SECTION 1

General principles

SECTION CONTENTS

For any discussion of orthopedic massage to be complete, it is essential to address some fundamental concepts. Section one addresses the basic principles necessary for the practitioner to have a proper context in which to understand the use of massage in treating orthopedic problems. The field of orthopedics is expansive, since it is the branch of medical science that deals with the movement systems of the body. To accurately address pathological problems in locomotor structures, the practitioner must understand how they work in a healthy system as well as when they are injured. A comprehensive discussion of how each of the primary locomotor tissues works in the healthy body is beyond the scope of this text. However, the most common pathological problems with the major locomotor tissues are discussed. Understanding these processes will be essential for the practitioner to identify the nature of most soft-tissue problems, and to determine the appropriateness and application of massage treatment.

This first section also discusses the fundamental principles of massage as a therapeutic intervention. While this text is not meant as an instructional manual in basic massage therapy applications, it is important to include general guidelines about the methods of massage for those who have not had much exposure to it. There are numerous books, videos and educational programs that cover the basics of massage in more detail. The reader is strongly encouraged to get adequate training in basic massage skills before attempting the advanced treatment methods suggested in this text.

Chapter 1

Introduction to orthopedic massage

CHAPTER CONTENTS

Orthopedic massage is a relative newcomer to the many current massage modalities. As a broader category, orthopedic massage applies to treatment of conditions resulting from any number of activities, such as work, sports, or accidents. Current studies show increasing use and acceptance of massage.[1,2] One of the primary reasons for massage's popularity is the success massage has had in therapeutic applications. In the last 50 years massage has developed from a primarily relaxation and stress release solution to a therapeutic modality applied to complicated musculoskeletal disorders.

Orthopedic massage offers practitioners working in this setting an organized and effective approach to handling the greater needs of today's clients. Orthopedic massage practitioners are found working with professional sports and dance teams, in occupational therapy settings, and with physical therapists, chiropractors, and osteopaths. In many cases, massage is proving to be more effective than other modalities for treating certain conditions. In fact, millions of people have sought complementary care for musculoskeletal problems.

Similar to sports massage, there are different systems of orthopedic massage and it has yet to be standardized as one system or approach. Consequently, those educators using the term orthopedic massage to refer to a particular system may or may not be talking about the same thing. While there are distinct differences in these systems, there are also fundamental similarities, particularly assessment, treatment variability, and knowledge of common pain and injuries.

In this text, orthopedic massage is presented as a comprehensive system for the treatment of soft-tissue orthopedic disorders. By system, it is meant that to effectively treat pain and injuries a systematic approach should be employed. As in other orthopedic massage approaches, assessment and technique variety are key components. What sets this system apart perhaps is its emphasis on establishing a physiological rationale for a particular treatment approach or technique. Thus, matching the condition to the treatment is argued to be essential for effective therapeutic solutions. This system also promotes the idea that a full therapeutic treatment must understand and integrate standard rehabilitation protocols for the various soft-tissue dysfunctions. The orthopedic massage system presented in this text is increasingly emerging as a generally accepted model of orthopedic massage as evidenced in trade journal publications and courses taught in schools.

MUSCULOSKELETAL DISORDERS AND MASSAGE

Musculoskeletal disorders (MSDs) are one of the primary reasons people seek medical care worldwide. In the United States MSDs are rampant and are the second most common reason for visits to the doctor, infectious diseases being the first.[3–5] Many of these disorders result from the repetitive demands of work-related activities. These repetitive stress injuries (RSIs), also called cumulative trauma disorders (CTDs), are a pressing burden on our health care system. Estimates suggest RSIs may account for as much as 56% of all occupational injuries in the United States.[6]

Recreational and daily activities place additional strains on the body's soft tissues. Sports, gardening, hobbies, exercise (or lack of), and general household tasks are prime scenarios for developing pain or injuries. Of course, accidents also motivate individuals to seek treatment for musculoskeletal dysfunction. Common conditions include a wide array of soft-tissue problems including strains, sprains, tendinosis, myofascial trigger points, nerve entrapment, and the ever-present host of biomechanical problems resulting from chronic muscle tightness.

Because MSDs primarily affect tissues of the locomotor (movement) system, they are properly classified as orthopedic conditions. Orthopedics is the "branch of medical science that deals with prevention or correction of disorders involving locomotor structures of the body especially the skeleton, joints, muscles, fascia, and other supporting structures such as ligaments and cartilage."[7] With the locomotor soft tissues making up the majority of our body structure, it is no wonder that MSDs are so pervasive.

Physicians, physiotherapists (physical therapists in the USA), occupational therapists, chiropractors, massage therapists, acupuncturists, athletic trainers, nurses, and other movement system specialists treat MSDs. Individuals seeking care for MSDs are increasingly turning to various complementary and alternative medicine (CAM) approaches; particularly massage.[2,8–11,18] In the United States data suggest that individuals visit massage therapists over 114 million times per year.[2]

A 2005 study on the practice patterns of massage therapists found that about 60% of visits to massage therapists each year were for musculoskeletal symptoms.[10] Extrapolating those figures one could estimate over 68 million office visits to massage therapists each year to address MSDs. This number is likely to increase significantly with the aging of the baby-boomer population. Part of the reason for this movement away from mainstream treatment for these conditions is that historically the treatment options offered in that setting focused on drugs and surgery. Critiques of mainstream MSD treatment point to a deficiency in training to address minor musculoskeletal dysfunction.[3,12–14] A result is a gap in effective treatment options.

People are choosing massage treatment because soft-tissue therapy for MSDs is proving to be an effective and comparably affordable option. Massage therapists are the primary group offering massage treatment for MSDs and their hands-on, palpatory skills set them apart from other health care practitioners. Physical therapists help fill the treatment gap and are increasingly adding more manual soft-tissue therapy to their treatment protocols. Practitioners in other fields use massage for soft-tissue treatment as well. In this text we consider massage therapy a practice performed by professionals in a number of fields. In this text, references to practitioner and client designate the individual performing the treatment and the individual receiving the treatment, respectively, regardless of the practitioner's profession.

Unfortunately and for a variety of reasons, appropriate entry-level training for treating MSDs is lacking in massage therapy education. As a result, massage practitioners generally use continuing education seminars and workshops to improve their skills and knowledge in this area. However, the education gained in continuing education courses often does not go past simply amassing an arsenal of new treatment techniques. Clinical reasoning and analysis, in addition to sound knowledge of anatomy, physiology, and MSDs, are essential for effective treatment.[15,16]

Given the new popularity of massage as a pain and injury treatment, the goal of massage education today should be proper training at the entry and advanced levels. It is important to remember that while massage is generally a safe treatment, it is not benign. Massage produces effects; these effects can be beneficial or adverse. The first test of a qualified practitioner is the ability to determine the appropriateness of massage as a treatment for a condition. The better a practitioner understands anatomy, physiology, kinesiology, and massage treatment, the more likely that person is going to be capable of creating an effective treatment plan. For both practitioners and massage educators, this text provides a solid foundation in knowledge, skills, and abilities in using massage therapy for relieving the pain and suffering of common musculoskeletal disorders.

WHAT IS ORTHOPEDIC MASSAGE?

The orthopedic massage system presented here offers practitioners a systematic and effective approach to treating pain and injuries. *Orthopedics* is the "branch of medical science that deals with prevention or correction of disorders involving locomotor structures of the body especially the skeleton, joints, muscles, fascia, and other supporting structures such as ligaments and cartilage."[7] Thus, orthopedic massage is a modality that seeks to address *orthopedic conditions* – those pain and injuries affecting the locomotor soft tissues.

Orthopedic massage is often referred to as a comprehensive system. What this means is that an orthopedic massage approach moves beyond a focus on a particular technique to include a more comprehensive approach to rehabilitation. The orthopedic massage system presented here includes several key components: assessment, treatment technique variety, knowledge of conditions and physiology, understanding of the physiological effects of techniques, and rehabilitation protocols.

Similar to the learning of any skill, orthopedic massage takes practice and continual learning. Yet, becoming a superior clinician working with orthopedic disorders is a far greater challenge. One constantly faces unique clinical decisions that require creative thought and analysis. The ability to mentally step away from routine and assumptions, and apply analytical thought processes is the mark of an advanced clinical massage practitioner. Combining foundational knowledge with clinical decision processes allows the practitioner to adapt to the unique presentations of the client. This over-arching skill is a critical component of competent soft-tissue therapy.

THE FOUR PRIMARY COMPONENTS OF ORTHOPEDIC MASSAGE

Four components characterize the system of orthopedic massage: (1) orthopedic assessment; (2) matching the physiology of the tissue injury with the physiological effects of treatment; (3) treatment adaptability; and (4) appropriate use of the rehabilitation protocol.

Orthopedic assessment

A critical component to any orthopedic massage system is ***assessment*** and evaluation. Assessment is more than an abbreviated interview. Client expectations of massage therapists today demand more thorough evaluation skills. Massage practitioners who treat clients with either mild or more severe pain or injuries must develop the skills necessary to assess the nature of the client's condition and continue to evaluate it through the progression of treatment. A practitioner should never assume that a client's pain or discomfort is a matter of simple tension or stress. Initial assessment evaluates the appropriateness of massage in addition to the nature of the complaint.

Figure 1.1 Assessment is a crucial component of orthopedic massage.

Assessment does not need to be a drawn out activity. Indeed, sometimes evaluations are quick and simple. However, having the capability to pursue the suspicion of something more involved requires assessment knowledge and skill. Without knowing more about a client's condition, treatment becomes guesswork based on assumptions, not critical reasoning and thinking. Even with a physician's diagnosis, the skilled practitioner should be able to perform their own evaluation in order to gain the information needed for treatment.

While there can be basic treatment protocols for most conditions, treatment approaches should not be condensed into simplistic recipes. Orthopedic massage promotes the use of scientific and research-based knowledge in its treatment protocols. Sufficient and valid knowledge and understanding of the locomotor system, its tissues, and common pain and injury conditions is a prerequisite for orthopedic massage. Without adequate understanding of soft-tissue function, treatment may be at minimum futile and at worse complicate the condition. The goal of treatment is to reduce symptoms and improve tissue function in the involved tissues. This requires the practitioner should have some inclination as to the nature of the tissue pathology. Assessment also allows the practitioner to determine if massage is in fact appropriate for the condition and to refer the client to another health care provider if massage is contraindicated.

Assessment is ***the systematic process of gathering information to make informed decisions about treatment***. Treating pain and injuries requires the practitioner be able to assess the nature of the condition and understand its physiological characteristics. Fundamental questions about a condition are often answered in assessment; this allows the practitioner to make educated treatment decisions. What tissues are involved, and how, and the status of those tissues can be revealed through a proper evaluation. In the simplest terms, the practitioner should know whether the tissues involved are muscle, fascia, tendon, ligament, joint capsule, nerve, cartilage, or bursa.

A practitioner can also evaluate the potential type of dysfunction in the tissue (tear, hypertonicity, myofascial trigger point, strains, sprains, nerve conduction impairment, etc.). Evaluating the biomechanical forces that produce these tissue effects will also help the practitioner understand the status of the tissues. Assessment provides the practitioner with important information about the client's tissues in order to create a clinically sound treatment plan.[17]

Box 1.1 Basic Assessment Tools

History
Observation
Palpation
Range-of-Motion and Resistance Testing
Special Tests

There is a distinct difference between assessment and diagnosis. A physician uses assessment and the information gathered to determine a diagnosis. Diagnosis is the identification and labeling of a disease, illness or condition made by a licensed medical professional. Diagnosis is not within the scope of practice for the massage therapist; however, it is for other health care practitioners who may be using soft-tissue treatment in their practice. For the massage therapist, the point of assessment is not to come up with a hard and fast name for the client's problem. A massage practitioner should never tell a client they have a specific condition, as that is giving a diagnosis. A practitioner can discuss with the client the tissues they believe to be involved and how. Further identification of the condition should be referred to another health care practitioner.

Assessment used by the massage practitioner is an ongoing process that begins with the initial visit and continues throughout the duration of treatment(s). Gauging the client's pain levels and symptoms is integral to assessment. Noting these symptoms in an initial evaluation provides a baseline against which progress is measured. It allows the practitioner to keep track of their client's progress and make educated decisions about continued therapy approaches. In addition, both the initial and ongoing evaluations can supply information to other health care professionals working with the client. Skilled assessment also builds the client/practitioner relationship, further enhancing treatment.

Assessment, however, is not an exact science. It relies heavily on the skilled clinical reasoning of the practitioner. There are no specific evaluation techniques that can provide a 100% positive result in establishing the tissues and dysfunction involved. In some cases, the nature of the client's pain is straightforward. In other cases, the condition can be far more complicated. An immediate assumption about the nature of a client's pain or problem is best avoided. It is not uncommon for conditions to have similar or identical symptoms. In many cases, finding the source of a client's complaint is not possible, regardless of practitioner's experience or knowledge. In this case, continual exploration, monitoring, and referral to another professional are the best approaches.

Proper application of assessment strategies decreases the practitioner's guesswork and helps make accurate, knowledge-based decisions about treatment or referral. Those involved in finding solutions for musculoskeletal problems with soft-tissue therapy know that massage is not benign. Massage produces significant tissue changes and effects; thus its effectiveness in treating such conditions. While massage's effects are often beneficial, they can also be ineffective or contraindicated. It is advisable to refer clients with more severe pain or injuries to a more qualified health care professional.

Matching treatment to injury

A second integral component of this orthopedic massage approach is to ***match the physiology of the injury with the physiological effects of the treatment technique***. A host of therapeutic techniques are available to the massage practitioner. Yet, no single massage modality effectively treats all of the diverse pain and injury conditions. A practitioner should have a solid foundation in the most common treatment approaches for conditions. Having a diversity of techniques to draw from to address a client's complaint is advisable. However, the practitioner must understand how their techniques interact with tissues involved in a pain or injury condition. The orthopedic massage practitioner needs to be familiar with the physiological effects of each treatment technique to make a decision about the most appropriate treatment strategy.

Understanding the physiological effects of a technique means knowing physiologically how and in what way a technique is helpful for a particular tissue dysfunction. For the most effective treatment, the physiological effects of the treatment should specifically address the nature of the pain or injury condition. An example is soft-tissue treatment for carpal tunnel syndrome. Massage is a highly effective treatment for this condition, often preventing the need for surgery or other invasive techniques if the appropriate techniques are chosen. However, carpal tunnel syndrome involves entrapment of the median nerve underneath the flexor retinaculum. Any soft-tissue technique that exacerbates the nerve compression is contraindicated, for example transverse friction massage. A massage technique that would more effectively match the physiology of the condition would be deep longitudinal stripping to the wrist flexor muscle group, thus leading to a decrease in cumulative tension in the muscle-tendon units and subsequent reduction in the tenosynovitis that aggravates the median nerve.

Figure 1.2 Deep stripping to the wrist flexor muscles.

Adaptability is key, however, when applying a technique to a tissue dysfunction. Variations in injury or condition may result in a treatment working in one instance and not in another. Informed treatment decisions come not from the simple amassing of techniques, but more from being able to apply knowledge and critical thinking skills to the unique presentations of their clients. In addition, symptoms can mimic those of other conditions. For example, what may seem like an obvious case of carpal tunnel syndrome, using the example above, may not be. If the condition is due to nerve compression in the thoracic outlet longitudinal stripping on the wrist flexors, while perhaps resolving local wrist symptoms, would not lead to complete resolution of the problem. Without further exploration of the unique physiology of the condition, the client's symptoms would likely continue and could worsen. In this example, resolving tension and compression on the nerves in the thoracic outlet region is a crucial part of treatment.

Treatment adaptability

The third component of orthopedic massage is treatment adaptability. The practitioner should be skilled in the basic treatment techniques most frequently used for pain and injury massage. The techniques discussed in this text will provide soft-tissue practitioners with a solid foundation from which to build their skill base. The more techniques the practitioner masters, the more potential treatment tools they have at their disposal. Mastering the treatment techniques presented in this text is a wise goal for those working with orthopedic conditions. The best treatment plan for a condition is not based on highly specialized techniques but on the best technique for that particular tissue injury and client. Effective clinical reasoning plays a critical role in choosing which of those techniques are most effective in a particular clinical case.

Clearly, considering the diversity of problems with which clients may present, the practitioner should not rigidly adhere to any one particular technique. There is no single technique or method that works for all soft-tissue pathology. However, the practitioner should also be careful about simply amassing an encyclopedic array of different techniques. As the practitioner's practice develops and the basic therapeutic techniques are mastered, expanding one's technique options is an advisable goal. Further study of the techniques presented here will advance the practitioner's understanding of the techniques and their skills. The practitioner can then choose from a wide variety of treatment methods to find the approach that is most appropriate for each client's unique rehabilitation needs.

This text provides suggested treatment protocols for the conditions discussed, but these are a basic framework. These treatments should not be interpreted as prescribed treatment routines. The practitioner must be prepared to adapt to a particular presentation and/or alter a treatment course. Ignoring the uniqueness of the client's particular presentation will blind a practitioner to essential information needed for addressing the client's complaint. The practitioner must use their assessment and critical thinking skills to choose and adapt treatment methods or techniques to address the unique situation of each individual client.

Appropriate use of the rehabilitation protocol

The rehabilitation protocol is the final component in this system of orthopedic massage. The rehabilitation protocol is the course of injury management used to support recovery. Following this protocol is important for recovery. Rushing the soft-tissue injury repair process is a leading cause of treatment failure for musculoskeletal disorders. Massage can play an integral role at various stages of this process, particularly in normalizing tissues and regaining flexibility. How involved the soft-tissue practitioner is in managing a client's rehabilitation will depend on their skills and qualifications. However, the orthopedic massage practitioner can play an important part in the rehabilitative process with a wide-range of pain and injury conditions.

The rehabilitation protocol is a four-step process; although the steps often overlap. Each step is important and necessary for complete recovery from soft-tissue dysfunction or injury. These steps are especially important if the client will be subjected to the offending activity that created the problem initially. For example, the athlete who must return to training or the carpenter who must go back to work will benefit from following through on the process. At the same time, elements such as motivation, time pressures, and psychological factors must be considered when determining an effective rehabilitation plan.

The four steps of the rehabilitation protocol are to normalize soft-tissue dysfunction, improve flexibility, restore proper movement patterns, and strengthen and condition the tissues. An easy way to remember the four steps is with the acronym, NIRS. For proper rehabilitation from soft-tissue injury, the client should generally progress through these stages in the order presented. However, it is common for the steps to overlap and one step need not be fully complete before moving on to the next. However, following the general outline and order of the steps is important.

Box 1.2 Rehabilitation Protocol

Normalize soft-tissue dysfunction
Improve flexibility
Restore proper movement patterns
Strengthening and conditioning

The first step is to normalize the soft-tissue dysfunction. The practitioner should understand what the healthy function of the involved tissues is in order to return the tissues to as near that state as possible. For example, if chronic muscle tightness and myofascial trigger points are the complaint, then therapy that normalizes muscular tone and neutralizes myofascial trigger points would be used. Massage is a valuable treatment option in this stage of rehabilitation. Other modalities are also used at this stage including thermal modalities and therapies used by other health care providers.

The use of multiple modalities to normalize soft-tissue dysfunction is of great advantage. Interdisciplinary treatment encourages practitioners of different methods to work together for the most effective outcomes. Combining different treatment modalities can offer distinct advantages for certain conditions. For example, chiropractic treatment performed in conjunction with massage therapy can prove more beneficial because proper alignment of bony structure is easier to achieve if the muscles pulling on the bones are in a more relaxed state.

The second stage of the rehabilitation protocol is to improve flexibility. When this rehabilitation step should be introduced depends on the client's condition and other factors. Improving flexibility is sometimes integrated into initial therapies that seek to normalize the tissues. However, stretching may or may not be beneficial in the early stages of recovery. In some cases, stretching is not recommended. For example, if a client has severe carpal tunnel syndrome, any attempts to stretch the flexor muscles of the wrist may cause severe pain and aggravate the condition by stretching the median nerve. In this instance, flexibility training is not appropriate until a later stage in the treatment. Knowledge of the condition, client history, and the stage of rehabilitation are critical (see assessment above).

Dysfunctional compensating neuromuscular patterns can develop as a result of injury. Along with regaining normal function and flexibility, rehabilitation should include re-integrating proper movement patterns. Protective muscle spasm or biomechanical imbalance result from compensation as the body

Figure 1.3 Understanding how massage fits in with other aspects of any soft-tissue rehabilitation process is essential for effective outcomes.

attempts to compensate for the injury. Acquiring new neuromuscular patterns will be more successful when the patterns are repeated regularly and frequently.[18] Rehabilitation protocols generally incorporate methods to encourage the client to return to proper movement patterns. Biomechanical corrections such as postural change are an example. Massage can play a role in this aspect of rehabilitation as well. In an ideal situation, the tissue dysfunction is normalized and flexibility is restored prior to this step; however, this is not always possible and this step becomes interspersed with steps 1 and 2.

Strength training and conditioning for specific activities is the last stage of the rehabilitation protocol. Once flexibility and proper movement patterns are initiated, strengthening and conditioning help the body prepare for future movement demands. Rehabilitative exercises and stretching should only be performed when the tissues are able to accomplish these activities without being further injured or impaired. With greater conditioning, the likelihood of re-injury is reduced. Conditioning activities are routinely performed while the client is still establishing proper movement patterns (which can be a long process). Engaging increased muscular demand while focusing on correct mechanics facilitates proper movement coordination.

The average client is not always inclined to follow through with this aspect of his or her recovery, but this step remains important. Those in professional sports understand the critical role of conditioning. The physical demands from many occupations and weekend activities are enough to warrant the client follow through on a conditioning regimen. Soft-tissue practitioners can assist their clients in this process by explaining why rehabilitation is important and encouraging their clients to follow through.

For the average person strengthening and conditioning does not have to be a time consuming or difficult activity. Often it is a matter of simply using household items already available or simple exercises. Rehabilitation protocols are provided for each of the conditions discussed in this text (see the Section 2 chapters). Certain aspects of the rehabilitation protocol, such as supervised exercise programs, may be out of the scope of practice for some soft-tissue practitioners. In this case, the massage practitioner can work alongside other health care professionals for the most effective results. The practitioner who understands the rehabilitation process and can follow the different stages of their client's progress is much more effective in treating their client's complaint.

PRACTITIONER CARE

Orthopedic massage can be a particularly successful style of massage to incorporate in a practitioner's practice. Today's clients are increasingly seeking this type of therapy and meeting these demands can stimulate one's career. At the same time, orthopedic massage can be a physically demanding practice as are many other styles of more engaged massage. The soft-tissue practitioner who chooses to treat pain and injury conditions often uses techniques that require a high degree of force or effort; for example, the deep longitudinal stripping methods performed with active engagement. Longevity in today's massage career requires practitioners take as much care of their own physical needs as they do their clients.

Massage practitioners benefit from strength training and flexibility programs, not just for the wrist and hands, but for the forearms, shoulders, and back. General and regular conditioning is a good policy for massage therapists. Employing proper postural form is critical not only for correct technique application, but for reducing

Figure 1.4 The massage practitioner should be conscious about self-care in order to encourage the greatest career longevity. Massage is a physically demanding occupation and should be conditioned for accordingly.

practitioner discomfort and dysfunction. Following the standard body mechanics entry-level therapists learn is a great starting point. Many therapists also find tai chi practice to be particularly useful training, as the basic posture of tai chi is quite similar to that used in massage practice. A simple conditioning activity of drawing the letters of the alphabet in the air with a broom, while holding it in one hand is a great way to condition many of the muscles subjected to overuse in the daily practice of massage. Finally, massage therapists are vulnerable to cumulative trauma injuries. Utilizing the massage techniques for these types of conditions will prevent long-term dysfunction for the soft-tissue practitioner. Massage is always recommended for the massage practitioner!

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Chapter 2

Understanding soft-tissue injuries

CHAPTER CONTENTS

Treating orthopedic disorders effectively requires that the practitioner have a working knowledge of the soft tissues in health as well as in pathology. This chapter focuses on the basic function of the human body's major soft tissues and the most common ways in which they are injured or dysfunctional. The reader is encouraged to review their favorite anatomy and physiology texts for a more comprehensive discussion of healthy physiological function for these tissues.

The following will prepare the practitioner with a basic understanding of the common disorders that affect the soft tissues. There are a few basic injuries that can occur to the various soft tissues, for example hypertonicity, strains, sprains, and tears. The emphasis here is placed on the most commonly occurring problems as they appear in the particular tissue, for example hypertonicity in muscle or sprains in ligaments. Orthopedic disorders do not always have a special name, but are simply these common dysfunctions. Knowing how each tissue can be injured prepares the practitioner with information for evaluating a treatment protocol.

Section 2 (starting with Chapter 6) discusses the specific conditions that have unique clinical characteristics; again, the discussion is limited to those disorders most seen in the massage therapy clinic. This chapter provides the reader with information not presented in the later chapters on specific conditions. Understanding the basic framework of conditions discussed below will facilitate the reader's understanding of the conditions discussed in later chapters.

MUSCLE

Skeletal muscle is the most abundant tissue in the body, and makes up about 40–45% of the body's total weight.[1] With such a large amount of muscle tissue in the body it is not surprising there are so many muscle-related complaints. Despite their ubiquitous presence, muscles are often overlooked as a cause of soft-tissue pain and disability.[2,3]

The primary function of muscles is to contract in order to produce the acceleration, deceleration or static position of skeletal structures. Muscles must have a high degree of pliability and elasticity in order to function properly. They also have neurological connections for the transmission of sensory and motor signals to and from the central nervous system.

There are three types of muscle contraction. A concentric contraction is one in which the muscle shortens. Shortening occurs because the tension developed within the muscle overcomes the external resistance. For example, when the biceps brachii receives a contraction stimulus, and its contraction force is greater than any resistance, the forearm flexes at the elbow in a concentric contraction (Fig. 2.1).

When forces on the muscle are equal, i.e. when the tension developed within the muscle matches the external resistance, an isometric contraction occurs. No movement is produced at the joint with isometric contraction. In an eccentric contraction the external resistance is greater than the tension developed within the muscle. As a result, the muscle must lengthen while still receiving a contraction stimulus from the nervous system. Essentially the muscle is slowly letting go of its contraction. Eccentric contractions occur during the deceleration of movement. Eccentric contractions are the most common cause of muscular injury (Fig. 2.2).[4–7]

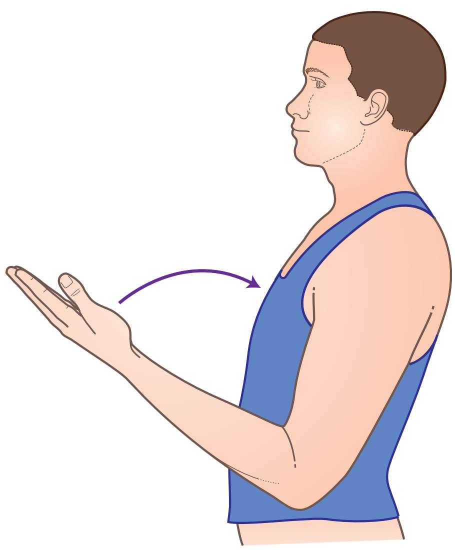

Figure 2.1 Concentric contraction of the biceps brachii.

Figure 2.2 Muscle injury in quadriceps from eccentric contraction.

Numerous factors cause muscle injuries. Overuse, lack of proper conditioning, metabolic stress, or fatigue are some of the most common causes.[8,9] These factors can lead to a number of specific pathological processes in the muscle tissue. The most common types of muscle pathology include hypertonicity, atrophy, strain and contusion. Each of these problems is explored in greater detail to develop a comprehensive understanding of muscular dysfunctions.

Hypertonicity

One of the most commonly occurring soft-tissue pathologies is muscular hypertonicity, or more simply, tight muscles.[10] Yet this problem rarely receives the level of attention it deserves based on its frequency of occurrence. It is almost as if the idea of tight muscles is too simple to be considered an orthopedic 'condition' in its own right. However, biomechanical disturbances are routinely attributed to muscle imbalance and tightness.

Muscle tightness appears for several reasons. It frequently develops due to an increased rate of contraction stimulus, causing the muscle to hold a higher degree of resting tonus than it normally would. Some form of stress causes the increased muscular tone. Possible stresses include: mechanical, such as a postural distortion; chemical, such as excessive intake of caffeine; or psychological.

Hypertonic muscles may appear shortened during postural evaluation or range-of-motion testing. They will feel tight when investigated with palpation compared to other unaffected tissues. Hypertonic muscles are also more resistant to stretching, and may therefore have limitations in range of motion. The client usually reports some degree of pain and/or discomfort with palpation or stretching of the muscle.

Trigger points

Another dysfunctional process that is related to muscular tightness is the myofascial trigger point. Trigger points have begun to receive attention as a serious cause of soft-tissue pain. It is through the monumental work of Janet Travell, MD and her colleagues that these issues first received widespread attention. Travell defined a myofascial trigger point as 'A hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. The spot is painful on compression and can give rise to characteristic referred pain, referred tenderness, motor dysfunction, and autonomic phenomena'.[11]

Medical researchers still don't fully understand trigger points, but current theories are evolving as to their cause. McPartland states that trigger points result from dysfunctional activity at the motor end plates in the muscle.[12] Trigger points result from lack of exercise, muscle overload, postural distress, metabolic problems, sleep disturbances, or various other causes.[10,12,13]

Identification of myofascial trigger points and their characteristic referral patterns is a crucial skill for any practitioner using orthopedic massage. There are numerous charts and maps of myofascial trigger point pain referral patterns that are useful references. However, the practitioner is encouraged to use these diagrams as a reference point, not as an infallible map because trigger point pain referral patterns can differ between individuals.

Atrophy

Muscular atrophy impairs function due to disuse and denervation (loss or impairment of nerve supply to the muscle). Denervation may be the result of nerve compression syndromes, systemic disease, or traumatic damage to the nerve or neuromuscular interface. Lack of proper neurological stimulation quickly leads to a loss in the size and contractile strength of the muscle. This size and strength loss can have significant detrimental effects on normal biomechanics.

Disuse atrophy is a frequent problem in muscles because it usually accompanies another injury where a limb is partially or fully immobilized during the healing process. There is greater atrophy if the muscle is immobilized in a shortened position. The primary anti-gravity muscles – such as the quadriceps, gluteals, and erector spinae – are most affected by disuse atrophy. The anti-gravity muscles are those that resist the downward pull of gravity when one is engaged in normal locomotion.

For example, muscle disuse atrophy that occurs with knee injuries is more common in the quadriceps than in the hamstring muscles. The quadriceps muscles are anti-gravity muscles, whereas the hamstrings are not. In addition, most injuries that require knee immobilization maintain the knee in an extended position, which puts the quadriceps in a shortened position while the hamstrings are lengthened.[8] Pain avoidance from an injury also leads to disuse atrophy. It is remarkable how quickly disuse atrophy may develop, and muscles affected by it will rapidly lose significant strength.[14]

Strain

Excessive tensile stress on a muscle can produce tearing of the muscle fibers; this injury is defined as a strain. The common name for a muscle strain is a pulled muscle. However, it is not an excess of stretch alone that produces the greatest number of strains on a muscle. Muscle strains occur most often from some degree of stretch tension on a contracted muscle, usually an eccentric contraction.[5,15] The forces are greater on a muscle in an eccentric contraction than during isometric or concentric contractions. It is this increased load on the fibers that causes more strain injury from eccentric contractions.[16]

The muscles that are most susceptible to strain injury are those which cross more than one joint (multi-articulate muscles), such as the hamstrings. Multi-articulate muscles are not designed to allow full lengthening over all joints at the same time.[5] Thus they are more vulnerable and their capacity to extend can be reached with abnormal stress, and injury can result. Strains can occur in any region of the muscle, but they are most prevalent at the musculotendinous junction.[17,18] The musculotendinous junction is a region where one tissue that has a great deal of pliability (muscle) is meeting another tissue that has very limited pliability (tendon). The point of interface between these two tissues is a site of mechanical weakness.

Muscle strains are graded at three levels – first degree or mild, second degree or moderate, and third degree or severe.[19] In a first-degree strain only a few muscle fibers are torn. There is likely to be some level of post-injury soreness, but the individual will be back to normal levels of activity rather quickly. In a second-degree strain there are more fibers involved in the injury. There is likely to be a greater level of pain with this injury, and a clear region of maximum tenderness in the muscle tissue. A third-degree strain involves a severe tear or a complete rupture of the muscle tendon unit. In a complete rupture there is likely to be significant pain at the time of the injury. Notably, pain may be minimal if the muscle ends are completely separated because moving the limbs will not put additional tensile stress on the separated ends of the muscle.

Third-degree strains usually require surgery to repair the ruptured muscle. However, in some instances the muscle may not have a crucial role, and the potential dangers of surgery do not outweigh the loss of partial muscle action. In this situation the physician may recommend leaving the injury alone. Ruptures to the rectus femoris, for example, are commonly left as is since the other three quadriceps muscles can usually make up for the strength deficit.

Box 2.1 Signs of Muscle Strains

- First degree:
  - Minor weakness evident
  - Minor muscle spasm
  - Swelling possible, minor
  - Minor loss of function
  - Minor pain on stretch
  - Minor pain in resisted isometric contraction
- Second degree:
  - Weakness more pronounced
  - Weakness due to reflex inhibition
  - Moderate to major spasm in injured muscles
  - Moderate to major spasm in nearby muscles
  - Moderate to major swelling
  - Moderate to major impaired function
  - Pain likely strong during stretch
  - Pain likely strong with resisted isometric contraction.
- Third degree:
  - Pronounced muscle weakness
  - Muscle may not function
  - Spasm if muscle is intact
  - Surrounding muscles in spasm
  - Moderate to major swelling
  - Loss of function due to reflex inhibition
  - Pain severe at injury, but may recede

Contusion

A contusion is an injury – usually caused by a direct blow – to the muscle that causes a disruption in the fibers and/or their neurovascular supply. Ecchymosis (bruising) usually follows a contusion as the blood from damaged capillaries leaks out into the muscle tissue. The period of healing for a muscle contusion depends on how severe the impact trauma was, and how much disruption of muscle fibers and neurovascular structures has occurred.

In some cases, a contusion can develop bone tissue (ossification) within the muscle during the healing process; this is called myositis ossificans. Massage practitioners should be watchful for this condition after a contusion injury. Deep pressure of an area that has developed myositis ossificans could be detrimental to the healing process and can cause further injury.[20] It is most common in some of the anterior muscles of the body that are vulnerable to direct blows, such as the quadriceps group, biceps brachii, brachialis, and deltoid muscles.

TENDON

The primary function of tendon is to transmit the contraction force of the skeletal muscles to the bones in order to generate movement. Therefore, it is necessary for the tendon to have a great deal of tensile strength. Within the tendon, collagen fibers are oriented in a parallel direction to give the greatest amount of tensile strength in a longitudinal direction.

The tendons are a fundamental part of the contractile unit, but unlike muscles they are rarely injured with significant fiber tearing like a muscle is with a strain. The tensile strength in a tendon is often more than twice that of the associated muscle.[1] As a result, a severe tear or rupture will likely be in the muscular fibers near the musculotendinous junction rather than the tendon.

Tendinosis

The most common pathological problem involving tendons is caused by repetitive mechanical load placed on the tendon. It was previously thought that the tendon fibers tore and subsequently led to an inflammatory reaction in the tendon, thus the name tendinitis (-itis meaning inflammation). However, research into the cellular pathology of tendinitis has repeatedly demonstrated that this is not the case. This conclusion is supported by numerous studies of the condition. Research shows the pathology in the tendon to be devoid of inflammatory cells in this type of injury.[21–24]

The term tendinosis is proposed as a more appropriate referent to indicate a degenerative condition; this text uses this term. Note that many clinicians continue to define the condition as inflammatory. There is such a thing as tendon fiber tearing with inflammation (true tendinitis), but it is not the common tendon pathology that is associated with so many repetitive stress injuries.[25]

The primary problem in tendinosis appears not to be the tearing of tendon fibers, but a collagen breakdown in the tissue. Collagen breakdown leads to chronic pain and a significant loss of tensile strength in the tendon. This explains the greater time it takes to heal from tendinosis problems; if tissue tearing were the primary problem then the tissue would heal more quickly. Rebuilding damaged collagen is a much slower process.

While the collagen breakdown of tendinosis seems mostly caused by repetitive mechanical load, other factors play a role as well. Studies indicate that an increase in vascularity (blood flow) can be a significant part of tendinosis pathology.[25,26] Other studies show that decreased vascularity may also contribute to chronic tendon pathology.[27,28]

Tenosynovitis

Another chronic overuse problem affecting certain tendons is tenosynovitis. This condition does not affect all tendons only those enclosed within a synovial sheath. The synovial sheath, also called the epitenon, surrounds tendons in the distal extremities and a few other locations where excessive friction may irritate the tendon (Fig. 2.3). For example, a synovial sheath surrounds the tendon of the long head of the biceps brachii as it passes through the bicipital groove. The purpose of the sheath is to reduce friction between the tendon and the retinaculum that binds the tendon close to the joint. The tendon must be able to glide freely within the synovial sheath.

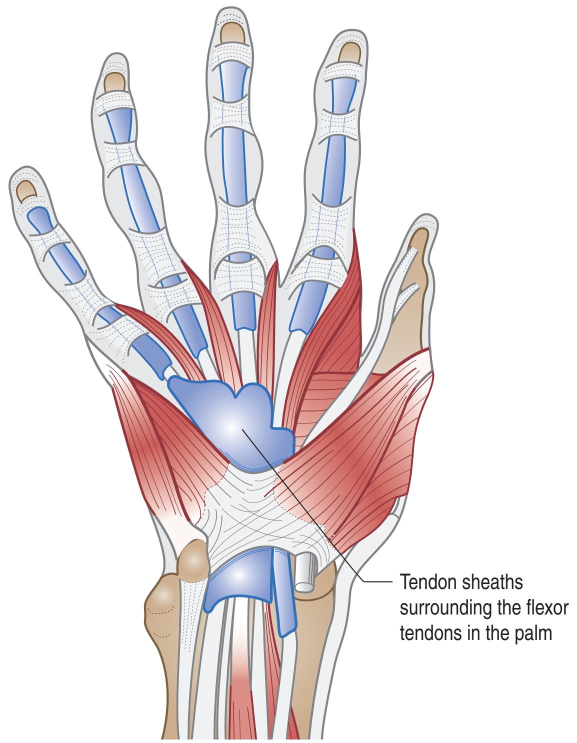

Figure 2.3 Tendon sheaths and their surrounding retinacula.

In tenosynovitis, chronic overloading or excess friction causes an inflammatory reaction between the tendon and the enclosing synovial sheath. The inflammatory reaction creates a roughening of the surface of the tendon and fibrous adhesion develops between the tendon and the sheath. The roughening of the tendon surface may cause crepitus when the joint is moved through a range of motion. The symptoms of tendinosis and tenosynovitis are very similar, but massage treatment of these conditions is virtually identical.

LIGAMENT

The primary function of ligament tissue is to connect adjacent bones to each other to establish stability in the skeletal structure. Ligament fibers are oriented primarily in a longitudinal plane to give the ligament fiber the greatest amount of resistance to tensile stress. Within the ligament there are also fibers that are oriented in other planes, to give the ligament some pliability and strength against forces in other directions.[1] Strength in multiple directions is important because joints are subjected to forces in multiple directions.

Sprains, plastic deformation

Ligament injuries usually occur from sudden high tensile loads on the fibers. For example, a blow from the lateral side of the knee puts excess tensile stress on the medial collateral ligament on the medial side of the knee. The severity of the injury is dependent on how much force the ligament must withstand. Ligament fibers have some degree of pliability and resistance to stretch. If the tensile stress is minor, the ligament can usually absorb the force with minor stretching of the fibers.

If the force is greater, the ligament fibers may stretch slightly. Stretching the ligament past the initial level of pliability in the tissue causes permanent lengthening called plastic deformation.[1] In plastic deformation the tissue stretches, but does not recoil to its original length. Plastic deformation of ligaments leads to joint instability and hypermobility, and may be the source of other disorders as well. Tensile forces that exceed plastic deformation produce tearing of the ligament fibers.

Ligament fiber stretching or tearing is referred to as a sprain. Magee describes the range of sprain injury as mild or grade 1, moderate or grade 2, and severe or grade 3.[19] In a mild sprain only a few ligament fibers are torn and the ligament has likely undergone stretching that is not permanent. The client is likely to feel pain with stretching the ligament, the joint may be swollen, and the muscles around the joint may be in spasm.

In moderate or grade 2 sprains a more significant number of ligament fibers are torn. The ligament has likely undergone some degree of overstretching, and will remain somewhat overstretched, with the result being some degree of joint laxity. Pain will usually be moderate to severe when the ligament is stretched, local spasm is likely in surrounding muscles, and there will likely be moderate swelling.

When the ligament is severely torn or ruptured the sprain is a grade 3 or severe sprain. Most if not all ligament fibers will no longer be intact, and will need to be reattached. Permanent changes in joint stability are likely. Pain will usually be severe at the time of injury, but may not be present later on with joint movement if the ends of the ligament are no longer connected. There will be a moderate level of swelling around the affected joint and local muscle spasm is likely.

Box 2.2 Signs of Ligament Sprains

- Mild or grade 1:
  - Few ligament fibers torn.
  - Temporary ligament stretching possible
  - Mild to moderate pain with stretch
  - Minor swelling
  - Local muscle spasm likely
- Moderate or grade 2:
  - More ligament fibers torn
  - Ligament overstretching likely
  - Joint laxity likely
  - Moderate to severe pain with stretch
  - Moderate swelling likely
  - Local muscle spasm likely
- Severe or grade 3:
  - Severe tear or rupture
  - Fibers likely need repair
  - Permanent changes in joint stability likely
  - Pain severe at injury
  - Pain may recede if ends detached
  - Moderate swelling likely
  - Muscle spasm likely

JOINT CAPSULE

There are two layers to the joint capsule, the outermost layer called the fibrous capsule, and the inner layer called the synovial membrane (Fig. 2.4). The fibrous capsule is primarily ligamentous in most joints as ligament tissue makes up a significant portion of the capsule around synovial joints. The joint capsule acts like a ligament to help maintain stability and support, but also houses synovial fluid and provides a protective covering for the synovial membrane. The synovial membrane secretes synovial fluid, which helps to lubricate the joint, supply nutrients, and remove metabolic waste products from the area. The fibrous capsule is richly innervated, so even minor levels of damage cause significant pain and discomfort.

Tears, adhesions, fibrosis

Damage to the capsule is often an acute injury. Examples include joint dislocation or injuries in which the joint is exposed to significant stress that tears the supporting ligamentous structure. The capsule is also susceptible to fibrotic changes that may occur for a number of reasons. Fibrous adhesion within the capsule may cause it to adhere to itself, such as occurs in adhesive capsulitis. Pain from osteoarthritis is also commonly ascribed to pathological changes that occur in the joint capsule.[29]

Tears to the joint capsule that occur from acute trauma are evaluated in the same manner as ligament sprains. Other pathological problems in the capsule, such as fibrosis, are evident with a specific pattern of movement restriction that is unique to each joint called a capsular pattern. Not all joints have capsular patterns; joints not directly controlled by muscles do not have capsular patterns, such as the sacroiliac joint.[19] If the joint's pattern of motion restriction is not the characteristic capsular pattern for that joint, the restriction is referred to as a non-capsular pattern. Testing for capsular patterns is performed in an assessment.

FASCIA

Fascia is an abundant connective tissue in the body and is intricately woven around organs as well as wrapped around every individual muscular fiber. It is the ultimate connective tissue, as one of its

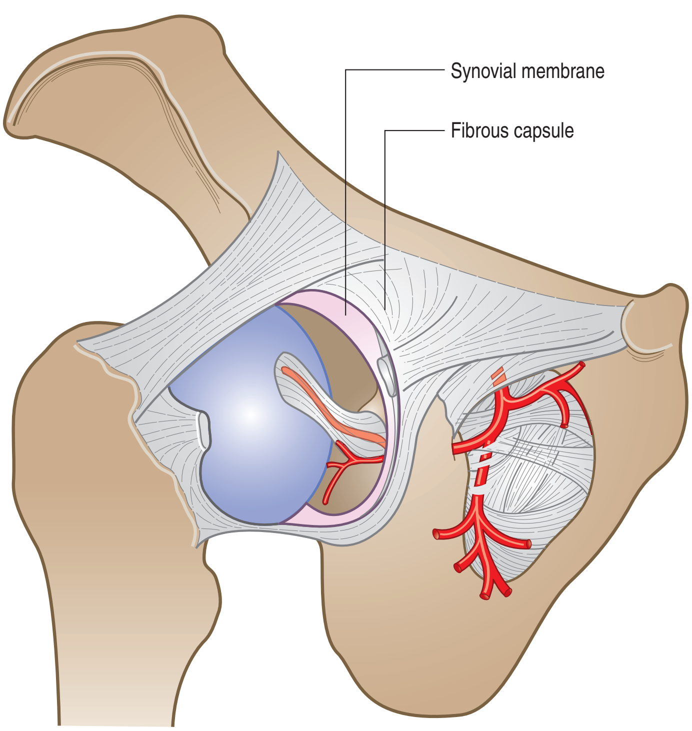

Figure 2.4 The components of a typical joint capsule.

primary functions is connecting different bones, organs, and other soft tissues together. Fascia is primarily composed of elastic collagen fibers. Its consistency ranges from thin and pliable to very dense and resistant. It has multiple functions, including providing support, shape, and suspension for most of the soft tissues of the body, aiding in force transmission, and providing extensive proprioceptive feedback.[30,31]

Fascia is found throughout the body and there is a special interdependent relationship between muscle tissue and fascia, both structurally and functionally. This relationship is so extensive that the two are described as *myofascial* tissues. From a structural standpoint, fascia is crucial in transmitting muscle contraction force to the bones (though some anatomy texts attribute all force to muscle–tendon attachments). Without the fascia that envelopes muscles and their individual fibers, the muscles would not be able to generate anywhere near the amount of force necessary for proper movement and function.[32–34] Notably, the force from muscles can be still be delivered to distal bones after cutting the muscle's primary tendon because of fascial connections with adjacent muscles.[30]

Fascia also plays a crucial role in neuromuscular function. Numerous receptor cells in myofascial tissues generate extensive sensory information that is necessary for regulation of movement and posture. This supply of sensory input is so extensive that it produces the greatest amount of afferent (sensory) information coming in to our central nervous system.[31] Consequently, the myofascial system is our largest sensory organ – greater than the eyes, nose, ears, and skin.

The importance of fascia in soft-tissue pain and injury conditions has gained increasing visibility with new research on fascial tissues. Previously fascia was considered an inert tissue, although one that was stretched by prolonged tensile force to the tissue. Fascia was previously described as a colloidal substance that responded to mechanical force or thermal applications by changing from a more gelatinous *(gel)* state to a more fluid *(sol)* state.[35,36] Recent investigations into the anatomical and physiological function of fascia provide an alternative explanation.

Current cellular physiology research has found active contractile cells within fascial tissue itself.[31,37–40] The presence of active contractile cells indicates that fascia is able to contract and elongate with some degree of neurological control. Changes in tissue consistency appear to result from neurological activity in these contractile cells and not from a conversion from gel to fluid.

Fascia also contains an abundance of specialized sensory receptors called Ruffini endings which respond to forces applied to tissues connected to or adjacent to them.[39] Activation of the Ruffini endings with tangential force techniques appears to cause a neurological response that decreases contractile activity in the fascia itself. Consequently the 'fascial release' felt by many practitioners is likely a neurological response of relaxation in the fascia just as it is in muscle tissue.

Fascia is injured in a variety of ways. Fascia has a great deal of elasticity, but extreme tensile stress on the fascia can cause it to tear or perforate. Many injuries involve damage to fascia as well as to the tissues it envelops, such as muscle. When fascia remains in a shortened position for prolonged periods it will have a tendency to adopt that shortened position.[41] Tension in associated muscle fibers activates contractile fibers within the fascia to maintain the shortened position. Long periods in a shortened position can also lead to fibrous cross-linking within the fascial tissue, which can result in motion limitation.

NERVE

Injuries to nerve tissue are an important source of soft-tissue pain and dysfunction. Due to their anatomical locations in the extremities, numerous nerve trunks are particularly susceptible to mechanical trauma. Both sensory and motor nerve fibers are at risk, so symptoms from nerve injury can involve both motor and sensory disturbances.

The nerves that leave the spinal cord have a dorsal root that carries sensory information and a ventral root that carries motor signals; these are called the spinal nerve roots. The two sections of the nerve root blend together shortly after leaving the spinal cord, and converge to make the major trunks of the peripheral nerves that travel down the upper and lower extremities and to all other areas of the body (Fig. 2.5).

Within the major nerve trunks there are individual nerve fibers that transmit nerve signals and several connective tissue layers. A connective tissue layer called the endoneurium surrounds each individual

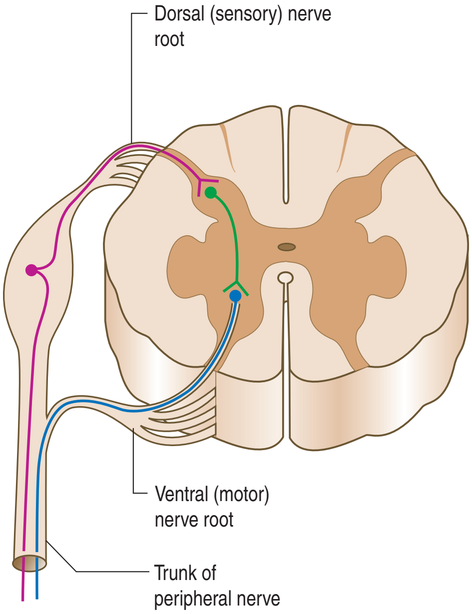

Figure 2.5 Sensory and motor nerve roots.

nerve fiber. The nerve fibers are collected into bundles called fascicles, and another connective tissue layer called the perineurium surrounds the fascicles. The fascicles are collected in bundles, which are all enclosed within another connective tissue layer called the epineurium (Fig. 2.6). It is the numerous bundles of fascicles that make up an entire peripheral nerve.

The different layers of connective tissue within a nerve play an important role in nerve tissue pathologies. Peripheral nerves are provided more support and protection from the connective tissue layers than the spinal nerve roots. The epineurium surrounding the spinal nerve fibers are poorly developed or non-existent.[42] This lack of protection makes the spinal nerves more susceptible to injury, particularly compression trauma.

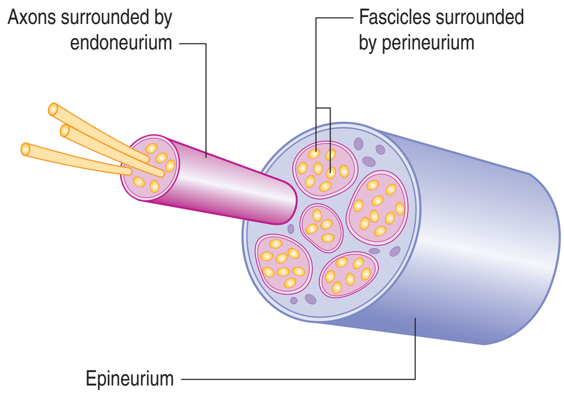

Figure 2.6 Connective tissue layers in the nerve.

The nerve needs adequate blood circulation to function properly so there is an intricate vascular supply to each nerve. There is a complex web of tiny blood vessels within the nerve. Neural ischemia due to compression is a known cause of neurological symptoms.[43] Most people are familiar with the experience of pins and needles that comes with neural ischemia from holding a limb or sitting in a static position for a length of time. Once circulation returns the sensations recede. Nerve tissue is generally pliable and resilient to mechanical injury, but excessive force can produce tissue damage.

In addition to carrying sensory and motor impulses, the nerve fiber serves another important function. The nerve carries its own nutrient proteins necessary for proper function. These substances are carried through the nerve by a slow flowing cytoplasm within the nerve cell called axoplasm. This two-way flow of axoplasm inside the nerve is called the axoplasmic flow. Disturbances to the axoplasmic flow affect the nerve in the local area as well as throughout the entire length of the nerve.

Most major nerve trunks carry sensory and motor fibers so pathology can produce both sensory and motor symptoms. Some nerve pathologies are more likely to produce sensory symptoms while others produce motor dysfunction due to the number of sensory and motor fibers in their associated nerve trunks. In the upper extremity, for example, the median nerve has a greater percentage of sensory fibers than motor fibers, so symptoms of carpal tunnel syndrome tend to be sensory before there is motor impairment. In contrast, compression of posterior interosseous nerve, which has mostly motor fibers, creates weakness before there is sensory impairment.[43]

Box 2.3 Nerve Compression/Tension Signs/Symptoms

- Reduced sensory input
- Reduced motor impulses
- Pain in a specific dermatome
- Motor weakness in a specific myotome
- Hyperesthesia or paresthesia sensations

Dermatomes, cutaneous innervation, myotomes

Becoming familiar with dermatomes, cutaneous innervation, and myotomes will help practitioners better understand nerve injury symptoms. A dermatome is an area of skin supplied by fibers from a single nerve root. The fibers from that one nerve root make up several peripheral nerves and innervate specific areas of the body. For example, the C8 nerve root has branches that make up portions of several upper extremity nerves, such as the median and ulnar nerves. Sensory symptoms from C8 nerve root irritation are felt in the ulnar side of the hand and medial side of the forearm and arm (Fig. 2.7).

Each peripheral nerve is made up of fibers deriving from the different nerve roots. A skin region supplied by a peripheral nerve is called the cutaneous innervation of that nerve (Fig. 2.8). There can be some overlap between the dermatome and the area of cutaneous innervation. For example, the ulnar nerve in the arm has fibers from C7, C8, and T1, yet its sensory fibers only supply the ulnar aspect of the hand and the last two fingers, whereas the C8 dermatome covers the ulnar aspect of the hand, as well as the entire medial forearm and arm.

Information about dermatomes and regions of cutaneous innervation is valuable in the clinical evaluation process. Using the example above, if

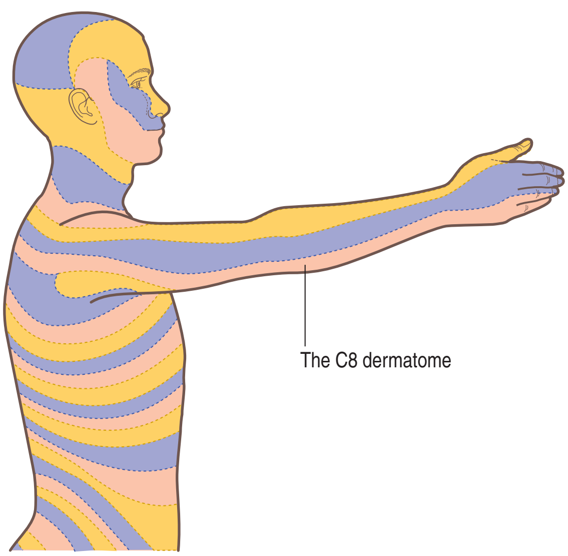

Figure 2.7 Dermatomes of the upper extremity. Each dermatome is associated with a specific nerve root.

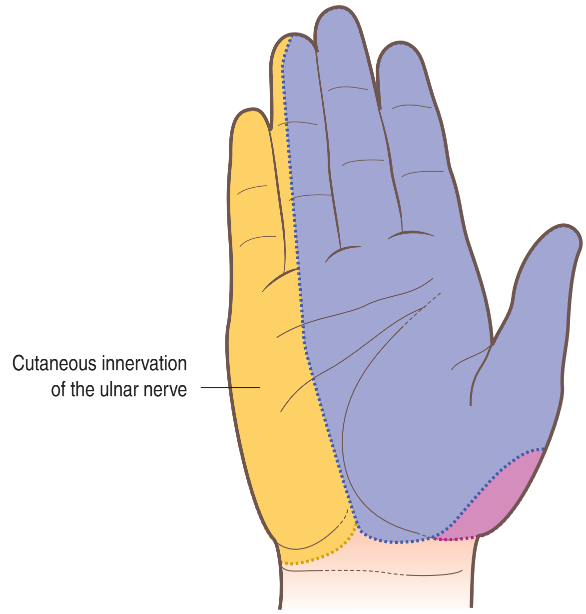

Figure 2.8 Cutaneous innervation for a peripheral nerve.

sensory symptoms are felt throughout the C8 dermatome, one would suspect nerve root involvement rather than a problem with the ulnar nerve. This is because the symptoms extend outside the ulnar nerve's cutaneous innervation area on the ulnar side of the hand. If symptoms are only in the ulnar side of the hand, ulnar nerve pathology is more likely. Keep in mind that symptoms may appear in only a part of the dermatome. Whenever sensory symptoms are reported in an extremity one should consider the possibility of the nerve root being the source of the problem.

Myotomes are somewhat similar to dermatomes. A myotome is a group of muscles that are innervated by the same nerve root. A single muscle can have fibers that come from several different nerve roots. Each peripheral nerve also has a number of muscles that it innervates. If there is weakness apparent in a group of muscles innervated by the same nerve root, i.e. the same myotome, then the problem is most likely at the nerve root level. Muscle weakness in a myotome is not always easy to detect because the muscle may only have a small number of fibers that come from the affected nerve root. For more on these conditions see the text, Orthopedic Assessment in Massage Therapy.

Nerve injuries

Nerve injuries generally develop from compressive loads, such as a direct blow to the nerve or a chronic low level of compression. With excess tensile stress the overall diameter of the nerve decreases compressing the fibers within the nerve; this condition is called adverse neural tension.[44–46] The symptoms of compression or tension pathology are similar because both cause degeneration of the nerve. Compressive and tensile forces can occur in numerous locations along the nerve, but several sites are most vulnerable for nerve damage.[46]

Radiculopathy, neuropathy

There are two terms that describe nerve injuries and which indicate the location of the pathology in the nerve. A *radiculopathy* is a nerve pathology that occurs at the nerve root. A common radiculopathy is the herniated nucleus pulposus (HNP) or herniated disc, in which the disc presses on a nerve root. Pathology farther along the length of the nerve is a *neuropathy*. It is also called a peripheral neuropathy indicating that the injury is in the peripheral nerves, distant from the nerve roots and spinal cord. Many nerve compression syndromes, such as thoracic outlet and carpal tunnel syndrome, are examples of peripheral neuropathies.

Box 2.4 Areas Where Nerves Are Most Vulnerable

Tunnels – soft or bony tissues may create tunnels the nerve must travel through, compression is the risk. Ex: carpal tunnel in the wrist, the cubital tunnel in the elbow or the tarsal tunnel in the foot.

Nerve branches – anywhere nerve tissue branches out to other areas there is the potential for increased neural tension. Ex: where the posterior interosseous nerve branches from the main radial nerve near the elbow.

Nerve is fixed – anywhere the nerve is tethered to an adjacent structure for stability is a region for potential compressive or tensile stress on the nerve. Ex: deep peroneal nerve where it is attached to the upper region of the fibula in the lower extremity.

Nerve passes by unyielding surface – passing close to unyielding surfaces like bone there is a greater chance of compression or tension. Ex: brachial plexus as it goes over the first rib in the upper thoracic region.

Tension points – the mid-point of a stretched nerve fiber, called the tension point of the nerve, is more susceptible to pathology.

Nerve degeneration

Nerve degeneration results from mechanical forces or from systemic disorders that attack the nerve, such as multiple sclerosis. Nerve injuries are classified by severity into three levels: neurapraxia, axonotmesis, and neurotmesis.[47,48] Either compression or tension injuries can produce these levels of nerve injury.

When there is impairment of the axoplasmic flow in one part of a nerve, the remainder of the nerve becomes nutritionally deficient and thus more susceptible to pathological changes. With additional regions of the nerve more susceptible to degenerative changes, a client may have symptoms of more than one nerve pathology. The presence of multiple sites of neurological pathology is called the double or multiple crush phenomenon.[49–51]

The nerves of the upper extremity provide a good illustration of double crush pathology. Brachial plexus compression near the thoracic outlet impairs axoplasmic flow and subsequent function of the distal regions of the upper extremity nerves. As a result simultaneous symptoms of thoracic outlet syndrome and carpal tunnel syndrome can develop.

Neurapraxia, axonotmesis, neurotmesis

Neurapraxia is the least severe nerve injury and involves the blocking of axon conduction. The nerve continues to conduct some signals above and below the primary area of compression or injury, but conduction velocity slows. Common symptoms include

Box 2.5 Nerve Injury Levels

Neurapraxia – mild sensory and motor deficits

Axonotmesis – sensory and motor dysfunction, significant pain

Neurotmesis – altered sensation or function, or no recovery mild sensory and motor deficits, which usually decrease when the nerve is no longer compressed.

The next level of nerve damage is called axonotmesis. There is a loss in continuity of the axon, but the surrounding endoneurium may still be intact. The outer layers of connective tissue are still intact as well. Typical symptoms include sensory and motor dysfunction, as well as significant pain. If the connective tissue layers are intact the nerve axon is likely to regenerate, although slowly. The rate of regeneration of nerve axons is estimated to be 1 mm per day or 1 inch per month, but in certain cases slower.[46]

A severe nerve injury is neurotmesis. At this level, damage affects not only the axons, but also their connective tissue layers. Because these layers are damaged, recovery from neurotmesis may not be possible. Neurotmesis occurs in severe crush injuries or situations where the nerve is severed. Axons can regenerate once severed, but because the connective tissue template is disrupted the axons may not grow back in their original locations. This is one reason some surgical repairs produce altered sensation or function in the region when the individual regains use.

CARTILAGE

There are three different types of cartilage. The first two, hyaline and fibrocartilage, are those which are relevant for orthopedic disorders. A third type, elastic cartilage, is the type that is found in areas such as the external portion of the ear or the epiglottis. Hyaline cartilage is located on the ends of long bones. It is also called articular cartilage. It provides a smooth gliding surface for movement at the joints, and aids in joint flexibility and support. The most common pathology affecting hyaline cartilage is compressive stress that causes a breakdown in the integrity of the cartilage matrix, and will eventually cause degenerative changes in the joint.

At the ends of the long bones cartilage performs as an important protective cushion. The cartilage is mostly devoid of nerve fibers, so there is very little, if any, sensation from the cartilage when degeneration occurs. Most pain sensations come from the subchondral bone (the layer of bone just below the cartilage) because it is richly innervated. Friction develops between the long bones as the hyaline cartilage degenerates, causing pain.[52]

Fibrocartilage is the other type of cartilage involved in orthopedic disorders. This is the strongest type of cartilage, and it is designed to provide rigidity and support. Fibrocartilage is located in areas of high compressive force between bones such as the intervertebral discs and the menisci of the knee. As with hyaline cartilage, the most common type of injury to fibrocartilage is with high levels of compressive stress that cause it to break down. The compressive forces causing the greatest problems are those involving heavy loads over a long period of time. Poor posture that increases the compressive load on the intervertebral discs in the lumbar spine is a good example.

While compressive loads routinely injure the menisci in the knee, fibrocartilage in the knee can also be injured from tensile forces. The tearing of the medial meniscus is an example. The medial meniscus of the knee has a fibrous connection to the medial collateral ligament. When there is excessive valgus force on the knee, the medial collateral ligament may stretch or tear. Since there is a fibrous connection of the medial meniscus with the medial collateral ligament, pulling the ligament fibers pulls on the cartilage as well. The cartilage may tear, especially near its edge, from these high tensile forces.

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