considerably higher frequency settings at 1,000 to 1,500 Hz. Some devices have a rotary potentiometer type control that provides a smooth frequency change over a narrow or wide range. It is difficult to select a precise and repeatable frequency with this type of control. Increasing the output signal frequency causes an increase in the intensity that the signal has on the body, and the subjective feeling experienced by the patient.

**PRECAUTIONS** in controlling **Frequency** include:

- When increasing the frequency during treatment, where the amplitude has been adjusted to address patient comfort and utility for the actual treatment, it is necessary turn down the signal amplitude on all outputs being used before switching to the desired higher frequency
- After increasing the frequency, the amplitude for all outputs then need to be readjusted as necessary for therapeutic effect following the precautions for amplitude control as previously described above
- Increasing the frequency without a corresponding reduction of the amplitude can lead to inducing stress analgesia

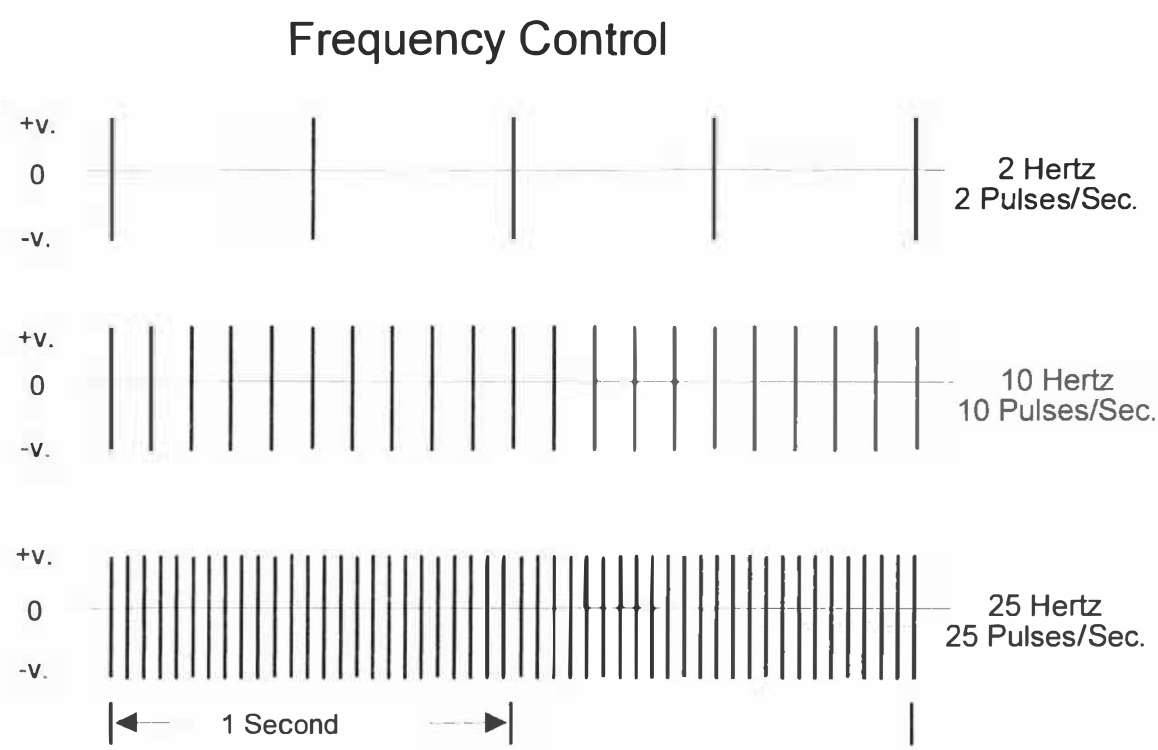


Figure A.3. Typical pulse patterns of selected frequencies

## Pulse Patterns

Most EN devices provide several different variations in output pulse patterns that offer certain advantages for specific type of treatments. Typical patterns include continuous, intermittent (discontinuous), and mixed (dense dispersed) operating modes (See Figure A.4).

### *Continuous*

Continuous wave output pattern is characterized by a steady train of output pulses at a constant frequency selected by the practitioner. This is the most common and useful operating mode applicable to standard clinical situations.

### *Discontinuous (Intermittent)*

The discontinuous or intermittent pulse profile consist of an output signal at the selected frequency that is on for only about three seconds followed by no output for about three seconds. This on-off pattern continually alternates as long as the discontinuous pattern is selected.

**PRECAUTIONS** in controlling **Discontinuous Mode Adjustment**:

- Amplitude in discontinuous mode is adjusted only during the "on cycle" period of operation
- Frequency is only changed during the “on cycle” period consistent with turning down the output amplitude before increasing the frequency and then readjusting the amplitude

### *Mixed (Dense Dispersed)*

In the mixed mode of operation a selected output frequency is provided for a short duration (approximately 3 seconds) followed by lower frequency for the same duration. The high and low frequencies portions of the mixed pattern continually alternate. In mixed mode, most devices only require selection of the high frequency with automatic generation of the low frequency component. Some devices allow selection of the low frequency setting as well.

**PRECAUTIONS** in controlling **Mixed Mode Amplitude**:

- Amplitude is only adjusted during the high frequency "on" period of the mixed cycle

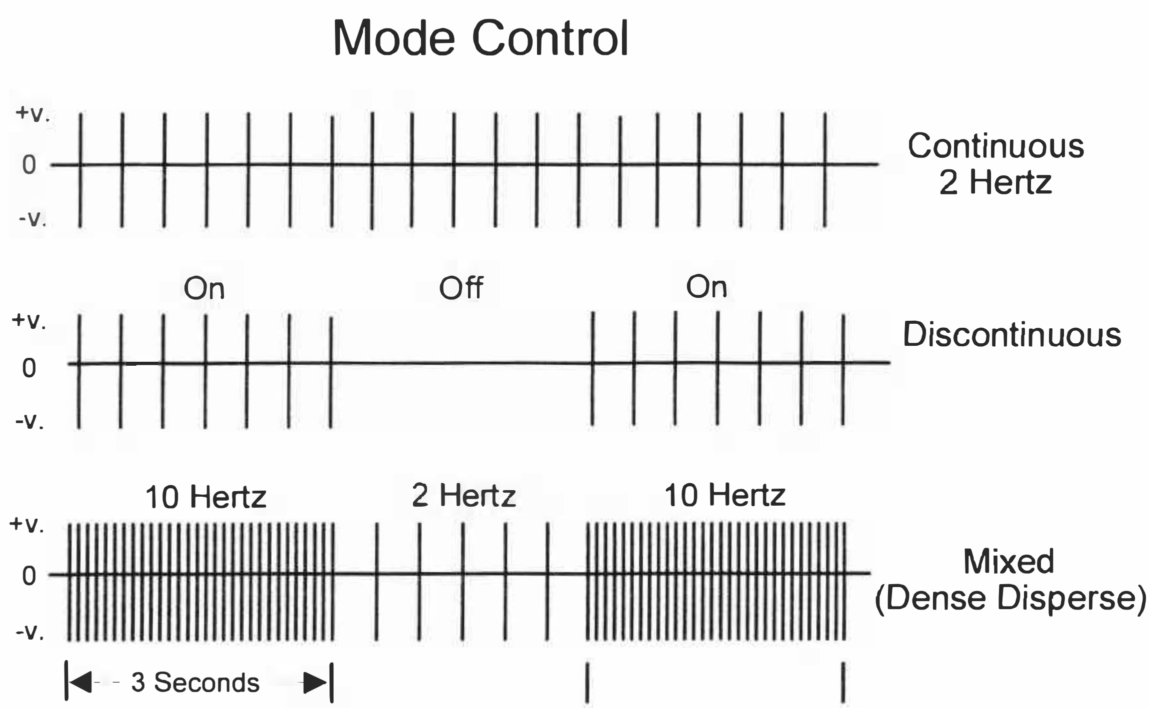


Figure A.4. Typical operational output modes

## General Operational Guidelines

The physiological features of the body allow the use of simple, rational, repeatable rules for the application of EN. This includes proper placement of the output leads to achieve the best therapeutic effect while at the same avoiding unwanted current paths in the body. Perhaps the most important consideration in the use of EN, and needling therapy in general, is the selection of candidate neurovascular nodes (acupoints) to be employed to achieve the best clinical outcome for the patient's condition. A rational approach for node selection is discussed in the following section. The first consideration is to decide if EN is appropriate for the presenting complaint and if it is suitable for the specific patient. Duration of treatment, output amplitude, output frequency, and selection of proper operating mode also need to be considered.

### When to Consider Using Electroneedling (EN)

Generally the application of EN stimulation greatly enhances the effect of needling therapy and can increase level of analgesia and significantly extends the period of treatment effectiveness. Insertion of needles into neurovascular nodes stimulate afferent proprioceptive and nociceptive fibers that activates spinal afferent processes eventually provoking descending control signals from the brain. The net effect is to restore visceral homeostasis, normalize autonomic balance, normalize blood flow, inhibit pain, reduce muscular contractions, and normalize motor functional activities. When very small electrical signals are applied to the needles this continuously supplies uninhibited signals along the afferent pathways to provoke stronger descending control.

In some individuals, EN induced analgesia is suitable for use in surgery or as an adjuvant to normal anesthetics. It is especially effective in reactivating neural centers habituated by drug and substance use. Use of EN can also be applied to enhance cervical dilatation and uterine contractions to induce labor. Stimulation promotes tissue repair and healing essential to treat many chronic disorders as well. In addition, EN application promotes regeneration of nerve fibers in situations where cell bodies of damaged nerves are still vital.

### Electroneedling (EN) as a Secondary Consideration

In the normal course of needling therapy the patient typically receives a series of three to seven or even more treatments depending on the particular condition. The effect of needling is somewhat transitory with some percentage of improvement being achieved on each treatment. It is important for the practitioner to evaluate the patient at each treatment to gage the case progress. This provides additional information to the practitioner and sometimes indicates the need to slightly alter the protocol to address the progressive improvement in the condition.

If the patient condition is improving as expected then the case would normally achieve the projected clinical outcome. On the other hand, if the case is not proceeding as expected or is not responding after three treatments, the application of EN would then be considered. Some practitioners apply EN as a primary modality for pain and musculoskeletal problems because of its ability to produce a strong analgesic effect. This may be appropriate for some cases but generally the immediate analgesic effect could mask valuable diagnostic information.

### Electroneedling (EN) as a Primary Consideration

The application of EN is a primary consideration in those situations where a profound analgesic effect is desired, such as in surgical or dental procedures. Use of EN can also be a primary consideration when employed in treating nerve dysfunction, paralysis, and atrophy. Use of EN is very effective in treating withdrawal symptoms of individuals quitting the use of addictive substances such as nicotine, alcohol, cocaine, opiates, and some prescription drugs. Practitioners often receive musculoskeletal case referrals that have been through a series of different treatment modalities. Usually these cases have accumulated significant diagnostic information, including laboratory tests and diagnostic imaging results. The condition of the patient is generally well known and hence the use of EN can be primary consideration.

### Placement of Leads

Physiological organization of the body that is critical to afferent and efferent processes affecting the vessels, viscera, muscles, and peripheral nerves is basically longitudinal and ipsilateral in nature. This feature is consistent with the physiological view of Chinese medicine. The spinal afferent processing system that provides ascending signals to the brain is basically ipsilateral. However, there is about a 40% crossover on the descending control restorative signals. This crossover features allows treatment of the opposite side to the one containing a problem to benefit the affected side, especially where the patient cannot tolerate direct treatment of the affected side. However, the ipsilateral nature of the ascending afferent signals dictates placing the positive and negative leads of one particular output channel of the EN device along vertical pathways on the same side of the body.

Application of EN, therefore, is directed to apply signals along these same longitudinal pathways in the body to obtain expected clinical effect. Leads are thus placed to enhance stimulated reactions to propagate along longitudinal pathways. One principal goal in lead placement is to conform which the segmental and axial organization of the body while making certain to prevent cross currents. Cross currents are to be avoided especially in preventing transcranial current pathways. It is also important not to generate cross currents through any of the major nerve plexuses, such as the brachial and lumbar plexuses.

This is accomplished by placing the positive and negative leads of one particular output channel of the EN device along vertical pathways on the same side of the body. If the presenting problem is ipsilateral in nature, such as pain in one shoulder, the positive and negative leads are placed at appropriate locations along the affected muscular pathway. If the problem is bilateral, such as low back pain, then one set of positive and negative leads, are placed on one side of the back, and another set placed at the same relative locations on the other side. In this situation it is necessary for both positive and negative leads to be located at the same relative level. If not, then cross currents could possibly develop from one channel output to the other. One easy rule is to always place the positive lead (red) on the upper location and the negative (black) on the lower aspect.

### Duration of Electroneedling (EN) Stimulation

Typical duration of EN application is 15 – 30 minutes. In cases of dental or surgical analgesia, the duration may by longer. In treatment of withdrawal from a powerful opiate, the duration may be increased to 45 minutes and applied twice a day for 3-4 days. Applying either EN or TENS stimulation for several hours in any one day can lead to tolerance and loss of any further therapeutic effect until the central nervous system is allowed to recover. This may require several days. When intermittent or discontinuous mode is applied, stimulation duration can be longer.

### Amplitude

Under most conditions, amplitude of the output signal is only adjusted to the level that the patient can detect a slight sensation that feels like tapping on the skin. In many cases of trauma and pain there may be a deficit in sensory perception. These patients may not feel the electrical signal even though strong muscular contractions are activated. Thus, amplitude is adjusted only to the level where either the patient feels a slight sensation or the practitioner observes small movements of the needle or perhaps very slight muscular contractions. Excess strength of stimulation can induce a stress response.

In addition, muscular tissue activated by electrical stimulation can sometimes recruit adjacent fibers to start contracting. If the signal amplitude is not reduced, very strong unwanted muscular contraction can be induced. This can result in worsening of the condition being treated. Patients should be checked every few minutes to assure their comfort and safety.

After several minutes of stimulation, control signals generated in the body, reduce the response to the stimulus and the patient no longer feels the EN stimulus. Thus, the amplitude is periodically readjusted to maintain an awareness of a slight tapping sensation. The control response generated by the body is mediated by descending neural pathways in the spinal cord. This is the prime effect that is sought in the treatment of all problems, including musculoskeletal and viscera conditions.

### Frequency and Operating Mode

Endogenous pain and autonomic control centers in the brainstem operate around 0.5-4 Hz. and stress can be induced above 12-14 Hz. when applied to the brainstem area. In addition to endogenous pain control, humans and animals also have stress analgesic mechanisms that can be invoked at about 100 Hz. This seems mostly operative at specific spinal segmental regions and may involve different neurotransmitters at different segmental levels. This endogenous system may be responsible for providing analgesia in severe trauma and/or provides for merciful predation. If chronic pain patients are treated by induced stress analgesia, they feel fantastic at first but later the problem gets worse. So care needs to be taken not to induce stress by either excess amplitude or using frequencies that are too high.

Low frequency application (2 Hz.) always invokes the analgesic and restorative processes of needling therapy. This frequency (2 Hz.) is suitable for use in treating all pain conditions, substance abuse, osteoarthritis, rheumatoid arthritis, vascular or blood distribution problems and organ dysfunction. Higher frequencies (25-50 Hz.) are selected where nerve dysfunction or paralysis is involved and this is usually in conjunction with a low frequency (mixed mode). Frequencies of 25 Hz. and above can produce tonic contraction of muscles and is useful in treating certain muscular conditions when applied in discontinuous or mixed mode. General considerations of mode selection involve the following:

**Continuous mode:** Used for most conditions, especially in treating pain, substance withdrawal symptoms, visceral problems, inducing labor, and using EN for surgical analgesia.

- Normal treatment duration is about 20-35 minutes and there is little risk of developing tolerance even if this is applied several times a day
- When used for surgical or dental analgesia, the duration may be extended
- Tolerance can be produced after many hours of continuous application or in several days with a few hours of daily EN stimulation

**Mixed mode:** Is considered when clinical condition involves paralysis, atrophy, and impairment due to loss of nerve function. Mixed mode can also be applied to enhance segmental levels with the higher frequency component as well as activating axial effects with the lower frequency component.

**Discontinuous mode:** Employed where a longer period of stimulation is needed and also where stimulation is directed strengthen particular muscular areas or treating complex problems such as scoliosis.

- In situations of long duration EN, use of discontinuous mode (about 3 sec. on and 3 sec. off) can be considered to reduce potential of developing tolerance

### Precautions and Contraindications

Profound analgesia induced by electroneedling (EN) puts patients at risk of self injury, and they must be advised or restricted from engaging in strenuous physical activity after treatment. Stimulation by EN is usually contraindicated in patients with cardiac pacemakers, imbedded neural stimulators and other electrical devices used on the body. Electrical stimulation should not be used on lower body or leg points in case of pregnancy, especially during third trimester, except in the case where it is used to induce labor, or used in support of normal labor. High frequency or high amplitude application may induce stress, which is contraindicated in cases of hypertension. Electroneedling (EN) can over sedate older patients causing risk of falling asleep after treatment and therefore these individuals should be driven to and from clinic. Excess EN and TENS can produce tolerance by depleting central serotonin but is not addictive.

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- Not to be used on lower body or leg points in case of pregnancy, especially during third trimester
- High frequency or high amplitude application may induce stress, which is contraindicated in cases of hypertension
- Electroneedling (EN) can over sedate older patients causing risk of falling asleep after treatment; hence patient should be driven to and from clinic, usually by a friend or family member
- Excess EN and TENS can produce tolerance by depleting central serotonin potentially causing exacerbation of the presenting condition