PART 4
SPECIAL CONSIDERATIONS

CHAPTER
27

Gregory S. Johnson

Soft Tissue Mobilization

Manual treatment of the soft tissues has existed since the beginning of recorded history in the form of massage and manipulation.[1] The primary purpose of these approaches was apparently to treat symptomatic soft tissues. The functional orthopaedics approach to soft tissue mobilization (STM) has been developed not only to evaluate and treat soft tissue dysfunctions that precipitate myofascial pain but also to evaluate and treat those dysfunctions that alter structure and function and produce mechanical strains on symptomatic structures.[2] In addition, STM offers a functional approach for evaluating and improving the patient's capacity to achieve and maintain a balanced posture, which enhances the ability to learn and perform efficient body mechanics. This approach is integrated into a broader treatment strategy of joint mobilization and neuromuscular reeducation and is coupled with a specific training, conditioning, and flexibility program.

STM is intended to be used as a component of a complete manual therapy program that includes evaluation and treatment of articular, neurovascular, and neuromuscular dysfunctions. The approach encompasses evaluation of the soft tissue system and application of specifically directed manual therapy techniques to facilitate normalization of soft tissue dysfunctions.[2,3] This integrated treatment approach has been termed *functional mobilization.*[4]

This chapter defines STM and describes its contribution to the conservative care of musculoskeletal dysfunction. This is achieved by (1) defining the relevant soft tissue structures; (2) outlining a specific system of subjective, objective, and palpatory evaluations; (3) presenting basic treatment techniques; and (4) providing clinical correlations and case studies to develop an anatomic, biomechanical, and conceptual rationale for the use of STM.

SOFT TISSUE COMPONENTS

The four primary soft tissues of the body are epithelial, muscular, nervous, and connective.[5,6] All soft tissue structures have individual and unique functions, integrated into a dynamic biomechanical unit.[7,8] Grieve[7] emphasized this by stating that "the nerve, connective tissue, muscle, and articular complex produces multiple and varied arthrokinetic systems, which are functionally interdependent upon each other."

Many authorities have stated that dysfunctions of the soft tissue system play a primary role in the onset and perpetuation of musculoskeletal symptoms.[7,9-13] Grieve[7] stated the following: "An explanation of the incidence of vertebral joint syndromes, and of some unsatisfactory long-term therapeutic results, might be assisted by regarding joint problems in a wider context than that of the joint alone. Much abnormality presenting, apparently simply, as joint pain may be the expression of a comprehensive underlying imbalance of the whole musculoskeletal system, i.e., articulation, ligaments, muscles, fascial planes and intermuscular septa, tendons and aponeuroses …"

The human system can develop to be efficient, strong, and flexible by responding appropriately to the various types of controlled physical, mental, and emotional stress.[14-16] When the system is unable to adapt appropriately, physical compensations occur (Figure 27-1).

The most common factor that precipitates soft tissue pain and functional impairment is trauma.[17,18] Trauma, whether from a significant external force or from repetitive internal or external microtraumas, can produce long-standing soft tissue changes (Box 27-1).[19,20] These soft tissue dysfunctions may be the primary source of symptoms or the secondary source through impeded structural and functional capacity.

All injuries, regardless of site, have a basic inflammation cascade. Inflammation has three distinct phases: (1) acute, (2) granulation, and (3) remodeling. The first phase, acute, occurs 0 to 4 days after injury. The ruptured cell releases debris and chemicals (prostaglandins) into the plasma, which attract leukocytes. The white blood cells clean out the bacteria and prevent infection. Prostaglandins are released from the injured cell, causing pain.[21]

The granulation phase is marked with the arrival of macrophages. Macrophages digest the cellular debris and secrete enzymes to aid the breakdown of ligament molecules. Macro-

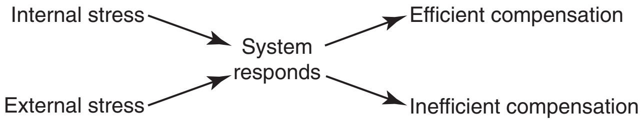

Figure 27-1 Internal and external stresses that affected the health of the system.

BOX 27-1 Macrotraumas and Microtraumas

External Macrotraumas	Internal or External Microtraumas
Blows	Faulty posture
Falls	Improper neuromuscular mechanisms
Improper heavy lifting	Poor body mechanics
Surgery	Muscular imbalance
Whiplash	Improper foot wear
	Repetitive stressful activities
	Poorly organized work surfaces
	Nonsupportive sitting and sleeping surfaces
	Chronic anxiety or depression
	Overweight

phages release growth factors, which stimulate the regeneration of blood vessels, intercellular matrix, and fibroblasts. Fibroblasts repair ligamentous cells. The combination new blood vessels and fibroblasts cause the fullness that can be felt at the injury site. Fibroblasts make massive amounts of collagen at the fibro-osseus junction—the site of ligament attachment to the bone.

During the third phase of healing, remodeling, the new collagen will be organized into a new ligament. The fibroblasts make single long molecules, which will begin to entwine to form a triple helix—a collagen fiber. The collagen fibers begin to contract, and the molecules become tighter and shorter. The collagen loses water with noted decreased laxity. The third phase lasts for weeks. Each phase is dependent on the previous phase for initiation of the next phases.[22] Occasionally, changes occur in the organization of collagen irregularities.[23]

Structurally, a balanced posture is no longer available because of the lack of flexibility of the soft tissue structures. This affects the efficient distribution of weight into the base of support and alters articular range of motion. These changes in soft tissue extensibility and mobility can cause abnormal forces and compressions to articular structures and can be a factor in precipitating and perpetuating pathologic and symptomatologic conditions.[7,9,11,24,25]

Soft tissue dysfunctions can be specifically identified through an organized and precise subjective, objective, and palpatory evaluation. The therapist should have a working knowledge of the body's normal functional anatomy, biomechanical function, and neuromuscular control to conduct and interpret this evaluation and to provide effective treatment. An understanding of soft tissue pathokinetic mechanisms is essential to correlate the objective findings with possible soft tissue dysfunction. STM primarily addresses the evaluation and treatment of four soft tissue structures: (1) irregular and regular connective tissues, (2) skin, (3) skeletal muscle, and (4) neurovascular components.[5,26-28] For an in-depth description of the connective-tissue structures, see Chapter 1.

CONNECTIVE-TISSUE STRUCTURES

The primary connective-tissue structures evaluated and treated by STM are the regular or dense tissues such as tendons and ligaments and the irregular or loose tissues such as fascia, intrinsic elements of muscle, articular capsules, and aponeuroses.

Fascia

All connective tissue is made up of fibers, proteoglycans, and glycoproteins. The fiber component, produced by fibroblasts, consists of collagen and elastin. Proteoglycans are core proteins with sulfated glycosaminoglycan (GAG) side chains. The GAG attachments absorb water to provide hydration of the extracellular matrix. Glycoproteins stabilize matrix of connective tissue and regulate cell functions and cell connection to the maxtrix.[29]

The delicate balance of each component within it determines the properties of connective tissue. Both collagen and elastin resist tensile loads. Proteoglycans and GAGs provide hydration within the matrix and resist compressive loads. Recent studies have shown that fibroblasts may also have the gene that can express contractile elements in fibers.[30] Imbalances of the connective-tissue matrix caused by disease and trauma can lead to regions of decreased mobility or restriction.

The fascial system is one of the primary soft tissues treated by STM. The fascial system ensheathes and permeates all tissues and structures; supplies the mechanical supportive framework that holds and integrates the body together and gives it form; provides passive support during lifting activities;[31] provides for the space and lubrication between all bodily structures; and creates pathways for nerves, blood, and lymphatic vessels.

Hollingshead[8] states the following: "If it were possible to dissolve out all the tissues of the body so as to leave only the fibrous (irregular) connective tissues, the essential organization of the body would still be represented and recognizable."

The fascial system is composed of laminated sheathes of connective tissues of varying thickness and density. These sheathes extend from the periosteum of bone to the basement membrane of the dermis. They are continuous throughout the body and are interconnected with the connective-tissue structures of muscle (intrinsic elements, tendons, and aponeuroses), the articular structures (ligaments and capsules), and the intrinsic elements of peripheral nerves (endoneurium, perineurium, and epineurium).[5,6,8,26] This ensheathing organization of fascia allows structures to have independent three-dimensional (3-D) mobility while connecting the system together into an integrated functional unit.[5,17]

Any system designed for function must have interfaces that allow motion. For the skeletal structures, these interfaces are termed *joints,* whereas in the soft tissue system these interfaces are termed *functional joints.*

Functional Joint Concept

Gratz[32] defined the normal spaces that are maintained between all structures by fascia as *functional joints.* He defined a functional joint as "a space built for motion." Each functional joint creates a mechanical interface that allows the adjoining structures to make 3-D movements in relation to each other.[2,13,17,32] In myofascial structures, the functional joints maintained by facial tissues include the spaces between individual muscle fibers on the micro level, as well as the spaces that exist between a muscle and the surrounding structures. All these spaces are maintained and lubricated by the amorphous ground substance. The amorphous ground substance is a viscous gel containing a high proportion of water (60% to 70%) and long chains of carbohydrate molecules called *mucopolysaccharides,* principally GAGs.[6,26,33]

In an optimal state, the 3-D mobility that exists at functional joints is termed *normal play.*[2,33,34] The degree of normal play varies according to the functional demands and requirements of the individual structures and their mechanical interface. When the normal extensibility, accessory mobility, and biomechanical function of the tissues and surrounding structures are restricted, this dysfunctional state is called *restricted* or *decreased play.* These dysfunctions are clinically identifiable through skilled palpation, range-of-motion testing, and observable alteration in function.[2,34]

Mennell[35] stated the following: "It is very remarkable how widespread may be the symptoms caused by unduly taut fascial planes. Though it is true that the fascial bands play a principal part in the mobility of the human body, they are often conducive to binding between two joint surfaces."

DYSFUNCTIONAL FACTORS

No exact scientific explanation exists for restricted play and decreased extensibility of tissues, and further research is needed to provide more in-depth physiologic understanding. However, some possible physiologic explanations include the following.

Scar Tissue Adhesions

After an injury, laceration, or surgery, fibroblastic activity forms new connective-tissue fibers to reunite the wound as part of the postinflammatory fibroplastic phase.[36,37] These fibers are formed through random fibroblastic activity. If the appropriate remodeling stimuli are not applied during the healing process, then the scar will become inextensible, with poor functional capacity.[10,14,38-41] Localized adhesions are generally produced as scar tissue forms.[10] In addition, often a restrictive matrix exists that has spiderweb-like tentacles attached to surrounding structures that can alter and limit their normal mobility.[42,43] For example, the restrictive matrix of the scar tissue that is formed after abdominal surgery can often be palpated in other regions of the abdominal cavity.

Hollingshead[8] states that scar tissue "may be a major factor in altering the biomechanics of the whole kinematic chain, placing strain on all related structures." The abnormal strain caused by adherent and inextensible scar tissue may contribute to a chronic inflammatory process and further perpetuate symptoms.[10,42,44] The scar tissue matrix may also compromise neurovascular and lymphatic structures affecting the nerve conduction, the fluid balance, the exchange of metabolites, and the removal of waste products from the region.

Lymphatic Stasis and Interstitial Swelling

An increase in interstitial fluids alters the mechanical behavior of the adjacent structures and restricts normal mobility of the functional joints. This fluid imbalance may be related to immobility, poor lymphatic drainage, scar tissue blockage, or inflammation.[45,46]

Ground Substance Dehydration and Intermolecular Cross-Linking

Research has been conducted to determine the effects of forced immobilization on the periarticular tissues of various mammalian populations. This research has revealed that such immobilization contributes to soft tissue changes and development of restricted mobility of joints.[47-50] Researchers have identified biochemical and biomechanical compensations within the ligaments, tendons, capsule, and fascia of these restricted regions.[33,51] A primary component of these dysfunctions is ground substance dehydration.[33,47,48,52-54] Two results of this dehydration are (1) thixotropy and (2) loss of critical fiber distance.

Thixotropy is a state in which the ground substance becomes more viscous, resulting in increased tissue rigidity and stiffness. This increased viscosity of the ground substance requires more force to elongate and compress the tissues.[11,54]

With the loss of water from the ground substance, the critical distance that is required between fibers and structures is diminished. In this state a higher potential exists for and a significant increase in formation of restrictive intermolecular cross-link fibers (Figure 27-2).[40,47-49,54] These intermolecular cross-links restrict interfiber mobility and extensibility, and may be partially responsible for restricted soft tissue mobility and play. Furthermore, it has been shown that this reduced mobility affects the synthesis and orientation of new collagen fibrils, which further contributes to the pathogenesis of restricted fascial mobility.[54] (See Chapter 1 for a description of the effects of immobilization on connective tissue for biomechanical changes and intermolecular cross-linking.)

RESPONSE TO TREATMENT

It is reasonable to postulate a correlation between these research findings and the clinically identifiable decreased mobility and

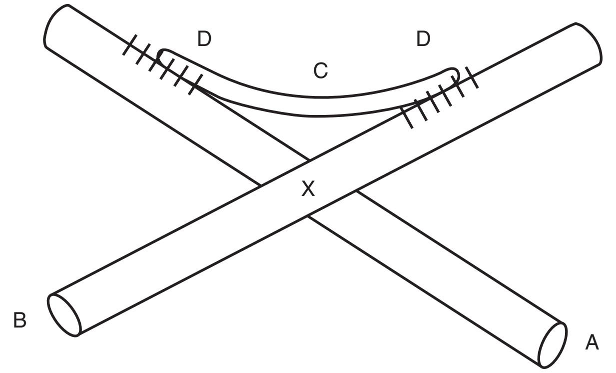

Figure 27-2 Idealized model of a collagen cross-link at the molecular level. **A-B,** Preexisting fibers; **C,** newly synthesized fibril; **D,** cross-link as the fibril joins the fiber; *(X)* nodal point where the fibers normally slide freely past one another. (From Akeson WH, Amiel D, Woo S: Immobility effects on synovial joint: the pathomechanics of joint contracture, Biorheology 17:95, 1980.)

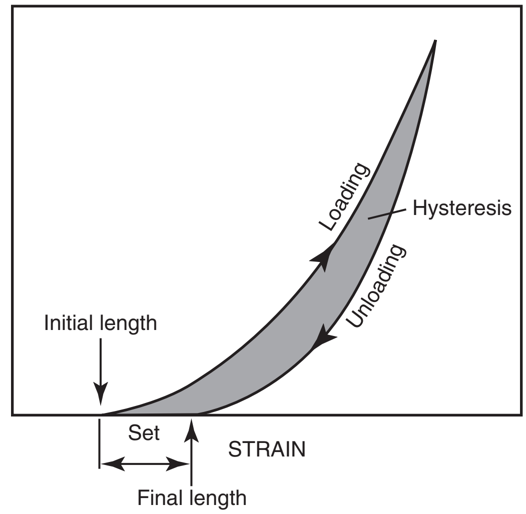

Figure 27-3 Hysteresis. When unloaded, a structure regains its shape at a rate different from that at which it deformed. Any difference between the initial and final shapes is the "set." (From Bogduk N, Twomey LT: Clinical anatomy of the lumbar spine, New York, 1987, Churchill Livingstone.)

play found in dysfunctional soft tissues. Clinically, through the application of STM, the mobility of these dysfunctional soft tissues can be improved. These results may be a result of one or more of the following factors: [55-58]

1. An alteration of the scar tissue matrix[42,50]
2. A redistribution of interstitial fluids [7]
3. The stimulation of GAG synthesis, restoring normal or improved lubrication and hydration
4. The breaking of restrictive intermolecular cross-links[43,54]
5. The mechanical and viscoelastic elongation of existing collagenous tissues through the phenomena of creep and hysteresis, as demonstrated by the stress-strain curve (Figure 27-3)[59-61]
6. A neuroreflexive response that may alter vascular, muscular, and biochemical factors related to immobility[62-66]

SKIN

The skin is composed of two layers: (1) an outer epidermis of ectodermal origin and (2) the deeper dermis of mesodermal origin.[67] The skin is continuous with the deep fascia and underlying structures through the attachment of the superficial fascia to the basement membrane of the dermis.[6] Because of the orientation and weave of the collagen and elastin fibers, the skin demonstrates considerable mechanical strength and a high degree of intrinsic flexibility and mobility. This intrinsic mobility allows the skin to have considerable extensibility and, because of its elastin content, the ability to recoil to its original configuration.[40,59] Because of the pliability of the superficial fascia, the skin also has extensive extrinsic mobility in all directions along the interface with deeper structures.[8,26] The skin in regions superficial to joints allows motion through its ability to fold and stretch in response to the underlying movements.[10,40]

The skin can lose normal mobility secondary to trauma, scar tissue formation, and immobility. With the loss of this mobility, the underlying structures can be impeded in their functional capacity, and the normal coordinated movement patterns of the kinetic chain can be altered.

Response to Treatment

Dysfunctions of the intrinsic and extrinsic mobility of the skin can be assessed and specific foci of restrictions identified. The mobility of these dysfunctions can be improved through the application of specific soft tissue techniques. These structural improvements are often clinically associated with dramatic reduction in pain and improved musculoskeletal function. These improvements may be related to the following possibilities:

1. More efficient biomechanical function because of release of fascial tension
2. Local and general changes in the vascular and lymphatic circulation[45,64]
3. A neuroreflexive inhibition of muscle tone and pain (This may be a response to the existing pathologic condition in deeper structures,[63,64] including that of underlying spinal dysfunctions.[7,68,69] These are passed through both afferent and autonomic pathways.[70])

SKELETAL MUSCLE

The two basic components of skeletal muscle are (1) the muscle fibers (the contractile components) and (2) the surrounding connective-tissue sheaths (the noncontractile components). The connective-tissue components are the endomysium, perimysium, and epimysium (Figure 27-4). They envelop each muscle fiber, fascicle, and muscle belly, respectively, and invest at the

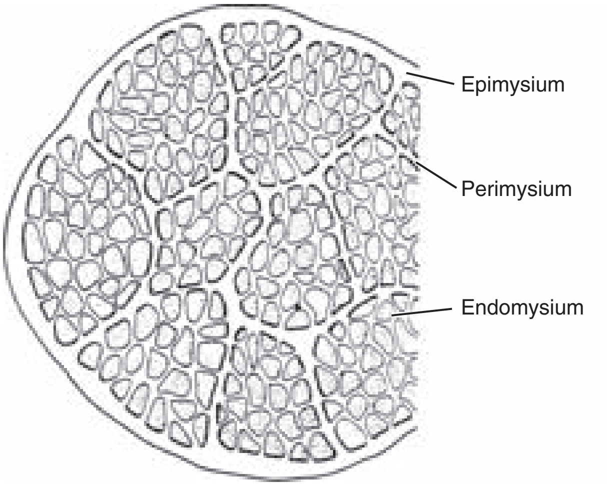

Figure 27-4 Connective-tissue components of muscle. (From Ham A, Cormack D: Histology, ed 8, Philadelphia, 1979, Lippincott Williams & Wilkins.)

muscle's terminus to form tendon, fascia, and aponeurosis.[6,26] These connective tissues provide for the following:

1. The mechanical and elastic characteristics of muscle for broadening during contraction and lengthening during passive elongation (functional excursion)[42,71] (They may be the major component affected by passive muscle stretching.[72])
2. The elastic property of muscle, possibly because of the parallel arrangement of these sheaths with the contractile components[73]
3. The tension regulation of the muscle, which influences contractile strength,[72] ability to withstand high-impact loads, and adaptive and recoil capability[74]
4. The support, cohesion, and protective restraint of the muscle[75]
5. The space and lubrication for normal extensibility and play of (a) the intrinsic contractile elements and (b) the muscle belly (through the epimysium) in relation to surrounding structures[8,10]
6. A soft tissue continuum (the myofascial unit) as they interconnect with each other, as well as the loose connective tissue and fascia surrounding the muscle through the superficial epimysium[13]
7. A conduit for blood vessels and nerve fibers (see Chapter 1)[6,26]

DYSFUNCTIONS OF THE MYOFASCIAL UNIT

Several authors believe that the myofascial unit is often the primary precipitator of pathologic conditions and symptoms.[9,12,76,77] The primary structural and functional dysfunctions of the myofascial unit include the following:

- Restrictive scar tissue[18]
- Restricted muscle play[78]
- Weakness or increased tone through impaired peripheral and central innervation

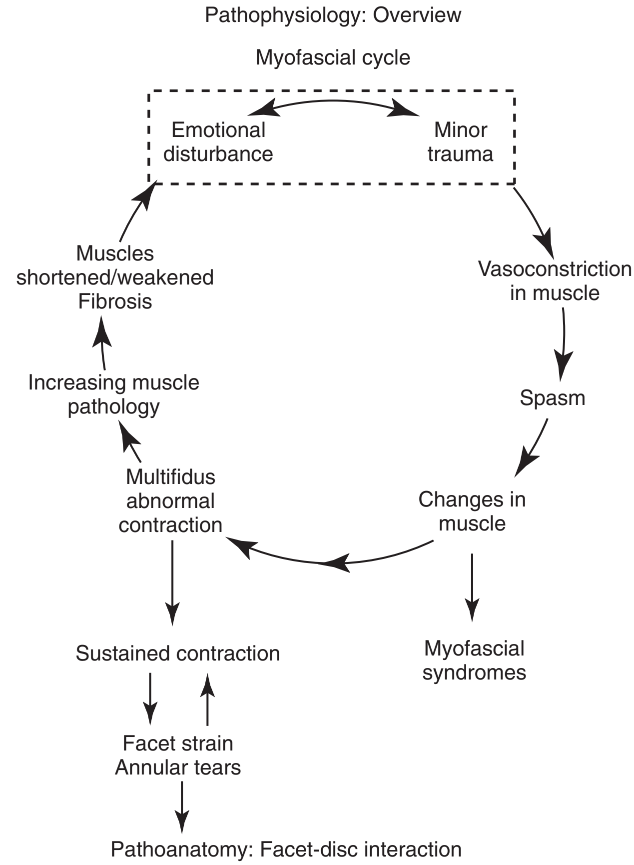

Figure 27-5 Myofascial cycle. (From Kirkaldy-Willis WH: Managing low lack pain, ed 3, New York, 1992, Churchill Livingstone.)

- Restricted extensibility and play of the connective-tissue elements (fibrosis)
- Adaptive muscle shortening, possibly through the loss of sarcomeres[10,13,46,79,80]
- Injury of the musculotendinous structures[72]
- Generalized hypertonus[1] and localized myofascial trigger points[12]
- Alteration in motor control and recruitment[9,81-83]

Myofascial Cycle

Dysfunctions of the myofascial cycle can be attributed to a variety of factors. Kirkaldy-Willis[9] has proposed a model for the evolution of spinal pathologic condition termed the *myofascial cycle.* This model presents possible courses of degeneration termed the *degenerative cascade,* which leads to spinal pathologic and symptomatologic conditions (Figure 27-5). This cycle begins with a minor trauma or emotional disturbance that facilitates a chronic neuromuscular response. This response facilitates chronic muscular changes such as fibrosis, weakness, limited extensibility, and altered recruitment patterns. Specifically, when the multifidi become dysfunctional, significant alteration of the arthrokinematic movements of the spinal segment occurs, leading to possible facet and disk deterioration.[84] Grieve,[7] in discussing tone, which Kirkaldy-Willis[9] refers to as the *chronic neuromuscular response,* states that tone in striated muscle is due to three sets of influences:

- The elastic tension of the connective-tissue elements
- The degree or extent of interdigitation overlap of the actin and myosin elements
- The number of active motor units

Myofascial Trigger Points

The number of active motor units can be influenced by multiple factors, such as trauma,[7,13] scarring from disease or injury,[13] supraspinal influences,[7] protective spasm, chronic reaction to situational stress, and repetitive habitual holding and movement patterns.[2,85] In a pathologic state, these foci of increased tone have been termed *myofascial trigger points* by Travell and Simons.[12]

Myofascial trigger points are defined as "hyperirritable spots, usually within a taut band of skeletal muscle or in the muscle's fascia, that are painful on compression and that can give rise to characteristic referred pain, tenderness, and autonomic phenomena."[12] Travell and Simons report that the palpable hardness identified with myofascial trigger points may be caused by increased fibrous connective tissue, edema, altered viscosity of muscle, ground substance infiltrate, contracture of muscle fibers, vascular engorgement, and fatty infiltration.[12] Within the STM system, myofascial trigger points are included in the category of specific or general muscle hypertonus.

A state of increased tone may be the primary source of symptoms[12] or a secondary one through a reflex response to underlying or related pathologic condition. In addition to local and referred pain, increased muscle tonus and myofascial trigger points may also precipitate altered movement patterns[86] and restricted range of motion.[9,12,42,81] Because of the individual variability of response to pain and the possibility that referred pain or protective spasm may be caused by the hypertonic state, the location of muscle tone or tenderness is often not a reliable indicator of the location of the source of pathologic condition.[7] Both muscular hypertonus and myofascial trigger points usually normalize in response to a treatment program of STM. However, if the hypertonus or trigger points are in protective or secondary spasm because of a primary dysfunction elsewhere, then the objective signs and symptoms often return, partially or completely, within a short period of time.[2]

NEUROMUSCULAR CONTROL

Another factor that must be taken into consideration when addressing the myofascial system is neuromuscular control. The movement control of the neuromuscular system must be precise and allow for few deviations to protect the articular and soft tissue structures.[17,76,87] Many authors report that dysfunctions of the myofascial unit are often preceded by faulty posture, poor neuromuscular control, and altered recruitment patterns.*

*References 17, 76, 82, 83, 88, 89.

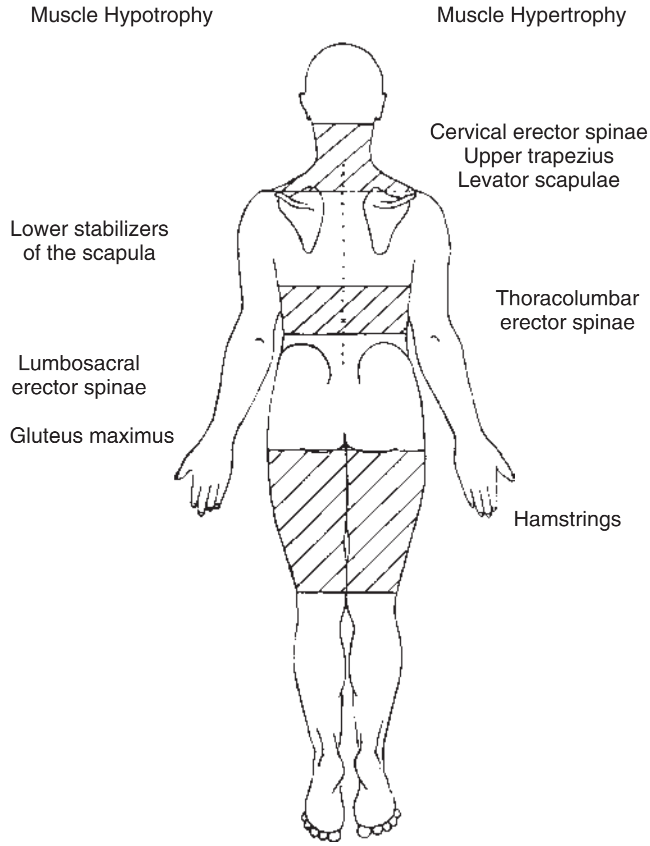

Figure 27-6 The layer syndrome. (From Jull G, Janda V: Muscles and motor control in low back pain: assessment and management. In Twomey LT, Taylor JR, editors: Physical therapy of the low back, New York, 1987, Churchill Livingstone, p 253.)

These conditions often lead to length-associated muscle imbalances between antagonistic muscle groups and affect the balanced force production, coordination, fine motor control, and distribution of forces necessary to protect the spinal segment during movement and static postures.[7,17,76]

For efficient neuromusculoskeletal function to occur, normal joint and soft tissue mechanics must be present. Normal voluntary and involuntary neuromuscular control is developed primarily through learned activities. Various factors may precipitate a state of altered recruitment patterns.[17,76] Janda[76] has observed that consistent neuromuscular patterns occur when altered recruitment exists. Muscles composed primarily of tonic (slow twitch) fibers become chronically facilitated and respond to stressful situations and pain by increased tone and tightness. Those that are primarily composed of phasic (fast twitch) fibers are inhibited, becoming weak, atrophied, and overstretched, thus creating length-associated muscle imbalances (Figures 27-6 and 27-7).[76,86]

Recent research[90,91] has confirmed the long-held proprioceptive neuromuscular facilitation (PNF) concept regarding the importance of the multifidus in stabilization of individual spinal segments and in controlling motion between those segments. In conjunction with the multifidus, researchers have

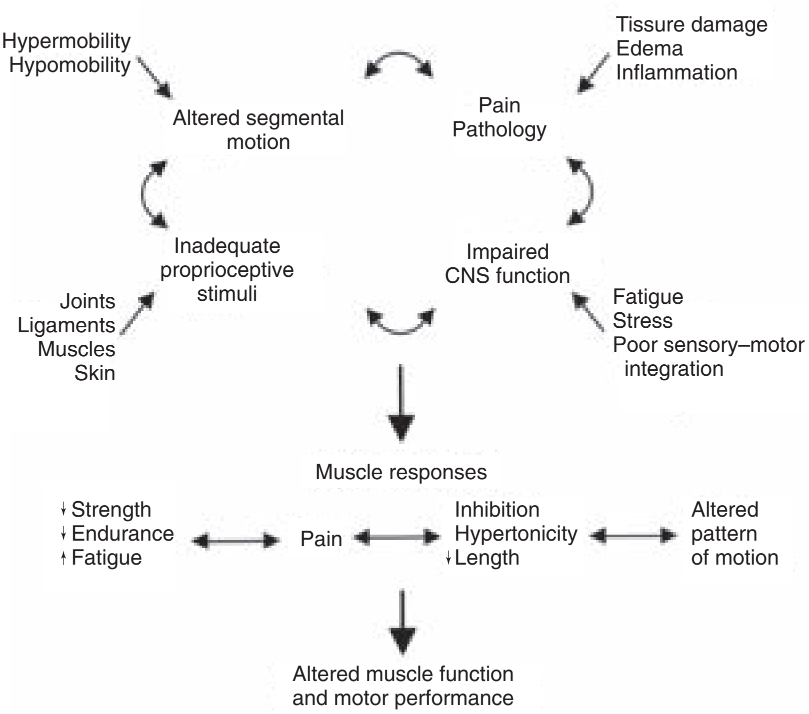

Figure 27-7 Sources of adverse stimuli and muscular responses. (From Jull G, Janda V: Muscles and motor control in low back pain: assessment and management. In Twomey LT, Taylor JR, editors: Physical therapy of the low back, New York, 1987, Churchill Livingstone.)

found that the transversus abdominis contracted before the other abdominal muscles and in conjunction with the multifidus to produce stability.[92-94] Other researchers have also found that the multifidus is inhibited in individuals with low-back pain.[95-98] Even in individuals with first-time acute episodes, the multifidi will frequently be inhibited and will not demonstrate the normal recruitment patterns. Research has found that the multifidus does not recover normal function after the episode has resolved. Therefore through the functional mobilization approach to rehabilitation, the following treatment strategy would be followed. Initially, manual therapy would be applied to normalize the condition of the myofascial and articular structures. Then specific training would be used to facilitate contractions of the deep stabilizing muscles (multifidus, transverse abdominis, deep fibers of the psoas and quadratus lumborum) through PNF trunk patterns and functional movement patterns (described later). Specific body mechanic training to use proper biomechanics and motor sequencing would follow this. An important aspect of the functional manual therapy approach is the facilitation of the core muscles' "tonic fibers." This is accomplished through the use of prolonged holds.

An example of an altered recruitment pattern is excessive activation and tightness of the trunk extensors during a poorly performed sit-up. In an individual who exhibits such an altered movement pattern, one can palpate the extensors while the sit-up is being performed and note substantial activation. This unnecessary activation of the extensors creates a state of neuromuscular imbalance that decreases the facilitation of the lower abdominals. This motor recruitment dysfunction is carried over to the performance of daily activities and alters the normal neuromuscular, postural, and mechanical dynamics of the lumbar spine. The treatment strategy for this condition would include STM and elongation of the shortened extensors,[2,11,76,86] strengthening of the weakened flexors,[11,79,98] neuromuscular reeducation to restore proper movement and recruitment patterns,[17,82,83,88,99] and body mechanics training to change stressful activities of daily living (ADL) patterns.[98]

Patients who are forced into inefficient postures because of soft tissue dysfunctions often have difficulty performing dynamic, coordinated, and balanced motions while simultaneously maintaining trunk stability and controlled mobility. STM directed toward improving posture often elicits an almost immediate improvement in neuromuscular control, recruitment patterns, and stabilization abilities.[2,98]

ABILITIES

Neurovascular Components

The connective-tissue components of the central nervous system (CNS) are the meninges and in the peripheral nervous system the mesoneurium, epineurium, perineurium and endoneurium. The vascular elements include the heart, arteries, and veins. It is important to understand that these neurovascular components have a mechanical interface with connective tissue, skin, and skeletal muscle. Often times these interfaces can have adherences that contribute to one having restricted range of motion, altered movement patterns, pain, adverse neural tension (discussed later), and impaired function. Through STM these adherences can be treated to restore the mobility of the neurovascular structures.[100]

Evaluation

A specific, organized evaluation system is an integral part of a rehabilitation and manual therapy program. The subjective and objective evaluation process is systematic and specific, providing baseline data from which to develop and perform a treatment program and to assess the effectiveness of treatment. The following components of evaluation can assist the therapist in identifying musculoskeletal dysfunction and determining the vigor of the treatment process:

- Patient's subjective report
- Structural analysis
- Motion analysis
- Palpation

Subjective Evaluation

Through a careful subjective evaluation, a therapist can identify many of the factors that cause and precipitate musculoskeletal symptoms. The subjective evaluation is the critical link between the patient's symptomatic and historical report and the objective findings. Cyriax and Cyriax[101] stated that most soft tissue dysfunctions have "distinctive histories."

The four primary goals of the initial subjective evaluation are as follows:

1. To develop rapport with the patient
2. To gather detailed historical information
3. To understand the specific symptoms and their irritability
4. To make the patient aware of his or her condition and of the need to take responsibility for his or her own care

Within the framework of a normal subjective evaluation, asking certain questions is important in determining soft tissue involvement. These questions[14,93,102] are designed to identify the following:

- Location and type of symptoms
- Course of symptoms and irritability
- Duration of symptoms
- Precipitating trauma or activity
- Previous traumas
- Previous surgeries
- Stressful employment, leisure, and recreational activities
- Postural and sleeping habits

Location and Type of Symptoms

The patient is guided in listing each symptom, beginning with the most bothersome and proceeding to the least bothersome. Each symptom is analyzed for its precise location, type, quality, and intensity.

Course of Symptoms and Irritability

Identifying the general or average course of symptoms assists in determining the degree of irritability and identifying the symptom-generating structures. The patient is asked to identify the postures and motions that exacerbate or ease the symptoms, and the therapist attempts to secure quantifiable measures of irritability.

Duration of Symptoms

The therapist should inquire primarily about those symptoms related to the chronic protective spasm and inactivity that could precipitate fibrotic changes within muscles and a remodeling of soft tissues.

Precipitating Trauma or Activity

It is important to carefully identify the direction of trauma and the movement pattern that occurred. This information is helpful in understanding the presenting symptoms, in analyzing the structural deviations, and in identifying which soft tissues should be evaluated. It is often important to know the patient's emotional state at the time of injury.[17]

Previous Traumas

One should look for earlier traumas that may have precipitated soft tissue changes, altered the biomechanics of the kinematic chain, or affected the performance of normal motor function. These alterations contribute to the presenting symptoms.

Previous Surgeries

It is important to inquire about previous surgeries, because scar tissue can dramatically affect efficient function in the whole kinematic chain. The authors have seen several cases in which restriction of scar tissue from abdominal surgery was a primary factor in the onset of shoulder symptoms. This was due to the restricted extensibility of the anterior region that altered the kinetics of throwing a ball and serving in tennis.

Stressful Employment, Leisure, and Recreational Activities

It is important to identify repeated patterns of postural dysfunction and aberrant movement patterns that may create dysfunctional soft tissue and muscular changes related to the presenting complaint.

Postural and Sleeping Habits

One should identify prolonged and habitual positions that may cause adaptive shortening of soft tissues and perpetuate symptoms.

OBJECTIVE EVALUATION

In clinical practice, therapists must make many choices every day in providing effective patient care. Some of these decisions are minor and obvious, whereas others are difficult and require careful analysis. Informed decision making is most effectively accomplished when all of the pertinent facts are gathered and analyzed. However, facts alone are not enough. Once the information is compiled, one must use discernment to sift through it. Discernment is drawn from previous experience; knowledge of anatomy, pathologic condition, and kinesiology; and a flexible scientific and intuitive decision-making process. This process requires a consistent and organized objective evaluation system.

A carefully performed objective evaluation provides a means to assess the physical and functional status of the whole patient. The objective evaluation assists in identifying abnormal postural and functional factors in both the symptomatic and the related asymptomatic regions. The organization and vigor of the objective evaluation are determined by data gained from the subjective evaluation (location, type, irritability, and nature of the symptoms). The components of an objective evaluation are observation (structural, movement, and functional analysis), palpation, neuromuscular control, and neurologic and special needs testing.

Data gathered through the objective evaluation will assist in developing a treatment plan, setting realistic goals, and objectifying the effectiveness of treatment.[86,103] Objective evaluation includes three components: (1) structural evaluation, (2) movement analysis, and (3) palpation assessment.

Structural Evaluation

Through careful observation, the postural and soft tissue components are analyzed for patterns of dysfunction that are directly or indirectly related to the patient's symptoms. They are observed through structural and postural analysis, as well as through soft tissue contours and proportions.

Structural and Postural Analysis

The structural and postural analysis is the building block of an objective evaluation and is based on the interrelationship that exists between structure and function. A system's inherent functional capacity is dependent on its structural integrity. Functionally, the body uses both static and dynamic postures. Static postures are primarily used for rest, whereas dynamic postures provide support for all functional activities.

Taking into account the natural asymmetrical state of each individual, efficient posture can be defined as the balanced 3-D alignment of the body's skeletal and soft tissue structures in an arrangement that provides for optimal weight attenuation, shock absorption, and functional capacity. This balanced posture is termed *neutral alignment.* This optimal skeletal arrangement provides for minimal energy expenditure and efficient neuromuscular control. In the neutral alignment, articulations are inherently protected in their midrange position, muscles are at an optimal length for function, and biomechanical potential is established for optimal coordinated function.

This should not imply that all functional activities occur in this neutral structural alignment. However, the capacity to assume this structural arrangement gives the neuromuscular system a flexible supportive structure and provides optimal function and protection for the articular and myofascial components.

Inefficient posture is often a major factor in the pathogenesis and perpetuation of symptoms.[17,104] Improper postural alignment places abnormal stress on sensitive structures and affects normal weight distribution, shock absorption, segmental biomechanics, and energy expenditure. These alterations can precipitate pathologic condition and symptoms in the articular and soft tissue structures. Poor skeletal alignment is especially significant clinically when symptom-producing postures are sustained and repeated for extended periods of time.

Inefficient alignment is usually a result of two closely interrelated factors: (1) structural and mechanical dysfunctions or (2) functional compensations.

Structural and Mechanical Dysfunctions

Structural and mechanical dysfunctions are defined as hyper- or hypomobility of articular and soft tissue structures that alter normal functional capacity.

Functional Compensations

Functional compensations are chronic or habitually held postures that alter the system's structural and functional capacity. Functional compensations develop because of either habitual use of stressful postures and motions or chronic unresolved emotional or mental physical responses.[86] The neuromuscular skeletal system compensates for these habitual or unresolved responses through unnecessary muscular effort, inefficient postural alignment, aberrant movement patterns, and reduced kinesthetic awareness. These functional compensations, when unidentified, may be primary factors in causing and perpetuating unresolved symptoms.

Observational evaluation begins with a global view of the patient that guides the therapist to regions in need of specific assessment. One should generally assess the overall body type,[14] as well as the contour, integrity, and balance of the patient's posture. The structural vertical and horizontal alignment should be evaluated for general patterns of imbalance and poor alignment, which may precipitate excessive stress on symptomatic structures.

Once regions and patterns of dysfunction are identified, a regional evaluation is conducted. A systematic regional structural evaluation begins with the analysis of the base of support and then progresses superiorly to scan each movement segment. (Figure 27-8 provides a block representation of the movement segments.) It is at the transitional zones between these general movement segments that many dysfunctions and symptoms occur. Each segment is assessed for position, relationship of the structural and soft tissue components, and relative structural proportions of each movement segment.[2,85,105-107] Special attention is given to the evaluation of the symptomatic region or regions, with a focus on the patient's capacity to assume a neutral posture.[2,86,104]

The regional assessment is followed by a specific evaluation to closely assess the dysfunctional regions for specific structural and movement dysfunctions. This evaluation is most effectively conducted in conjunction with exploratory palpation. Combining observation with palpation provides a valuable learning experience and an opportunity to correlate the observed structural changes and palpable findings. The specific evaluation can progress to the vertical compression test.[98,108]

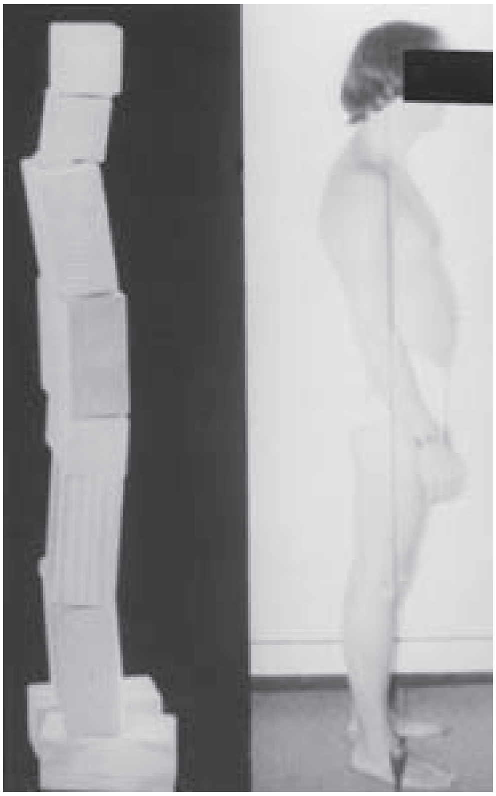

Figure 27-8 Positional relationships of movement segments.

The vertical compression test assesses the integrity and force attenuation capacity of the spine and extremities in weight-bearing positions. The test evaluates for the quality of weight distribution, the compliance of the structural components, and the symptoms produced by habitual postures.[78]

The vertical compression test is performed in weight-bearing postures such as standing, sitting, and on the hands and knees by applying a gentle vertical pressure to the head, shoulders, pelvis, or knees (Figure 27-9). During the application of vertical compression, the therapist evaluates the inherent stability of the weight-bearing structures.

When the test is applied in an optimal state, the structure will be stable, with the force felt and seen to be transmitted directly through each movement segment into the base of support. However, if a segment or a combination of segments is malpositioned, then vertical compression will produce noticeable buckling or pivoting at the transitional zones. These unstable transitional zones are often the regions of presenting symptoms, and they will be increased by the test if a postural component to the symptoms exists. These zones will often be used as primary fulcrums during functional activities. This excessive overuse of individual segments often alters neuromuscular patterns, precipitates degeneration, develops a low-grade inflammatory response, creates hypermobility, facilitates chronic muscular activity, and produces associated soft tissue adaptations.[109]

The therapist, while applying the vertical compression test, questions the patient about the status of the symptoms. Caution must be used with the force and number of retests applied, especially with highly irritable patients or those suspected of being load sensitive. The test can help patients recognize exist-

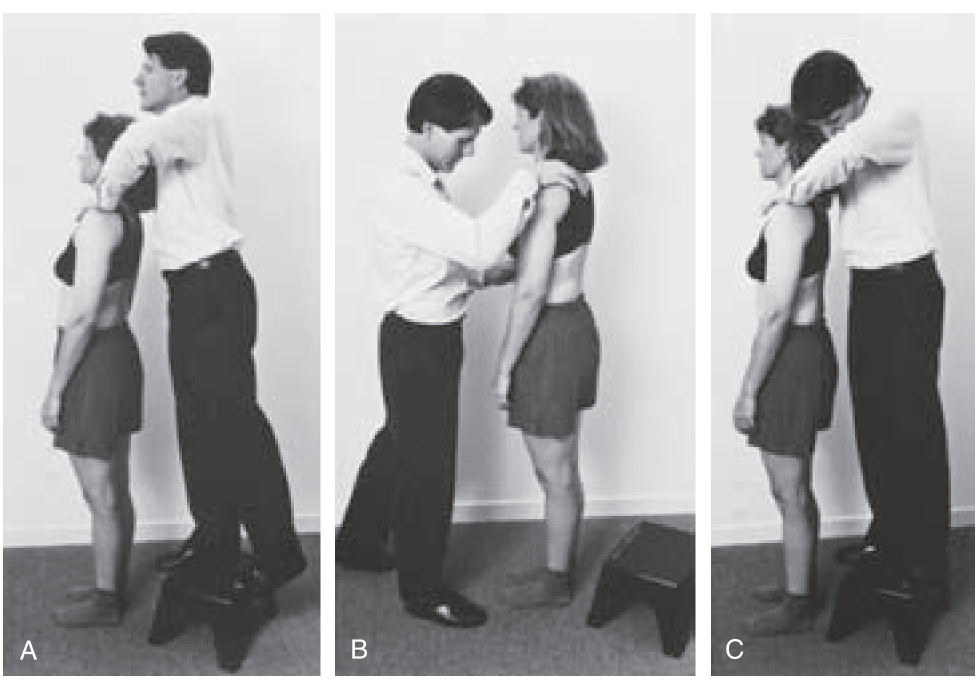

Figure 27-9 Vertical compression. **A,** Test. **B,** Correction. **C**, Retest.

ing postural deviations and their functional and symptomatic effects. The vertical compression test can be graded on a scale of 1 to 5, much like conventional manual muscle testing (MMT).

TREATMENT STRATEGY

Once the dysfunctional segments are identified and symptoms assessed, the next goal is to improve the patient's posture. Using both manual and verbal cues, the therapist guides each segment to a more balanced neutral position. When a more efficient alignment is achieved, vertical compression is again applied to reevaluate the vertical integrity and associated symptoms. Several postural corrections may be needed to achieve an optimal stable position. The retest also provides the patient with further kinesthetic feedback on the more stable and balanced alignment.

Those segments that cannot be repositioned because of structural limitations are identified for more in-depth soft tissue evaluation and treatment. For example, in the lumbar spine the most important and most frequently identified alignment problem is backward bending of the thoracic cage in relation to the pelvis.[2,101] The myofascial structures that are most often found to be dysfunctional are the deep fibers of the psoas, the lumbar extensors, and the anterior cervical muscles. When these and associated articular dysfunctions are normalized, the patient can assume a more balanced alignment with greater ease. Evaluation should progress to testing for the lumbar protective mechanism; balancing reactions and functional training should be emphasized.[98,108]

Except in cases in which a forced posture controls pain (e.g., maintaining a pelvic tilt to open the intervertebral foramens in cases of advanced foraminal stenosis), increased muscular effort should not be used to assume an improved posture against underlying soft tissue tension. The effort of forcing a fixed posture often causes secondary compensations, biomechanical stresses, and structural shortening.[2,83] Therefore restrictive soft tissues should be normalized through STM and stretching so that an improved alignment can be assumed with greater ease. This decreased effort enhances patient compliance and comfort.

With improved postural alignment, increased emphasis should be placed on body mechanics training and a conditioning exercise program to strengthen weak muscles, lengthen shortened structures, develop core muscle facilitation of the lumbar protective mechanism, reestablish proper movement patterns, and improve kinesthetic awareness and balancing reactions.

Soft Tissue Observation

A symbiotic relationship exists between the soft tissues and the underlying supportive bony structure. The following soft tissue components should be assessed for dysfunctional states:

- The surface condition for changes in texture, color, moisture, and scars
- The surface contours by assessing the body's outline for circumferential and segmental bands, regions of bulges or protrusions, and areas that appear flattened or tightened
- The soft tissue proportions by comparing the bulk of soft tissues between the front and back, right and left, and inferior and superior (Areas of imbalance can lead to the identification of regions of overdevelopment or a general deconditioned state or atrophy. Any proportional imbalances in soft tissue development require further evaluation and the initiation of an appropriate muscle-conditioning program.[2,85,106,107])
- The inherent patterns of dysfunction (The full structure is assessed using a global view to note any patterns in the organization of the soft tissue dysfunctions. These patterns often exist in observable and palpable zigzag and spiral patterns away from the central dysfunction. If a pattern is identified, then one should try to determine where the primary restrictions exist and if they are due primarily to underlying mechanical dysfunctions or to functional compensations (Figure 27-10). Frequently, normalization of these primary restrictions enhances the rehabilitation program by reducing the inherent stress placed on symptomatic structures.)
- The 3-D structural proportions (In the efficient state, each individual has an inherent proportional balance between the

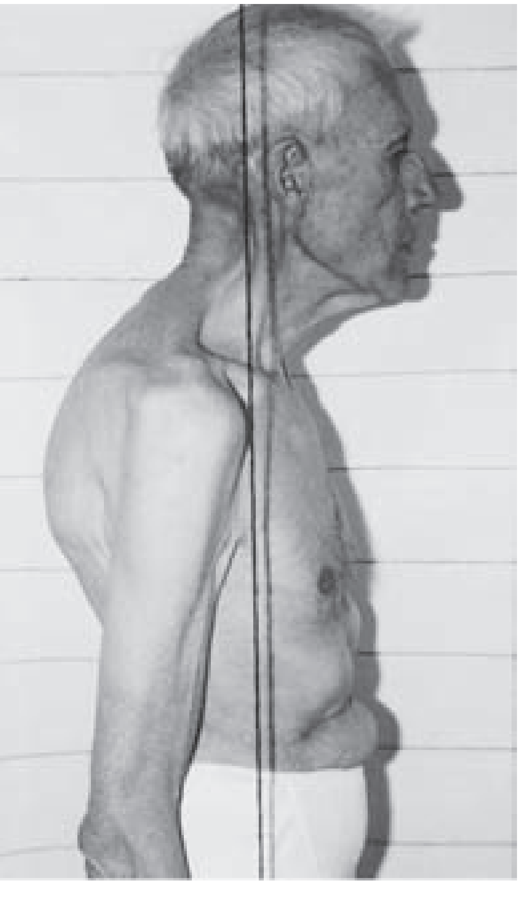

Figure 27-10 Evaluation of patterns of spiral and zigzag soft tissue compensations.

length, width, and depth of his or her structural components [skeletal and soft tissue systems]. Dysfunctions often diminish one dimension and restrict functional capacity and weight distribution.[85,106,107] The treatment strategy is to increase the diminished dimension through manual therapy and reeducation.)

Movement and Functional Analysis

Once postural abnormalities and soft tissue changes are identified, it is important to evaluate the mobility of these regions while the patient performs physiologic and functional movements. An important and often-overlooked assessment of the soft tissue system is the observation and palpation of these regions during the performance of guided motions and functional activities. Because the soft tissue system is continuous, movement that occurs in one region precipitates normal adjustments throughout the soft tissue and skeletal systems. However, dysfunctions in one region can affect the mobility and quality of movement in related regions, possibly altering the efficient function and overall adaptive potential of the entire kinematic chain.

Dysfunctional soft tissues impede efficient movement by limiting the ability of structures to elongate, fold, conform, and/or slide in relation to each other. Increased strain occurs as the motion transfers from regions of relative immobility to regions of relative hypermobility or vice versa, resulting in alterations in the function of the underlying articulations.

Through careful observation of the patient's ability to perform physiologic movement patterns, normal functional activities, functional movement patterns, and the adverse neural tension test, the therapist can identify soft tissue dysfunctions and grade the effects of those dysfunctions on movement performance.

Physiologic Movement Patterns

The conventional active range of motion (AROM) evaluation yields significant information about the mobility of articular and soft tissue structures. Movement evaluation is performed in weight-bearing postures such as standing, sitting, and quadruped. The evaluator should look and palpate for the following:

- Quality and sequencing of motion
- Range of movement (delineating structural and symptomatic limitations)
- Effect of movement on the intensity, location, and type of pain
- Mobility of individual segments
- Mobility of soft tissues in relation to each other
- Freedom of soft tissues to move in relation to underlying structures
- Ability of soft tissues to elongate and fold
- Proper use of the base of support

Note: Careful assessment and recording of specific limitations of physiologic motions provide the therapist with parameters for reevaluation and thus the ability to correlate the effects of soft tissue treatment.

Normal Functional Activities

Observation of an individual performing normal ADL, particularly those that produce symptoms, often reveals soft tissue dysfunctions associated with the presenting complaint and exacerbations. Many of the patients who have nontraumatic muscular skeletal symptoms have what is described as the *self-inflicted pain syndrome.* In any patient whose symptoms are perpetuated through stressful use, the aim of therapy is to assist the patient in becoming aware of the relationship between actions and pain, as well as educating the patient in the use of less stressful body mechanics.

A functional evaluation should include all functional activities frequently performed by the patient that may stress the symptomatic region, including the following:[85,98]

- Coming to sitting
- Sitting
- Rising to standing
- Walking
- Bending
- Reaching
- Pushing
- Pulling
- Lifting

Functional limitations such as a tight calf compartment, limitations in hip range of motion, and restrictions in shoulder girdle mobility are frequently identified through careful analysis.

Another critical component of a functional evaluation is the assessment of dynamic balance and balancing reactions. As anyone who has studied ballet, gymnastics, martial arts, or any athletic endeavor discovers, performance is often dependent on proper structural alignment, neuromuscular coordination, muscular strength, soft tissue compliance, and balancing capacity.

When a functional approach is used, the success of treatment can be gauged through documented improvements in the tested functional activities and abilities.[98]

Functional Movement Patterns

Functional movement patterns[3] were adapted primarily from the PNF diagonal movement patterns[88,99] and Awareness Through Movement lessons developed by Feldenkrais.[83] These movement patterns provide a means to quickly and effectively assess motor control; muscle recruitment patterns; soft tissue compliance; and articular mobility of specific body segments, regions, and/or the body as a whole. Functional movement patterns offer additional tools for evaluating specific limitations in dynamic range and sequencing of motion. For example, lower-quadrant movement patterns such as the pelvic clock, lower-trunk rotation, unilateral hip rotation, and pelvic diagonals can provide information about 3-D active compliance of the soft tissues, mobility of the underlying articulations, and quality of neuromuscular control. In addition, movement patterns such as side-lying shoulder girdle circles and arm circles reveal the mobility and compliance of the rib cage and upper-extremity soft tissues.

Treatment is applied through sustained pressure on the dysfunctional tissue or joint while the patient actively performs the functional movement pattern. The motion can vary from large excursions to very small ones. The purpose is to produce intermittent pressure and relaxation on the dysfunctions. After the resolution of these dysfunctions, the therapist performs neuromuscular reeducation by having the patient integrate the functional movement pattern into the new range in slow, controlled motions. Initial concern is evaluating the quality of contraction and strength of the core musculature in the region treated. This is accomplished through a prolonged hold. Motor control training immediately follows this, in which the therapist facilitates the patient to integrate the new range of motion in slow, coordinated combination of isotonic and isotonic reversals. The movement pattern can then be transferred to a home program for further training and strengthening.

Adverse Neural Tension Test

Adverse neural tension tests, as described by Maitland,[103] Elvey,[28] and Butler,[27] test the extensibility and mobility of the neural components from the dural tube through the peripheral aspects. Restricted motion and symptom production indicate a dysfunction through possible compression, adherence, or contractile and noncontractile restriction.[110]

Evaluations for both upper- and lower-limb neurovascular structures are performed by placing the individual nerves on selective tension through movement of the trunk and extremity. In the efficient state, when the neurovascular structures are placed at their lengthened range, a springy end feel is noted and the patient does not experience any discomfort. In a dysfunctional state, the range is restricted, palpable tension exists, and the patient reports reproduction of symptoms or discomfort. The most efficient procedure for evaluation of the peripheral nerve in all regions where it is accessible for palpation is to have the patient perform oscillatory motions of the distal component (using the wrist for the upper extremity and the ankle for the lower one). The therapist palpates the nerve along its course, assessing for free motion and efficient play. When restricted mobility is identified, sustained pressure is placed on the dysfunctional tissues while the oscillations continue to be performed at the distal and/or proximal components.[4]

Palpatory Evaluation

Palpatory evaluation is performed by placing selective tension on the tissues to be assessed. Through palpation, mechanical dysfunctions that restrict structures from their efficient functional excursion and independent play are identified.

Palpation evaluation is guided by the data gained through the subjective, postural, and movement evaluations and includes the specific assessment of the condition and the 3-D mobility of the individual layers of tissues. The soft tissues are initially evaluated in their resting positions; however, the associated functional deficits may be appreciated better by palpating the tissues during the performance of passive, active, or resisted motions.[3] The assessment is organized to evaluate the condition and the 3-D mobility of each layer, beginning superficially and progressing deeper. The individual layers are defined by the individual strata of muscles. This is important because skin, muscles, and neurovascular elements all exist in individual layers and compartments and are separated by loose connective tissue.[2,111]

Through proper layer palpation, most dysfunctional soft tissues can be identified. These dysfunctions exist within a specific layer or extend through several distinct layers. Such restricted regions have a single or several central epicenters of maximal restriction. Epicenters vary from the size of a pea to the size of a grain of sand. Most restrictions have spiral patterns of adherence that should be identified. A strong indicator of soft tissue dysfunction is tenderness to normal palpation. Therefore patients can assist in locating the epicenter of tenderness. It should be noted that some tissues without any identifiable dysfunction will be tender to normal palpation. These tissues may be in a state of low-grade inflammation, resulting in dysfunction of soft tissue structures.[2]

Referred pain is another clinical aspect of dysfunctional soft tissues. Referred pain patterns are elicited and assessed through normal palpation to epicenter restriction. By assessing these referred pain patterns, the therapist can discern whether the dysfunction is a primary or secondary source of symptoms or dysfunction.[63,101]

Although performing a palpatory evaluation, the therapist must remember that proper and sensitive palpation is a critical means of communication. One of the fastest ways to develop the patient's confidence is through a caring and competent touch. Often the difference between successful and unsuccessful manual treatment is the development of patient confidence, which influences the patient's ability to relax. It is recommended that the therapist strive to develop skills of touching and to assist this process by frequently asking patients for feedback and assistance.[112,113]

Soft tissue dysfunctions are identified through palpable changes in tissue extensibility, recoil, end feel, and independent play.[2]

Extensibility and Recoil

Tissue extensibility is the ability of tissues to elongate to an optimal range and still have a springy end feel. Tissue extensibility is evaluated through precise direct pressure on the tissues or through elongation of those tissues by joint motion. Recoil is evaluated by how the tissue returns to its normal resting length.

As soft tissues are deformed through their functional excursion, points of increased resistance may be palpated. These restrictions or changes in density may exist through all or part of the tissue excursion. The specific restrictive points, epicenters, and direction of greatest restriction must be identified because the treatment technique is applied to the adherent tissues at the point and direction of greatest restriction.

End Feel

Tissue end feel[42] is the quality of tension felt when a tissue is manually deformed to the limit of its physiologic or accessory range. In a healthy state, tissues have a springy end feel that can be compared with the quality of elasticity and recoil felt when a new rubber band is taken to end range. The excursion (range of deformation) of soft tissues varies throughout the body, but in a healthy state the end feel is consistently springy.

Dysfunctional tissues have varying degrees of hard end feel and motion loss. These limitations are defined by their specific 3-D limitation of precise depth, direction, and angle of maximal restriction. The goal of this evaluation process is to localize the dysfunction so that treatment can be more specific, more effective, and less invasive.[2]

Independent Play

All soft tissue structures in their efficient state have independent accessory mobility in relation to surrounding structures. The degree and extent of mobility vary from structure to structure. In a healthy state this is described as *normal play.* In a dysfunctional state, reduced play is noted between adjoining tissues. In myofascial tissue this is termed *restricted muscle play.* Dysfunctional tissues and structures can be evaluated most effectively by conducting palpation during passive and active movements that reveal associated functional limitations.

EVALUATION PROCEDURES FOR SOFT TISSUE STRUCTURES

The following are the individual structures specifically assessed through layer palpation: skin and superficial fascia, bony contours, and myofascial tissues (Figure 27-11).

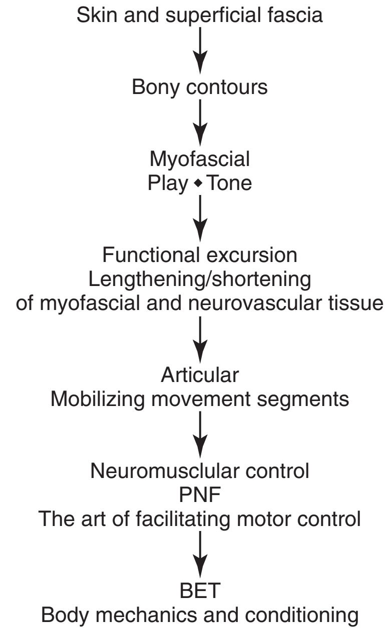

Figure 27-11 Selective and layer treatment progression. (Courtesy The Institute of Physical Art, Steamboat Springs, Colo.)

Skin and Superficial Fascia Assessment

The skin is assessed for changes in tissue texture, temperature, and moisture by running the fingers or the back of the hand lightly over the surface of the skin. Changes in any of these parameters can guide the evaluation to underlying acute or chronic conditions.

The skin is evaluated for intrinsic and extrinsic mobility by fingertip palpation. The intrinsic mobility (within the skin) is assessed for extensibility, end feel, and recoil. The extrinsic mobility is assessed for independent play of the skin in relation to underlying structures.

Techniques for evaluation of the skin and superficial fascia include skin gliding, finger sliding, and skin rolling.

Skin Gliding

Skin gliding is performed by using either general (forearm, palm, elbow, knuckles) or specific (fingertips and thumbs) contacts. The skin's two-dimensional (2-D) mobility is evaluated for its ability to slide in relation to underlying structures (extrinsic mobility).

To evaluate, the manual contact point is fixed to the skin over the region to be assessed. The skin is pulled to the end range, evaluating the functional excursion, quality of extensibility, and end feel. The exact location of the adherence that is limiting its mobility is found through tracing and isolating along the direction of restriction. Restrictions are assessed using the clock face concept. Through this approach of evaluating the 360 degrees of 2-D motion around a single contact point, restrictions are localized.

Finger Sliding

Finger sliding evaluates the ease with which the fingertips slide across the skin (Figure 27-12). In normal tissue the finger slides with ease, creating a wave of skin in front. In restricted regions, the ability of the finger to slide across the skin is diminished. The goal is to isolate the specific location and direction of maximal restriction. Skin sliding is often used initially to trace and isolate regions of restriction, and finger sliding provides a means to localize the precise location and direction of restriction.

Skin Rolling

Skin rolling is performed by lifting the skin between the thumb and the index and middle fingers to evaluate its ability

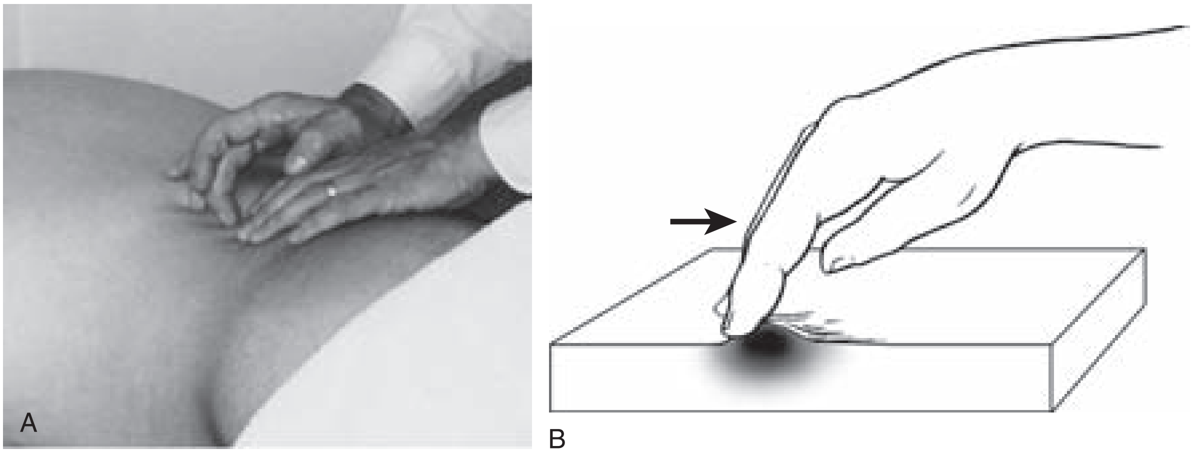

Figure 27-12 Skin and superficial fascia assessment: finger sliding.

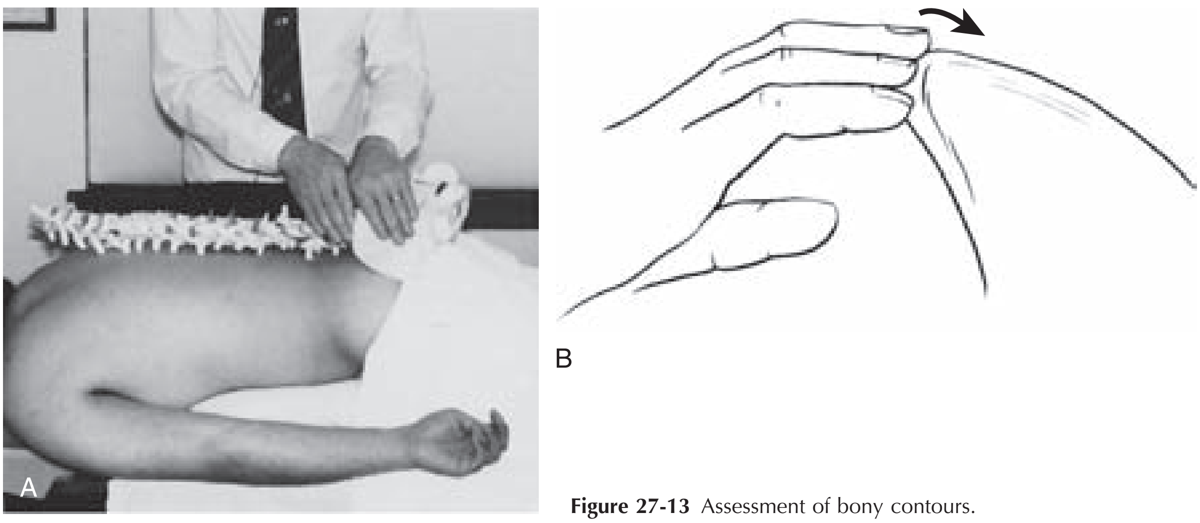

Figure 27-13 Assessment of bony contours.

to lift from underlying structures. Skin rolling is accomplished by keeping a wave of skin in front of the thumb while the finger feeds tissue toward the thumb. This procedure is especially effective over bony prominences.

Bony Contours Assessment

Scott-Charlton and Roebuck[114] state that "a great deal of spinal pain may well be pain felt where muscle, tendon, ligament and capsule are attached to sensitive periosteum of the spine." Therefore evaluation of the soft tissues along bony contours (i.e., iliac crest, vertebral bodies, scapula, tibia) may provide valuable information related to the overall condition of the multiple layers of soft tissues that attach to the bony contour. In addition, the bony contours are often the primary avenue for lymphatic drainage. If lymphatic drainage is impeded by restricted soft tissues, then further immobility may result.

A bony contour evaluation is performed by sliding the fingers parallel (longitudinally) at progressively deeper depths along the edges of the bone, noting any points of adherence and restricted mobility. The restrictions are defined by depth and direction, using the clock face concept (Figure 27-13). Corrective treatment often facilitates functional and symptomatic improvements, possibly because of enhancement of the normal dynamic soft tissue tension and mobility altering the stress on affected structures.

Myofascial Assessment

Evaluation of the myofascial structures should include assessment of the four conditions of (1) muscle tone, (2) muscle play, (3) muscle functional excursion, and (4) neuromuscular control.

Muscle Tone

Muscles in a state of increased tone feel harder, denser, and often tender to normal palpation.[32,115] When in a state of increased tone, myofascial tissue always has specific points or epicenters of maximal density. These points exist whether the entire muscle belly is involved or the dysfunction is localized to the individual foci of hypertonia. More specifically, the exact location, depth, and direction of the increased tone should be located and treated.

Muscle Play

Concepts of muscle play have been discussed previously in the section on the concepts of functional joints. The assessment of muscle play includes the following:

- The quality of accessory mobility of a muscle in relation to the surrounding structures, which allows full functional excursion and efficient biomechanical function during muscular contraction
- The ability of the muscle belly to expand during contraction, which allows full muscular shortening
- The ability of the muscle cell bundles to slide in relation to each other, which allows full passive and active functional excursion of that muscle

Muscle play is evaluated through perpendicular (transverse) deformation and parallel (longitudinal) separation of the muscle belly from surrounding structures. Each restriction is noted for its specific depth and direction. Because of the functional limitations caused by restricted muscle play, evaluation should also be conducted during passive and active motions.

Muscle Functional Excursion

Muscle functional excursion is defined as the muscle's capacity both to lengthen and narrow and to shorten and broaden. A muscle's ability to lengthen and narrow is evaluated by stretching the origin of the muscle from its insertion, identifying the specific direction of maximal restriction, and treating with STM in conjunction with contract or hold-relax techniques (Figure 27-14).[82,88,116] The patient can assist in the evaluation process by identifying where the stretch is felt when the muscle is positioned in a lengthened range.

The ability of a muscle to shorten and broaden can be evaluated through passive and active methods. Passive evaluation is performed through transverse fiber palpation to assess the play of the intrinsic fiber components. Active evaluation is similar, except that active or active-resisted movements may be performed during the evaluation, which offers additional information on the dynamic capacity of the muscle.

General Three-Dimensional Evaluation

A 3-D palpation involves evaluating the general ease or difficulty with which soft tissues surrounding a segment of the body move. An example is evaluation of the mobility of the circumferential soft tissues of the upper thigh, in which one hand is placed over the region of the quadriceps while the other hand is placed over the hamstrings (Figure 27-15). The therapist can evaluate the mobility of each layer circumferentially around the leg by moving the tissues in congruent motions of superior or inferior, internal or external circumferential rotation, or in a motion combining diagonal and spiral directions. Through this evaluation, one can identify those patterns in which the tissues are restricted and those in which they move freely. This distinction helps identify movement patterns that are frequently used to produce tissue mobility and those that are not used to create tissue immobility.[3,85]

Proprioceptive Neuromuscular Facilitation Patterns

Through the use of PNF patterns, one can identify inherent tissue tension patterns that limit the normal execution of the pattern. Because of the dynamic spiral nature of PNF patterns, many of the soft tissue restrictions that limit function can be identified (Figure 27-16). When those patterns of restriction are corrected, the PNF patterns that were previously restricted should be performed to reeducate movement within the new available range.[80,88,10]

Neuromuscular Control

Neuromuscular control is effectively evaluated and treated by using the principles and techniques of PNF (Figure 27-17).[88,99] Inefficient core muscle contraction coordination, recruitment,

Figure 27-14 Evaluation of muscle functional excursion of the shoulder extensors.

Figure 27-15 Three-dimensional (3-D) evaluation of the soft tissues of the thigh.

Figure 27-16 Proprioceptive neuromuscular facilitation (PNF) lower-trunk extension pattern with emphasis on the spinal intersegmental muscles and the quadratus lumborum.

Figure 27-17 Performance of a proprioceptive neuromuscular facilitation (PNF) shoulder girdle anterior elevation pattern.

and sequencing of normal patterns of movement often lead to strain on the soft tissues. Improvement in neuromuscular control decreases the stress on articular structures and ensures long-term maintenance of improvement in posture, available movement, and symptoms.[84,98,103]

Associated Oscillations

Associated oscillations are rhythmic oscillatory motions that are manually applied to a body part. They are executed at a rate and excursion that will create wavelike motion in the soft tissues under evaluation. Associated oscillations are used to assess the patient's ability to relax, the mobility of the soft tissues, the play of muscles, and the ease of segmental motion.[2,3] Through the application of associated oscillations, the therapist can quickly identify general and specifi c sites of soft tissue restriction. These region are identified because of the fact that dysfunctional tissues oscillate at a slower and impeded rate or are completely restricted and appear not to move. These restricted regions are termed *still points.*

Treatment Approach

Physical therapy is based on the ability to touch in a knowledgeable, conscious, therapeutic, and sensitive manner. The primary tools of the profession are based on the manual art of skilled palpation. This is an art that all therapists should develop. Initially, some students possess more enhanced natural palpation perception, but the ultimate mastery of the skill in all cases is achieved through experience and extensive directed practice. Because the ability to palpate is a foundational component of the profession, students should practice the art of palpation from the fi rst day and continue throughout their undergraduate and postgraduate training.

Evaluation and treatment must be interrelated for the application of STM to be effective. Treatment is based on subjective and objective measures such as signs, symptoms, and the mechanical behavior of the symptomatic region.[103,117] The success of treatment is also dependent on the active involvement of the patient with the process through conscious relaxation and appropriate feedback.

Treatment Strategies

Two interrelated but distinct treatment strategies exist: (1) localized and (2) biomechanical.[3]

Localized Approach

The localized approach focuses primarily on evaluation of the painful or dysfunctional region, providing treatment of the localized symptomatic and dysfunctional structures. This treatment strategy is guided by changes in the presenting signs and symptoms.

Biomechanical Approach

The biomechanical approach is a systems analysis and treatment approach directed at optimizing the function of the kinematic chain. Through this approach, dysfunctions of posture, mobility, and neuromuscular control affecting the symptomatic region are identifi ed and treated. These dysfunctions are often asymptomatic, but they precipitate perpetuation of symptoms and slowing of the healing processes through repeated irritation and reinjury. The primary evaluation tools used are analysis of the positional relationship of segments, vertical compression, 3-D proportions analysis, functional movement patterns, PNF, and functional activity evaluations.

The following example is provided to illustrate the use of the biomechanical approach. A load-sensitive right-lumbar problem that was not resolving with a localized treatment approach was assessed biomechanically.[118] It was noted that the patient's right shoulder girdle was positioned anterior and limited in its ability to be seated (like a yoke) and centered on the convexity of the rib cage. It appeared that the primary factor contributing to the patient's position was limited functional excursion of the right pectoralis minor. This dysfunctional position affected the shoulder girdle's normal arthrokinematics and force distribution capacity. Two primary biomechanical compensations were potentially affecting the lumbar spine.

Thoracic Spine

The shoulder girdle and arm were forced into an anterior position to the frontal plane, shifting the center of gravity of the upper body asymmetrically anterior of the vertical axis. The patient compensated for this imbalance by bending the thoracic cage backward from the midlumbar spine. This backward-bent position altered the vertical alignment, accentuated the lumbar lordosis, and increased the strain on the posterior elements of the symptomatic movement segments. Reproduction of symptoms and noticeable instability of the lumbar spine occurred during application of the vertical compression test.

Cervical Spine

When optimally positioned on the rib cage, the shoulder girdle distributes the weight and force of upper-extremity loading into the rib cage, the trunk, and the base of support. However, because of the protracted position of the patient's shoulder girdle, the primary mechanism of shoulder girdle support and force distribution was assumed by the shoulder girdle muscles attached to the cervical spine. This alteration in cervical muscular function placed abnormal strain on the cervical spine and precipitated myofascial adaptive shortening. The primary muscles affected were the longus coli, anterior scalenes, levator scapulae, upper trapezius, sternocleidomastoids, and suboccipitals. These myofascial restrictions precipitated a forward-head position with an accentuated cervical lordosis. This further altered the weight distribution and postural balance, increasing the strain on both the cervical and the lumbar spines.

As the patient's ability to position the shoulder girdle and assume a balanced alignment improved, she noted that she was able to be upright for longer periods of time without exacerbating her symptoms. This enhanced both her rehabilitative program and her functional capacity.

PRINCIPLES OF TECHNIQUE APPLICATION

Patient Preparation

Before providing any manual treatment, the therapist should describe to the patient the treatment that will be performed. The patient should also understand his or her responsibilities during the treatment process. Treatment is most effective when the patient is placed in a comfortable position that also allows for the greatest accessibility of the affected tissues. The patient is instructed to attempt to soften and relax the region being treated. Breathing is one of the most important adjuncts that can assist a patient in relaxation. In addition, the patient can be instructed to perform small, active oscillatory, physiologic, or functional movement patterns.

Soft Tissue Layer Concept

A foundational concept of this treatment method is to respect and treat according to the specific layer of tissue restriction or motion barrier. The superficial layers are evaluated and treated before attempting to correct the restrictions of deeper layers. By following this rule, the therapist will require the least amount of force to access the deeper restrictions. In addition, correction of superficial dysfunctions often improves the condition of restrictions of deeper layers. Dysfunctions are identified by specific depth, direction, and angle of restriction.

Technique Application

After assessing and localizing a soft tissue dysfunction, the therapist selects a specifi c STM technique and applies the appropriate amount of force in the direction of maximum density and/or restriction. The goal in applying soft tissue techniques is to achieve the desired results while using the least amount of force. It is important for the therapist to be patient and give the tissues time to respond and to allow both the mechanical and the viscoelastic effects to occur.

Degree of Force

Increased force is only used as a last resort when all other options for release have been attempted or when less mobile tissues such as scar adhesions and contractures are present. These tissues may require more force. The exact amount of force is dependent on the extent of restriction, the amount of discomfort, and the degree of irritability. The general rule is to place sufficient force on the restriction, in the precise depth, direction, and angle, to take and maintain the dysfunctional tissues to their end range. As the restriction begins to release, the therapist should continue to maintain pressure on the dysfunctional tissues and follow the path of the tissues that are releasing.

Progression of Technique

During application of a soft tissue technique, improvement in the dysfunction should be noted through a palpable normalization in tissue mobility or density. If a palpable improvement is seen in the restriction, then the subjective and objective signs should be reevaluated. If the restriction does not begin to improve within a short period of time (e.g., 10 seconds), then the therapist should alter or choose another technique. If after the application of two to three separate techniques no change is seen, then as a general rule the therapist should do the following:

- Reevaluate the region for underlying or more remote dysfunctions.

- Treat other dysfunctions and return to the unresponsive dysfunction later during the treatment session.
- Reassess and treat the dysfunction during subsequent treatment sessions.

NOTE: Dysfunctions related to scar tissue, decreased muscle play, or fascial tightness generally maintain the improvements gained during treatment. However, dysfunctions related to hypertonus or swelling and those of a neuroreflexive nature may return with time. Gains are more likely to be maintained if improved postures and range of motion are reinforced through application of resisted neuromuscular reeducation techniques, if the patient is trained in efficient body mechanics, and if a specific conditioning and rehabilitation program is designed to address the soft tissue dysfunction.

TREATMENT TECHNIQUES

Techniques are applied by using one hand to apply pressure on the restriction while the other hand assists to facilitate a release. The treatment hand can apply pressure through specific (fingers or thumb) or general (heel of the hand, elbow, forearm) contacts. The multiple options of manual contacts provide the therapist with a mosaic of treatment options. The selection of a general or specific contact surface depends on the type and size of dysfunctional tissue or tissues and the degree of irritability caused by the presenting symptoms.

Treatment pressure is applied in the direction of the restriction, and as it releases, the slack is taken up to keep a consistent pressure on the resolving restriction. The direction of the restriction often changes as the release occurs, and appropriate adjustments in the direction of force are needed to maintain the pattern of release. An inherent aspect of effective application of STM techniques is the therapist's use of proper body position and mechanics.

A natural progression of technique application exists. This progression generally begins with sustained pressure. If the restriction does not release, then the therapist should add or progress to additional techniques until the restriction begins to disappear (Figure 27-18).

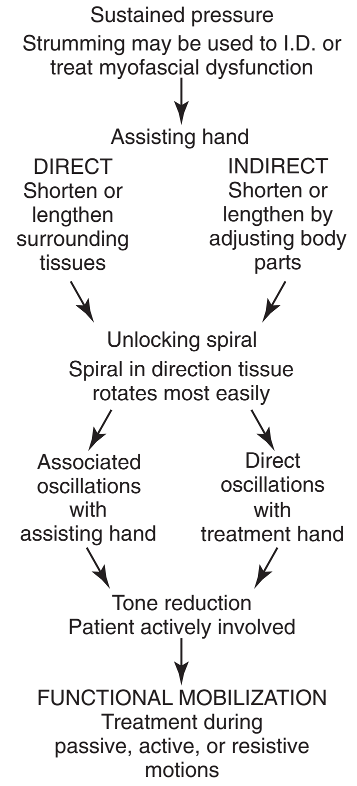

Figure 27-18 Cascade of techniques for progressive treatment of specific soft tissue restrictions. (Courtesy The Institute of Physical Art, Steamboat Springs, Colo.)

Figure 27-19 Sustained pressure with surrounding tissues placed on tension.

Treatment Hand Techniques

Sustained Pressure

Pressure should be applied directly to the epicenter of the restricted tissue at the exact depth, direction, and angle of maximal restriction. The therapist should be positioned so that the technique can be applied either away from (pushing) or toward (pulling) his or her body. The pressure is sustained, and as the restriction resolves, the slack is taken up (Figure 27-19).

When applied to bony contours or myofascial tissues, sustained pressure is further defined according to the direction of motion in relation to the boundary of the structure.

Unlocking Spiral

If a restriction does not resolve, the therapist can use an unlocking spiral to initiate a release. While maintaining a sustained pressure technique, the therapist assesses for the degree of tissue tension caused by clockwise and counterclockwise rotary motions. These motions are accomplished by moving the elbow away from or toward the body, spiraling the finger on the restriction as a screwdriver turns a screw. One motion creates greater tension in the tissues, while the other creates an easing of tension. When the direction of ease is identified, the therapist, while maintaining sustained pressure on the restriction, rotates in the direction of ease until the restriction begins to soften. At that point, the spiral motion is eased and the sustained pressure is continued following the pattern of release. On reassessment, the direction of tissue spiral that was of greater restriction (the opposite of the direction of ease) is evaluated for any remaining dysfunction and treated (Figure 27-20).

Direct Oscillations

The technique of direct oscillations involves an extension of the sustained pressure technique but with repeated, rhythmic, end-range deformation at the point of maxim dysfunction (grade III or IV of the Maitland system). These gentle oscillations places rhythmic pressure on and off a restriction (motion barrier). As the restriction resolves, the tissue slack is taken up.[103]

Perpendicular Mobilization

Perpendicular mobilization involves sustained pressure applied at right angles or transverse to a bony contour or myofascial tissue to improve muscle and soft tissue play (Figure 27-21). Direct oscillation and unlocking spiral techniques can be used.

Parallel Mobilization

Parallel mobilization involves applying pressure longitudinally to restrictions along the edge of the muscle belly, to the seam between two muscles, or along bony contours. The purpose is to normalize the restriction and to improve muscle play and

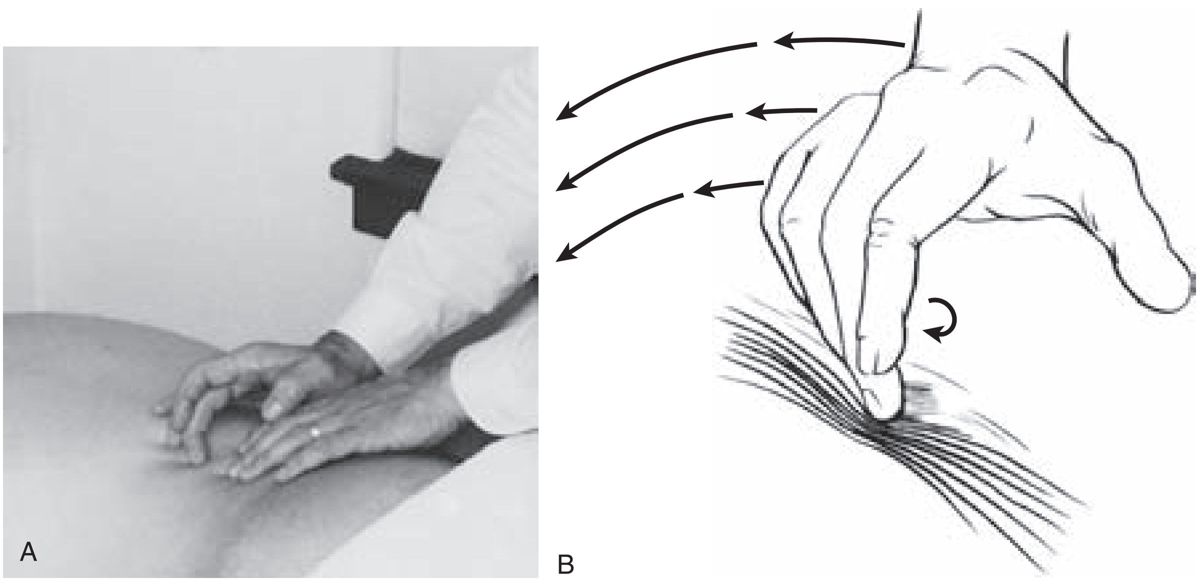

Figure 27-20 Unlocking spiral. The twisting action of the forearm and hand causes a spiral motion of fingers on restriction.

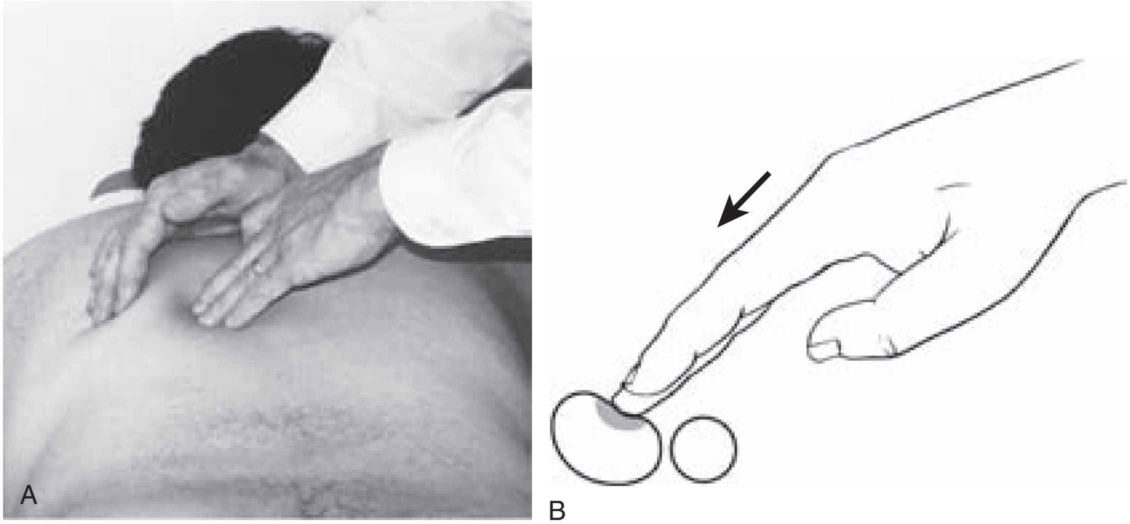

Figure 27-21 Perpendicular mobilization.

soft tissue mobility. Direct oscillations and unlocking spiral techniques can be used (Figure 27-22).

Perpendicular (Transverse) Strumming

Perpendicular strumming is used to evaluate for and treat increased tone and the loss of myofascial play. The technique is applied through repeated, rhythmic deformation of a muscle belly, as one would strum the string of a guitar. Perpendicular pressure is applied to the border of a muscle belly, deforming it until the end range is attained. The fingers are then allowed to slide over the top of the belly of the muscle as it springs back into position.

This technique produces rhythmic oscillations throughout the body. It allows the therapist to know if the patient is relaxing, and it provides the relaxation qualities of oscillatory motions (mechanoreceptors) (Figure 27-23).

Friction Massage

Friction massage is a technique defined by Cyriax[42] involving repeated cross-grain manipulation of lesions of tendinous and ligamentous tissues.[44,101]

Assisting-Hand Techniques

The following procedures applied by the assisting hand can be used with any of the previously mentioned treatment hand procedures to hasten or facilitate resolution of tissues being treated.

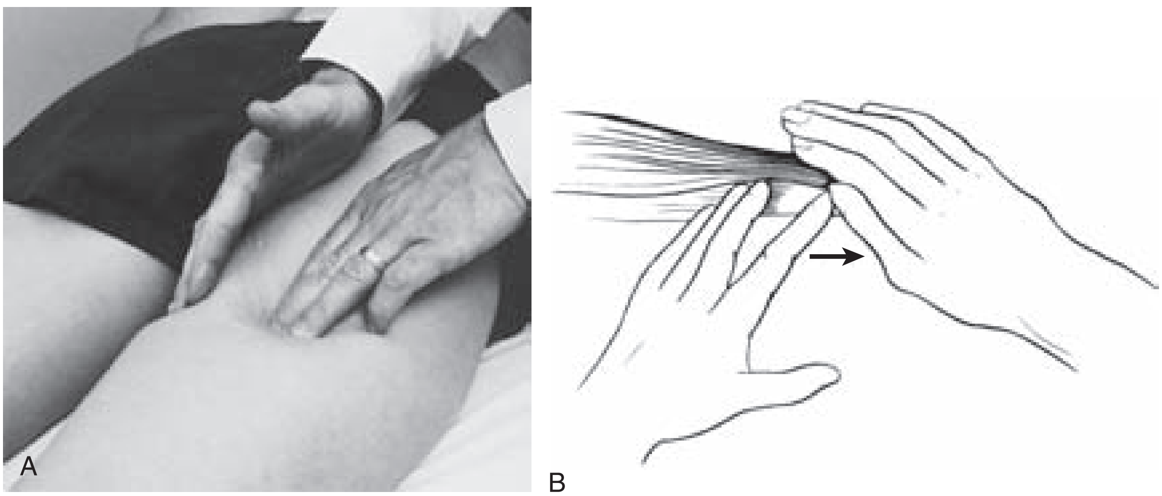

Figure 27-22 Parallel mobilization.

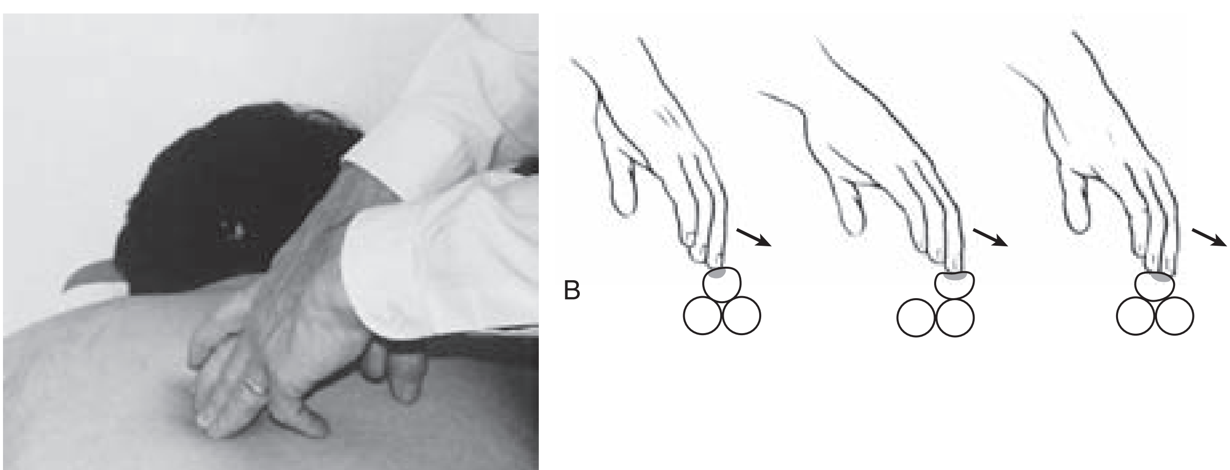

Figure 27-23 Perpendicular (transverse) strumming.

Figure 27-24 Placing tissues on slack with the assisting hand.

Figure 27-25 Placing tissues on tension with the assisting hand.

Placing Tissues on Slack

Placing tissues on slack involves adjusting the tissues surrounding the restriction in a shortened range to ease the tension on the restriction. This can occur from any direction in relation to the restriction (360 degrees). The tissues are shortened at the same tissue depth as the restriction.

Placing tissues on slack is generally the first assisting tool to be used, especially if the symptoms are acute or easily exacerbated. If a release does not begin within 10 seconds, then the therapist should choose another direction of shortening for the tissues or choose another assisting technique (Figure 27-24).

Placing Tissues on Tension

Placing tissues on tension involves adjusting the surrounding tissues in a lengthened range to place tension on the restriction. This technique is applied in the same manner as placing tissues on slack, with the exact depth and direction of tensing the surrounding tissues depending on the restriction. It is used more often in chronic conditions and as a means to place more demand on a restriction. All tissues should ultimately be checked in a lengthened position for the complete resolution of a restriction (Figure 27-25).

Using Both Hands

Conditions exist in which both hands are used together and no distinction is made between the treatment and assisting hands. For example, when performing a 3-D technique (which evolves from the 3-D evaluation covered in the previous section on palpatory evaluation), the two hands function together to improve the mobility of the tissues as an extension of the evaluation process.[3,85]

Passive Associated Oscillations

Trager first introduced the use of oscillations. This approach uses wavelike rhythmic oscillations to facilitate structural changes. Trager influenced the terms *associated oscillations, direct oscillations,* and *strumming.* Passive associated oscillations of a body part create a whole-body oscillation, but with focal oscillations on the restricted region. These oscillations are applied while sustained pressure is placed on the restriction. When used appropriately, these oscillations help the patient relax, decrease the discomfort of the pressure on the restriction, and promote normalization of the tissues. It is important to sense the degree to which the patient is able to relax and how well the oscillations translate through the body. The frequency of the oscillations varies according to the patient's body type and the type of dysfunction.[105,119]

Manual Resistance

While the treatment hand is maintaining pressure on restricted tissues, the assisting hand applies resistance to produce an isometric or isotonic contraction of the dysfunctional myofascial tissues. Many creative ways exist to use this assisting-hand tool. For example, in the side-lying position, treatment of dysfunctions of the soft tissues of the cervical spine can be enhanced by applying resistance to scapula patterns. These concepts are basic to the functional mobilization approach.[4,82]

Cascade of Techniques

The cascade of techniques flow chart can be used to better visualize and understand the options the therapist has for treating specific dysfunctions. This provides a mechanism for altering the treatment tools being used to meet the requirements of a specific restriction (Figure 27-26).

General Techniques

General techniques provide a larger contact surface to evaluate and treat larger regions of the body. They are often used when a general evaluation and treatment is desired, such as when a large region of restrictions is present and as an initial or completion stroke. General techniques are also useful to protect or reduce the use of fingertips and thumbs, which are stressed by the use of specific techniques (Figure 27-27).[120]

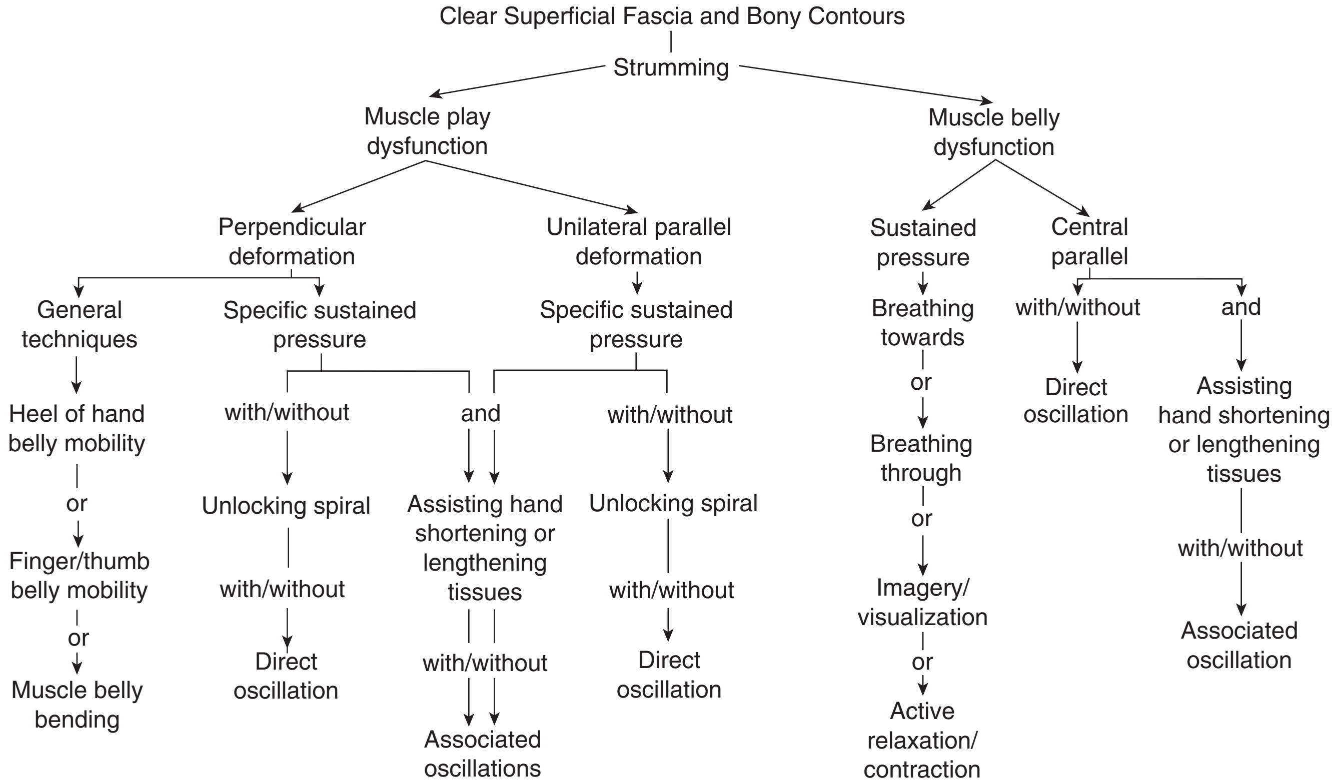

Figure 27-26 Myofascial cascade of techniques. (Courtesy The Institute of Physical Art, Steamboat Springs, Colo.)

Figure 27-27 General techniques for the paraspinals.

Functional Mobilization

Functional mobilization is the integrated use of soft tissue and joint mobilization combined with the dynamic principles and procedures of PNF. This is a step-by-step evaluation and treatment approach, which combines mobilization or stabilization with neuromuscular reeducation. With the combined tools of PNF and STM, the therapist is able to combine the evaluation of the condition of the soft tissues, articulations, and neuromuscular control of multiple movement segments. (Figure 27-28).

PROGRESSION OF CARE

As noncontractile and contractile soft tissues regain their normal state of free and independent mobility, decreased tone, and normal physiologic length, the patient can assume a more efficient alignment and move with greater ease and coordination (see Figure 27-28). New postures and range of motion should be reinforced through application of resisted neuromuscular reeducation techniques,[88,99] and emphasis should be placed on a specific core muscle control, body mechanics training, and rehabilitation program.[98,117]

Precautions and Contraindications

As with any manual therapy approach, the application of any treatment technique needs to be done in a judicious manner, with recognition of the known pathologic conditions and irritabilities and with common sense. The following list of contraindications and precautions is provided as a guide. Therapists with extensive experience and training in manual therapy may judiciously treat a condition that less experienced therapists should avoid.

- Malignancy
- Inflammatory skin condition
- Fracture
- Sites of active hemorrhage
- Obstructive edema

Figure 27-28 Postural changes after treatment. **A,** Initial. **B,** After 10 treatments. **C,** One year after discharge.

- Localized infections
- Aneurysm
- Acute rheumatoid arthritis
- Osteomyelitis
- Osteoporosis
- Advanced diabetes
- Fibromyalgia (while in an inflammatory state)
- Any symptoms that have previously been exacerbated by appropriately applied STM

CLINICAL CORRELATIONS

This overview of clinical correlations is intended to assist the reader in understanding the relevance of STM to the overall management of a patient and to illuminate the possible interaction of specific soft tissue restrictions with lumbar pathologic conditions. The lumbar spine has been chosen to illustrate the soft tissue dysfunctions associated with spinal dysfunction. Most of the functional changes reported are correlations made from observations after normalization of soft tissue dysfunctions.

SKIN AND SUPERFICIAL FASCIA

Improvements achieved through correction of skin restrictions are often dramatic in comparison with the subtleness of the restriction. The most frequently noted functional improvements (i.e., increased range of physiologic and functional motions, improvements in alignment and segmental spinal mobility, and reduced symptoms) are often noted after the treatment of abdominal or posterior surgical scars.[2,63]

Lumbar Muscles and Thoracolumbar Fascia

The lumbar muscles (Figure 27-29) can be divided into three groups and layers:[60] (1) the short intersegmental muscles (the interspinales and the intertransversarii), (2) the polysegmental muscles (the multifi dus, the rotaries, and the lumbar components of the longissimus, spinalis, and iliocostalis), and (3) the long polysegmental muscles (represented by the thoracic components of the longissimus and iliocostalis lumborum that span the lumbar region from thoracic levels to the ilium and sacrum).

The deeper intersegmental and polysegmental muscles, particularly the multifi di, are primarily stabilizers controlling posture and assisting in fine adjustments and segmental movement.[8,9,26,121] The multifidus is also believed to protect against impingement of the facet capsule during joint movements because of its attachments to the joint capsules.[60] Kirkaldy-Willis[9] reports that uncontrolled contraction of the multifidus may be a primary factor in the production of torsional injury to the facet joints and disk. The more superficial and polysegmental muscles (erector spinae), the longissimus, spinalis, and iliocostalis, produce the grosser motions of thoracic and pelvic backward bending, side bending, and rotation that increase lumbar lordosis.[9,26,122] Some authors have reported that the erector spinae are active in maintaining upright posture.[122]

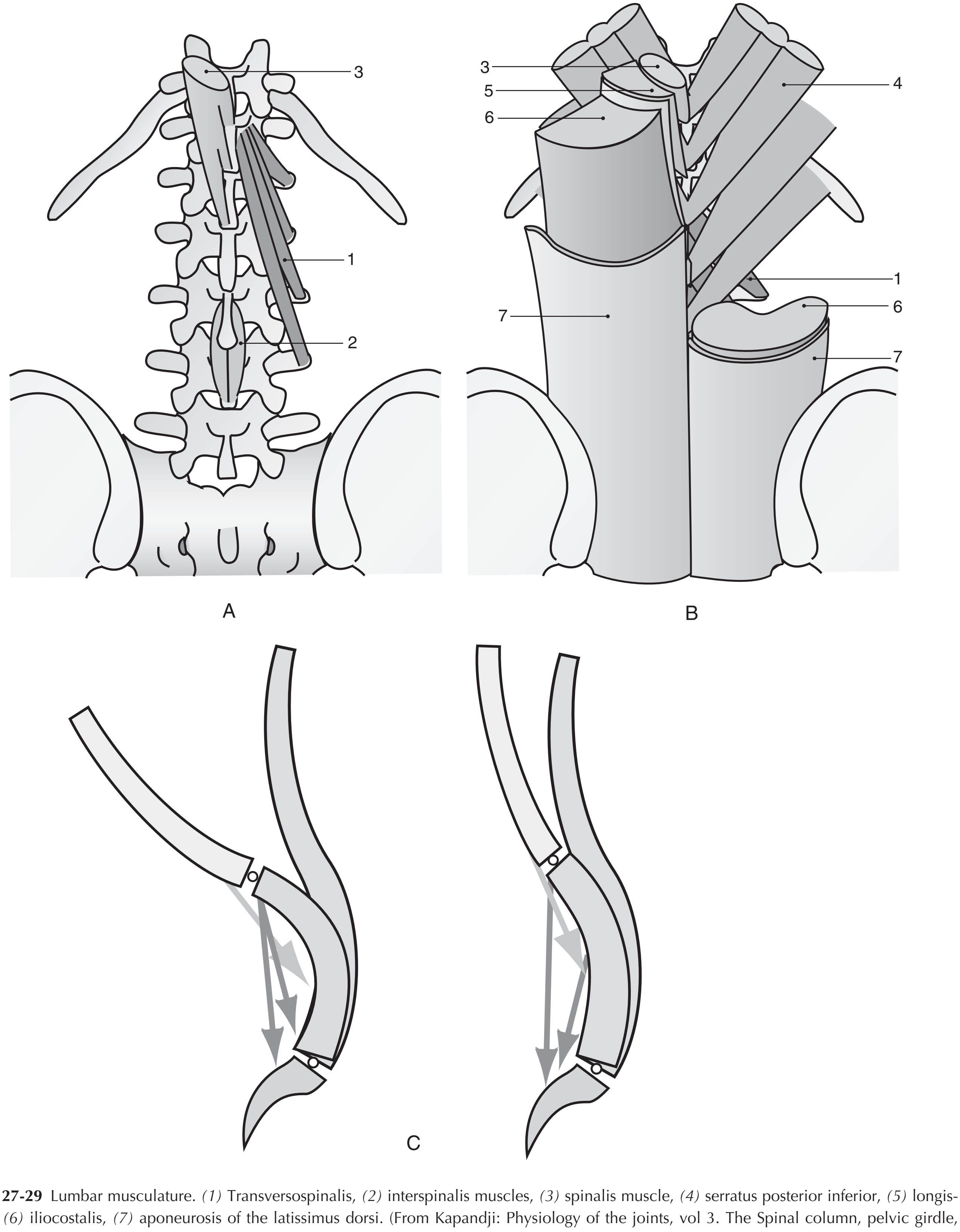

Figure 27-29 Lumbar musculature. *(1)* Transversospinalis, *(2)* interspinalis muscles, *(3)* spinalis muscle, *(4)* serratus posterior inferior, *(5)* longissimus, *(6)* iliocostalis, *(7)* aponeurosis of the latissimus dorsi. (From Kapandji: Physiology of the joints, vol 3. The Spinal column, pelvic girdle, and head, ed 6, Edinburgh, 2008, Churchill Livingstone.)

The extensive thoracolumbar fascia attaches to the transverse processes of the lumbar vertebrae, the iliac crest and iliolumbar ligament, the twelfth rib, the quadratus lumborum, the lateral portion of the psoas major, and the aponeurotic origin of the transversus abdominis.[26,123] Each layer of lumbar musculature is separated and compartmentalized by the thoracolumbar fascia and in an efficient state can be palpated for having independent mobility from surrounding structures. The lumbar musculature is most effectively assessed in the side-lying and prone positions. Its extensibility is most effectively appraised through evaluation of end ranges of PNF trunk patterns.

Restricted play of the erector spinae can limit range of motion of the lumbar spine because of the inability of the muscles to slide normally on each other. This is noted especially with the motions of side gliding (lateral shear), forward bending, and rotation. When muscles are in a state of increased tone or restricted play, they may have difficulty folding on each other and will restrict motions such as side bending to the same side and backward bending.

Increased tone of the deeper musculature can be the primary source of symptoms and can limit the mobility of individual segments. With unilateral soft tissue dysfunction, a deviation to the affected side often occurs during forward bending. In conjunction with the improvement of alignment, range of motion, and pain, improvement in the patient's ability to control active movement is often observed after treatment.

When the more lateral intertransversarii lateralis and quadratus lumborum have limited extensibility, the region often appears shortened and restricted in motions such as side bending and pelvic lateral shear (side gliding). The quadratus lumborum will often have restricted normal play in relation to the erector spinae and psoas, affecting most spinal motions.

Abdominal Scar

Scar tissue in the abdominal region often produces marked pathomechanics of the soft tissues and the articulations of the lumbopelvic girdle region. These scar tissue dysfunctions can alter efficient function from the superficial fascia to the deep abdominal region. Through careful palpation, spiderweb-like tentacles of restricted tissue can be traced, extending away from the central scar, possibly throughout the abdominal cavity, and to the posterior wall. If the palpation is performed with superimposed movement (e.g., a functional movement or PNF pattern), then the effects of these limitations and the altered biomechanics can be noted. This restricted matrix can affect proper alignment and functional movements such as forward bending (possibly because of the inability of the abdominal tissues to fold on themselves) and backward bending secondary to decreased extensibility of the anterior section.

In individuals with hypermobilities or spondylolisthesis, dramatic improvement in functional abilities has been observed through normalization of the abdominal scar. Improvement is often noted in static postures and in the performance of functional movement patterns such as the pelvic clock and lower-trunk rotation. Through appropriate STM the scar tissue may become more pliable, but the primary effect appears to be improved mobility of the surrounding structures and of the restricted spiderweb-like matrix. This probably facilitates a more neutral position of the lumbar spine and allows movement to be distributed through the spine into the pelvis more efficiently.

Rectus Abdominis

The rectus abdominis originates primarily from the costal cartilage of the fifth, sixth, and seventh ribs and inserts on the crest of the pubis. It is enclosed between the aponeuroses of the oblique and transversus, forming the rectus sheath, which separates it from the other abdominals.[26] If the rectus is adhered to the underlying structures, then motions such as rotation and pelvic lateral shearing are restricted because of the inability of the rectus abdominis to slide over the underlying abdominals. The umbilicus should also be evaluated for free 3-D mobility, because restrictions will also affect the mobility of the rectus abdominis.

The rectus abdominis will often be found to be in a shortened state that holds the rib cage down, increasing a forward-head posture and thoracic kyphosis. Often a compensatory backward bending of the thoracic cage occurs, increasing thoracolumbar or midlumbar lordosis. Clinicians often find shortened rectus abdominis muscles in individuals who do many sit-ups in a flexed position.

One of the myofascial complications of pregnancy is diastasis of the rectus abdominis. This is the separation of the two sections along the midline, the linea alba. Clinically, it has been observed that this separation occurs mostly in women who have restrictions of the lateral borders of the rectus abdominis, which prevent the muscle from stretching forward as a unit. This lack of mobility of the lateral aspect places excess stress on the central linea alba and produces separation.

Psoas and Iliacus Muscles

The psoas arises from the anterior surfaces and lower borders of the transverse processes of the twelfth thoracic vertebra and all of the lumbar vertebrae, creating a muscle with multiple distinct layers (Figure 27-30). At each segmental level it is attached to the margin of each vertebral body, the adjacent disk, and the fibrous arch that connects the upper and lower aspects of the lumbar vertebral body.[26,60] The iliacus originates primarily from the superior two thirds of the concavity of the iliac fossa and the upper surface of the lateral part of the sacrum, and most of the fibers converge into the lateral side of the psoas tendon.[26] The psoas and iliacus are covered with the iliac fascia, which attaches to the intervertebral disks, the margins of the vertebral bodies, and the upper part of the sacrum, and they are continuous with the inguinal ligament and the transversalis fascia. The iliopsoas flexes the femur on the pelvis or flexes the trunk and pelvis on the lower extremities. Some authors attribute a distinct postural component to the deeper spinal fibers of the psoas.[14,122]

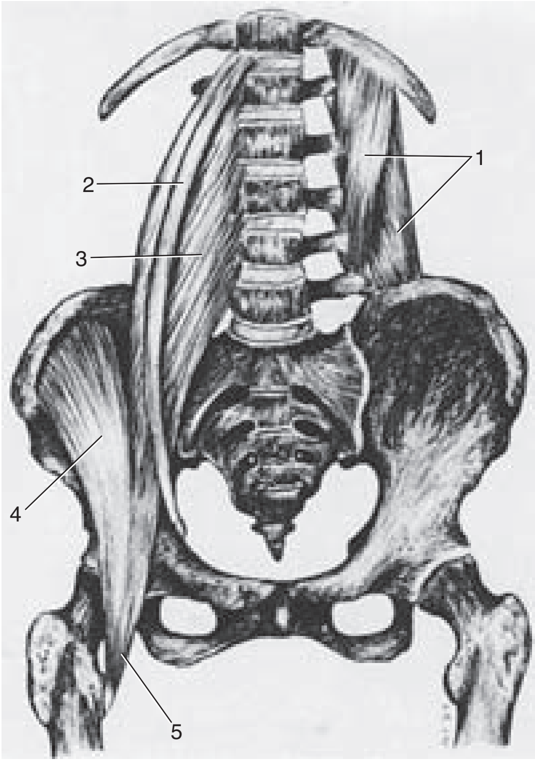

Figure 27-30 Muscles of the anterior spinal column. The intrinsic flexors of the lumbar spine: *(1)* two layers of the quadratus lumborum, *(2)* psoas minor, *(3)* psoas major, *(4)* iliacus, *(5)* conjoined attachment of the psoas and iliacus of and around the lesser femoral trochanter. (From Dupuis PR, Kirkaldy-Willis WH: The spine: integrated function and pathophysiology. In Cruess RL, Rennie WRJ, editors: Adult orthopaedics, New York, 1984, Churchill Livingstone.)

The iliopsoas muscles are often found to have limited extensibility, play, or increased tone at the level of spinal pathologic condition.[7,35,76,123] Because of the psoas' centralized biomechanical position, minor dysfunction of the psoas can have a dramatic effect on posture and the length of the lumbar region, and this can place excessive stress on the intervertebral disks and the performance of functional motions.[31,123] Restricted extensibility limits the posterior tilt of the pelvis, which increases lumbar lordosis. Such restrictions can decrease movement in all directions, especially limiting backward and forward bending. The function of the psoas is often altered by dysfunctions in the lower extremities, especially if the dysfunction is unilateral, thus altering the dynamics and the capacity for the two psoas muscles to act symmetrically during spinal function.

Through clinical experience it has been observed that, with improved length, play, and normalized tone of the psoas, an increase in forward bending of the lumbar spine often occurs. This improved mobility may be due to the ability of the psoas to fold on itself and the ability of the transverse processes, which are posterior to the central axis of motion, to separate from each other and allow the spine to bow convexly posteriorly. It has also been noticed that restricted play of a psoas at

Figure 27-31 Evaluation and treatment of the psoas.

a specific level can limit mobility of that segment, specifically affecting rotation and bending to the opposite side. Often pressure applied to the localized foci of tone will cause referred pain that duplicates the reported symptoms (Figure 27-31). In many cases, normalization of psoas mobility and improved neuromuscular control has facilitated dramatic improvements in symptoms and function.

Lower Extremities and Hip

Limited mobility of the myofascial structures of the lower extremities is a primary contributing factor that forces the individual to use the lumbar spine instead of the lower extremities as a primary axis of motion. Several authors have suggested a correlation between poor flexibility of the lower extremities and lumbar symptoms.[31,123] In addition, myofascial tightness of the lower extremities may cause a decrease in blood and lymph flow, which contributes to restricted mobility, fluid stasis, and greater muscular fatigability.

Of primary importance are dysfunctions that affect extensibility and normal play of the hip rotators, hamstrings, rectus femoris, iliotibial band, adductors, and gastrocsoleus (triceps surae).

Hip Rotators

Restricted play and decreased extensibility of these closely interrelated muscles limit hip mobility and affect pelvic motion and coordination for performance of forward-oriented tasks. The ability to rotate the body through the hips over a fixed base of support while maintaining a stable lumbar spine is affected when limited extensibility and play of the hip rotators is seen (Figure 27-32).

In addition, tightness of the hip capsule can be identified and treated in the prone position. In the efficient state, with the knee bent and the therapist palpating the posterior aspect of the greater trochanter, during passive internal and external rotation of the hip the femur remains in the same plain of motion. When it is restricted during external rotation, the femur migrates posteriorly; if it is restricted during internal rotation, the femur migrates anteriorly. Normalization of these

Figure 27-32 Function mobilization of the external rotators of the hip.

motions can be accomplished by impeding the dysfunctional motions and using contract-relax at the end ranges.

Hamstrings

Shortened hamstrings limit pelvic anterior tilt and therefore restrict a patient's ability to maintain a neutral spine while bending forward in standing and sitting. Restricted play between the three bellies can cause abnormal torsion on the ilium and affect the eccentric control of lower extremity and pelvic motions.

In the efficient state, the hamstrings fold around the femur during forward bending and rotational activities. This folding action provides additional range to the motions. However, the bellies of the hamstrings frequently become restricted together, preventing normal play. One of the most effective means to increase hamstrings range and function is to improve mobility at the interface between the hamstring bellies. The sciatic nerve between the bellies of the long head of the biceps femoris and the semitendinosus can be assessed. Restrictions of the hamstrings can be felt to restrict the mobility of the sciatic nerve.

Rectus Femoris

Decreased flexibility of the rectus femoris restricts the ability of the pelvis to tilt posteriorly on the head of the femur, often limiting the individual's ability to assume a neutral lumbar position in standing. Restricted mobility of the rectus femoris in relation to the sartorius, the tensor fascia lata, and the underlying quadriceps affects performance of each muscle's independent actions. Soft tissue restrictions within and around the rectus femoris can also limit hip extension during gait and result in compensatory backward bending of the lumbar spine.

Iliotibial Band

The iliotibial band is a lateral stabilizer and is important for maintaining posture during gait. Limited mobility and play of the iliotibial band is probably a major contributor to lumbar immobility and pain.[35] Tightness often reduces the individual's ability to shift weight over the base of support (because of lateral tightness) and to perform any lateral motion. In cases of sacroiliac hypermobility, limited extensibility of the iliotibial band is often seen on the side of hypermobility. Limited play, both at the lateral and medial borders and with the structures underneath, is the most common cause of limited iliotibial band extensibility. This limited play can be enhanced through directed STM, but mobilization also can occur through the use of small plungers or cupping devices.

Adductors

As with the iliotibial band, adductor tightness and limited play affect pelvic position, mobility, and the dynamics of lateral movements.

Gastrocsoleus

When the soleus is shortened, the heel lifts off the ground, decreasing the base of support and impairing balance during bending and lifting activities. This may further contribute to rearfoot deformities such as calcaneal valgus, which may cause aberrant lower-quadrant function. Restricted play between the bellies of the gastrocsoleus, and also between the soleus and the deeper toe flexors and posterior tibialis, can affect ankle coordination.

CASE STUDIES

Case Study 1

The following case study of a 38-year-old woman with right upper-quadrant symptoms illustrates the merging of STM in an integrated manual therapy program. This approach has been termed *functional mobilization.*[4]

Presenting Symptoms

The patient reported a 9-month duration of cervical and right upper-extremity pain with limited range secondary to involvement in a rear-end automobile accident. She denied experiencing any numbness, tingling, or weakness.

Mechanics of Injury

The patient was stopped at a traffic signal when another vehicle hit her from behind at approximately 40 miles per hour. At the time of impact her head was turned right, looking in the rearview mirror; her right hand was on the steering wheel, and her right foot was on the brake. This information is presented because the mechanical dysfunctions of the cervical spine, right shoulder, and pelvic girdle appear to have a bearing on the patient's posture and motion during the trauma.

CASE STUDY—cont'd

Symptom Onset and Progression

The patient reported an immediate onset of headache and cervical symptoms. Over the next 2 to 3 weeks, she developed right upper-extremity symptoms.

Test Results

Magnetic resonance imaging (MRI) revealed a minor disk bulging at the right C4-C5 level without thecal sac impingement.

Therapeutic Intervention and Symptomatic Progression

Initial therapeutic intervention consisted of antiinflammatory and muscle relaxant medications, which controlled the patient's symptoms so that she could return to her secretarial position within 1 week. One month after the trauma she continued to experience substantial symptoms, and her physician referred her for 6 weeks of physical therapy, three times per week, at another clinic. After 6 weeks of hot packs, ultrasound, cervical traction, and massage, the patient reported that she was experiencing increased symptoms, most notably in her right hand and wrist. On return to her physician, she was diagnosed as having carpal tunnel syndrome secondary to her frequent computer use and was given workman's compensation.

Six months later, she was referred to the clinic at the suggestion of a friend. She was still unable to return to work. Her presenting problems now included right shoulder limitation and pain. During the preceding 6-month period, she had received further physical therapy in addition to chiropractic care and acupuncture.

Diagnostic classification: Musculoskeletal 4B: Cervicalgia 723.1

Symptom Analysis

The following presenting symptoms are listed in the order of the patient's perceived intensity:

1. Right C7-T1 region: Pain at the approximate location of the first rib costovertebral articulation, described as a deep, boring aching pain.
2. Right C4-C5: Deep, sharp pain, especially with right rotation, side bending, and quadrant motions.
3. Right anterior and lateral shoulder pain. In addition to the range limitations, symptoms increased with flexion and abduction.
4. Right hand and wrist pain: Primarily the medial aspect of the hand, which increased with hand use.
5. Right medial scapula pain: Associated with forward oriented tasks.
6. Periodic right suboccipital and temporal headaches: Often precipitated with prolonged forward-oriented tasks or poor sleeping postures.

Significant Objective Findings

1. Cervical range of motion
   Right rotation: 50% with pain increasing at the right C4-C5
   Right extension quadrant: 30% with pain radiating into the right upper extremity to the hand
   Right side bending: 30% with pain radiating into the right-side neck and shoulder
2. Right first rib: Elevated with restricted caudal mobility, especially the posterior articulation
3. Right glenohumeral articulation range of motion
   Flexion: 140 degrees with the scapula stabilized
   Abduction: 80 degrees with pain in the subdeltoid region
   External rotation: 45 degrees
   Resisted test: Positive pain elicited with resisted abduction (supraspinatus) and external rotation (infraspinatus)
   Accessory mobility: Marked restriction of glenohumeral downward glide and acromioclavicular anterior mobility
4. Upper-limb nerve tension test: Tested according to the procedures of Butler[27] and Elvey[28]; positive with scapula depression, with radiation of symptoms into the hand; positive for the median nerve involvement
5. Right wrist: 70% extension
6. Pelvic girdle: Right innominate restricted in ability to extend and internally rotate (fixated in posterior torsion and outflare); region asymptomatic but functionally affecting the base of support, balance of the spine over the pelvis, and gait

Treatment Strategies

Treatment strategies for a patient with such complicated and system-wide problems require a multilevel and integrated approach. The following presentation emphasizes the progression and principles of treatment used for each dysfunctional region. Presented are the major components of the integrated treatment program:

1. Self-care was the initial emphasis of care. Training involved teaching the patient to use more efficient postures and body mechanics to reduce the self-perpetuated exacerbations. Education and training was the basic component of the treatment program and was addressed at each visit as symptoms and functional level improved.
2. During each visit a progressive and specific stretching, strengthening, and stabilization program was addressed. This program initially focused on the positive upper-limb tension sign, elevated first rib, limited cervical range of motion, self-resisted dorsal glide, and pivot prone for postural training.
3. In conjunction with education and training is the manual therapy treatment of the most obvious mechanical dysfunctions. This functional-mobilization approach includes STM, joint mobilization, and neuromuscular reeducation. The concept is to treat the soft tissue dys-

Continued

CASE STUDY—cont'd

functions before treatment of articular dysfunctions, combining each with neuromuscular reeducation.

The following is an overview of the treatment rendered to each dysfunctional region:

1. Thoracic girdle. The basic philosophy of functional mobilization is that dysfunctions of the base of support of a symptomatic segment should generally be normalized before treatment of the symptomatic structures. The thoracic girdle consists of the manubrium, the first ribs, and the first thoracic vertebra. The primary dysfunction of the thoracic girdle was the posterior aspect of the right first rib restricted in caudal glide.

Treatment strategy: The initial strategy was to normalize the superficial fascia, bony contours, and mobilization of the acromioclavicular articulation (Figure 27-33, *A*). In addition, STM was applied to the superior border of the scapula (Figure 27-33, *B*). There were significant restrictions of play and increased tone of the right anterior and medial scaleni muscles that, when reduced, improved the mobility of the first rib.

Mobilization of the first rib was performed in the supine position, with the soft tissues placed on slack through cervical right side bending. Sustained pressure was applied with the thumbs, the fingers, or the lateral first metacarpophalangeal to the most restricted portion and direction of the posterior first rib. Coupled with the sustained pressure was the use of directed breathing and contract relaxation (Figures 27-33, *C-D*).

Treatment progressed to sitting once the rib's mobility was returned to normal. The surrounding soft tissues were treated with the cervical spine in neutral and in left side bending to increase their functional excursion (Figure 27-34).

Home program: The patient was instructed to use a towel or strap to maintain the downward and posterior mobility of the first rib.

2. Cervical spine. Once the first rib was normalized, the amount of muscle spasm in the deep cervical musculature was reduced. Noted dysfunctions included the following:
   a. Marked superficial fascia tightness posterior along the spinous processes and in the right occipital and suboccipital region
   b. Adherence between the right semispinalis capitis and the splenius muscles, especially in the lower cervical spine (Figure 27-35, *A*)

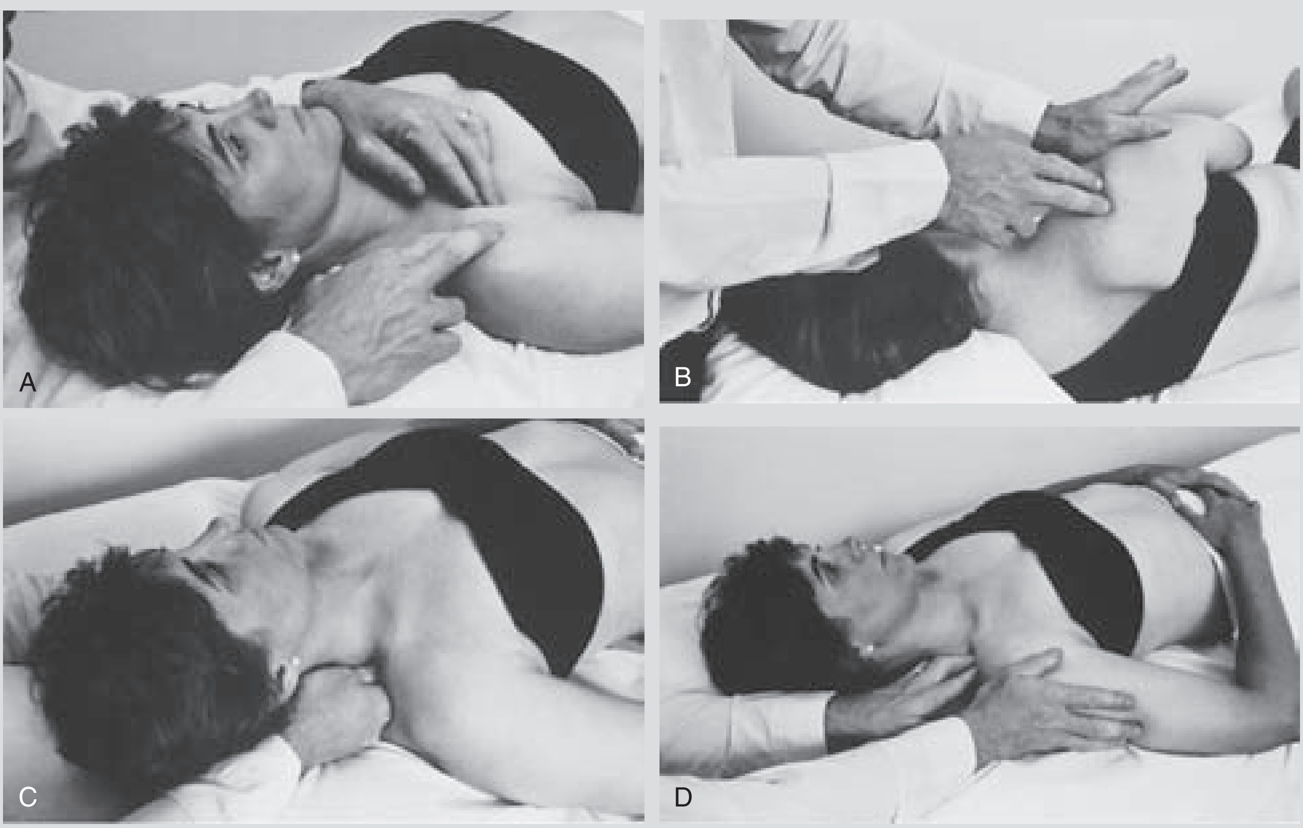

Figure 27-33 A, Mobilization of soft tissues of bony contours of the right clavicle and mobilization of the acromioclavicular joint. **B,** Mobilization of soft tissues of the superior right scapular border. **C,** Mobilization of the right first rib with soft tissues on slack. **D,** Mobilization of the right first rib with soft tissues on stretch.

CASE STUDY—cont'd

c. Dysfunctions of play and tone of the right longus coli, anterior and medial scaleni muscles, sternocleidomastoid, and upper trapezius (Figures 27-35, B-D)
d. Marked tenderness and swelling of the right C4-C5 articular facet

Figure 27-34 Mobilization of the right first rib in the sitting position coupled with cervical contraction and relaxation.

e. Limitation of C4 in left diagonal anterior glide and right rotation and side bending
f. General restriction of posterior longitudinal and interspinous ligaments, with most restriction at the C5-C6 level

Treatment strategy: The initial strategy was to treat the soft tissues to increase play and decrease tone. The tone of the muscles in the region of the right C4-C5 articular facet did not respond to tone-reducing techniques; therefore treatment progressed to improving mobility of that intervertebral segment. Using functional-mobilization techniques to localize the C4 restriction to the specific diagonal direction and using hold-relax procedures improved mobility and decreased the surrounding tone (Figure 27-36).

Additional treatment was used to reduce the tightness of the C5-C6 interspinous ligament by applying gentle fingertip traction to the C5 spinous process while the patient performed active axial extension. During the procedure the other hand performed STM to reduce anterior and posterior restrictions (Figure 27-37). To promote the ability of the cervical spine to balance on the rib cage, the O-1 and T1-T2 segments were mobilized (Figure 27-38).

Figure 27-35 **A,** Parallel technique to improve play between the right semispinalis capitis and the splenius. **B,** Strumming of the right longus coli. **C,** Sustained pressure to the right anterior scalenus. **D,** Soft tissue mobilization (STM) of the right sternocleidomastoid.

Continued

CASE STUDY—cont'd

Figure 27-36 Functional mobilization to improve left anterior diagonal mobility of C4.

Figure 27-37 Mobilization of the interspinous ligament between C5 and C6 to increase extensibility.

Figure 27-38 Mobilization of the upper-thoracic spine to increase backward bending of TI and T2.

Home program: The home program consisted of resisted axial extension, short-neck and long-neck flexor strengthening, and resisted pivot prone to improve scapular stability.

3. Right shoulder. There were both subjective and objective gains in the shoulder after treatment of the first rib and cervical spine. Treatment was directed to the following primary dysfunctions:
   a. STM, primarily strumming of the bodies of the infra- and supraspinatus muscles (Figure 27-39, *A*)
   b. Friction massage to the supraspinatus and infraspinatus tendons (Figure 27-39, *B*)
   c. In the left side-lying position, selected PNF patterns to the right shoulder girdle in conjunction with STM (Figure 27-39, *C*)
   d. Mobilization of the scapular thoracic articulation by lifting the scapula from the rib cage (Figure 27-39, *D)*
   e. STM to the subscapularis and pectoralis minor muscles in the supine position (Figure 27-40, *A-B*)
   f. Distraction of the humeral head with STM and contract relaxation (Figure 27-41)
   g. Mobilization of the head of the humerus caudally, performed with the patient sitting and resting her right elbow on the table while the therapist placed downward pressure on the humerus (Figure 27-42)
   h. Neuromuscular reeducation of the rotator cuff through manual resistance applied in the same position, with emphasis on the humeral depressors
   i. Increasing range of motion of the right upper extremity by placing the arm at restricted ranges and performing STM and contract relaxation on the restricted tissues (Figure 27-43)
   j. Using upper-extremity PNF patterns to identify and treat weaknesses and motor recruitment problems (Figure 27-44, *A-B*)

Home program: This consists of rotator cuff and upper-extremity diagonal resistance using a sports cord, arm circles, and stretching to assist in maintaining and gaining range of motion (Figure 27-45).

4. Upper-limb nerve tension. After improvements in the mobility of the right first rib, C4-C5, and glenohumeral function, the upper-limb nerve tension test was negative with shoulder girdle depression.

When the test was expanded to include a combination of shoulder girdle depression, 30 degrees of shoulder abduction, elbow extension, and wrist extension to 50%, the symptoms to the hand were elicited (Figure 27-46).[27,24]

Treatment for these symptoms was addressed over several visits with three different protocols:

a. Structures that may have been contributing to the adherent nerve (i.e., cervical spine, anterior and medial scaleni, clavicle, subclavius, first rib [also ribs two to four], clavicle, coracoid process, pectoralis minor, lateral boarder of

CASE STUDY—cont'd

Figure 27-39 A, Strumming of the right infraspinatus. **B,** Friction massage of the right superspinatus tendon. **C,** Proprioceptive neuromuscular facilitation (PNF) for posterior depression, scapular pattern, with soft tissue mobilization (STM). **D,** Mobilization of the right scapulothoracic articulation.

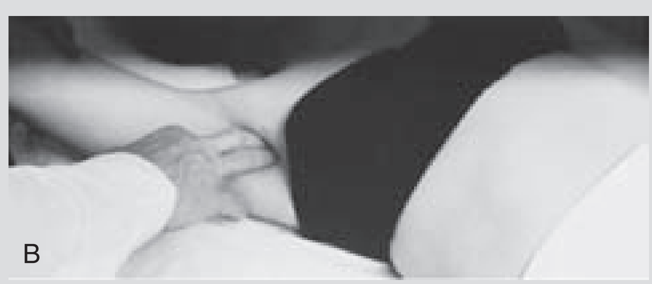

Figure 27-40 A, Soft tissue mobilization (STM) of the right pectoralis minor. **B,** Soft tissue mobilization (STM) of the right subscapularis.

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CASE STUDY—cont'd

Figure 27-41 Distraction of the right glenohumeral articulation with contract relaxation.

Figure 27-42 Caudal mobilization of the glenohumeral articulation with contract relaxation. Not shown is resistance to the depressors of the humeral head.

Figure 27-43 Proprioceptive neuromuscular facilitation (PNF) flexion abduction pattern with soft tissue mobilization (STM).

the scapula, soft tissues of the axilla arm and forearm region, and the nerves themselves) were evaluated and treated (Figure 27-47, *A*).

b. The upper-limb nerve tension test was performed, with the therapist moving the extremity until the patient or therapist first felt restriction. Through tracing and isolation, the therapist and patient identified restricted tissues and applied appropriate treatment techniques (Figure 27-47, *B*).
c. In the test position, the patient performed midrange wrist flexion and extension or cervical rotation and side bending while the therapist palpated the nerve to determine the locations of restrictions. This approach should not be used with irritable patients, because excessive motion will generally exacerbate symptoms.

Home program: The program was designed according to the protocol developed by Peter Edgelow.[124] This program includes diaphragmatic breathing, stretching of the upper thoracic spine and ribs over a fulcrum, and midrange oscillations of the wrist in a position short of beginning resistance.

5. Right wrist. Treatment was performed to increase wrist extension and improve the mobility of the ligaments. The primary mechanical dysfunctions limiting wrist extension were a restriction of the ability of the distal ends of the radius and ulna to separate and volar mobility of the lunate. It is possible that these dysfunctions occurred at the time of the accident and were a factor in the onset of wrist and hand pain secondary to computer keyboard use.

The initial purpose of treatment was to mobilize the soft tissues and articulations of the wrist. As mobility improved, the extremity was placed at the end of the flexion abduction and extension abduction patterns to further treat the mechanical limitations of wrist extension and to initiate selective neuromuscular reeducation (Figure. 27-48, *A-B*). Treatment of the wrist in weight bearing was the final phase of functional mobilization (Figure 27-48, *C*). The patient was sitting on the table and bearing weight on her hand, which was placed at the side in varying degrees of rotation. Weight-bearing mobilization was applied while the patient actively moved over the fixed base of support.

Home program: This consisted of stretching in weight bearing and resisted PNF wrist pivots with a sports cord.

6. Pelvic girdle. During the patient's second visit, the pelvic girdle dysfunctions were normalized. The right innominate fixation in flexion and external rotation was probably precipitated during the accident secondary to the foot's position on the brake pedal. Pelvic girdle dysfunctions alter the normal weight distribution, base of

CASE STUDY—cont'd

Figure 27-44 A, Extension adduction proprioceptive neuromuscular facilitation (PNF) pattern. **B,** Bilateral asymmetric reciprocal pattern for trunk and shoulder girdle stability while sitting.

Figure 27-45 Functional movement pattern: arm circles with soft tissue mobilization (STM).

Figure 27-46 Position for the upper-limb nerve tension test.

support, and motor recruitment of the upper quadrant. It is the authors' belief that the pelvic girdle should be evaluated for dysfunctions whenever the present problem involves a weight-bearing structure.

The following soft tissue structures were evaluated and treated: the right psoas, iliacus, and piriformis (Figure 27-49, *A-C*). The following articulations were mobilized: the right sacral base with a fulcrum technique (Figure 27-50, *A-B*) and extension and internal rotation mobilization of the right innominate (Figure 27-51). Mobilization of the innominate was performed in a prone position, with the patient's left leg off the table to stabilize the lumbar spine. The right lower extremity was placed at the end range of the extension abduction pattern, and contract relaxation was performed toward flexion adduction. During performance of the contract relaxation technique, pressure was

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CASE STUDY—cont'd

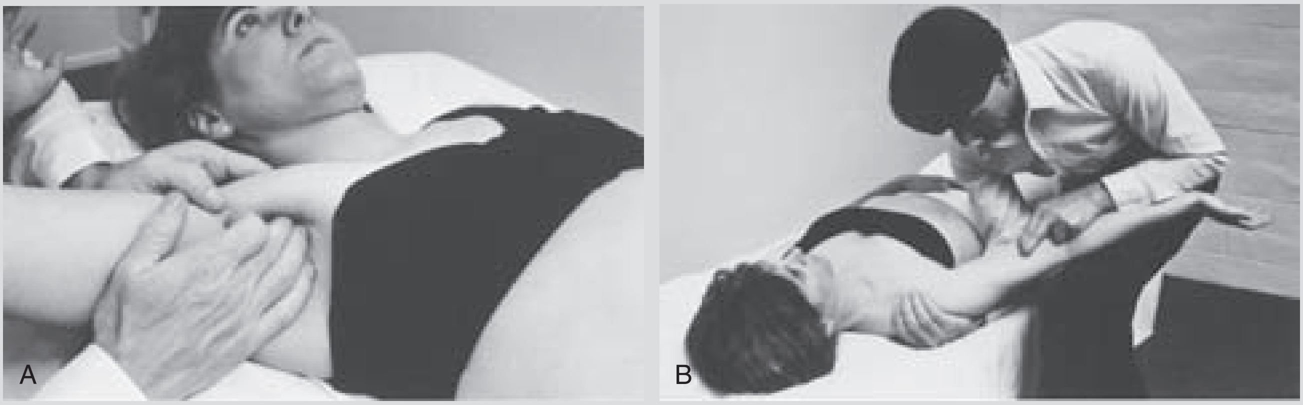

Figure 27-47 **A,** Mobilization of soft tissue around the axillary nerve track. **B,** Position for the upper-limb nerve tension test with tracing and isolating for soft tissue mobilization (STM).

Figure 27-48 **A,** Wrist soft tissue and joint mobilization in the extension abduction pattern. **B,** Resisted reeducation of a tight wrist in extension abduction. **C,** Mobilization of the wrist in weight bearing.

applied on the upper lateral iliac crest to mobilize the superior innominate anterior and medially.

Treatment Progression and Results

The patient was seen initially for 7 visits over a 3-week period, with emphasis placed on education and training and manual therapy applied to the primary dysfunctions. After this period, the subjective and objective signs of the cervical spine and shoulder improved 70% to 80%. The upper-limb nerve tension improved 40% to 50% and became the primary emphasis of treatment. The patient was then seen once a week for the next 5 weeks for further training and treatment of the remaining dysfunctions. The emphasis of this component of treatment was on having the patient perform and progress in her exercise program and increase her level of daily activities.

At the end of this 5-week period, the patient returned to work. After 3 days of work she experienced increased cervical and peripheral symptoms, and treatment was initi-

CASE STUDY—cont'd

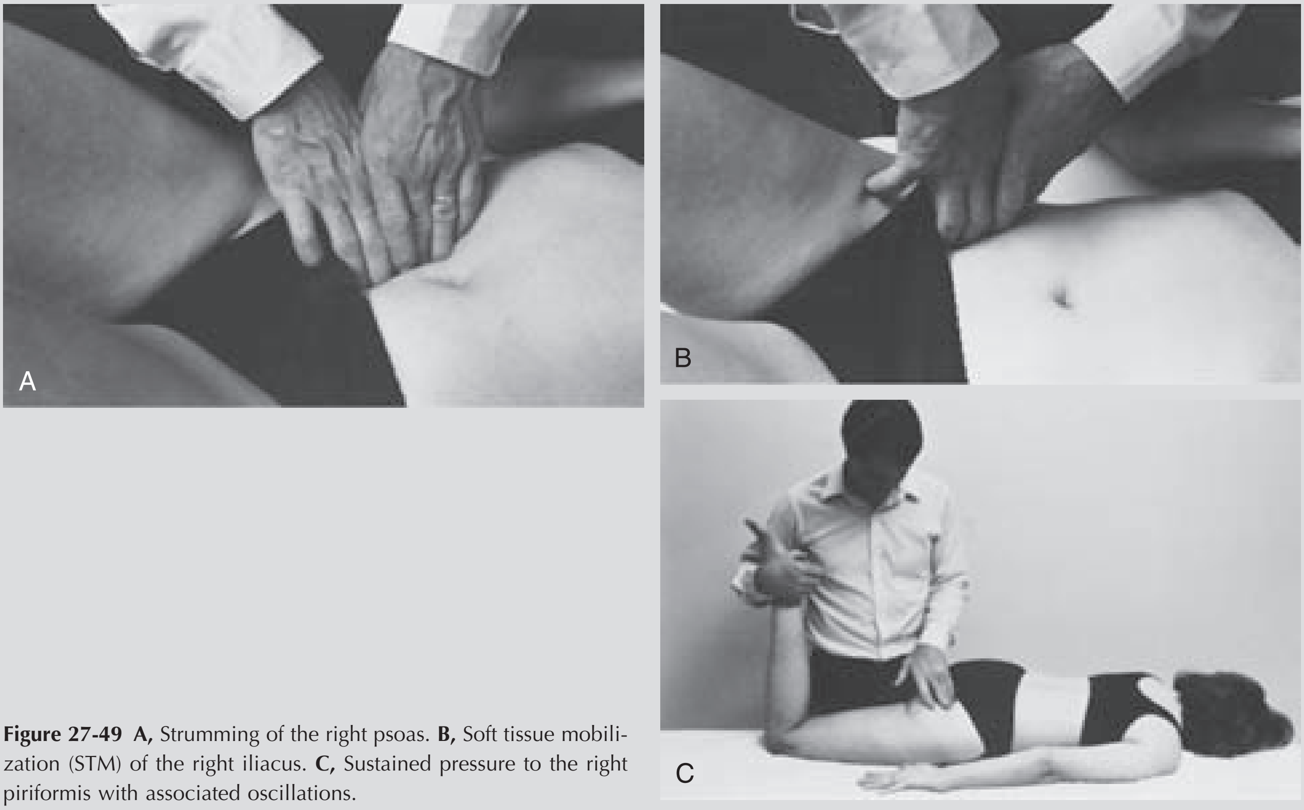

Figure 27-49 **A,** Strumming of the right psoas. **B,** Soft tissue mobilization (STM) of the right iliacus. **C,** Sustained pressure to the right piriformis with associated oscillations.

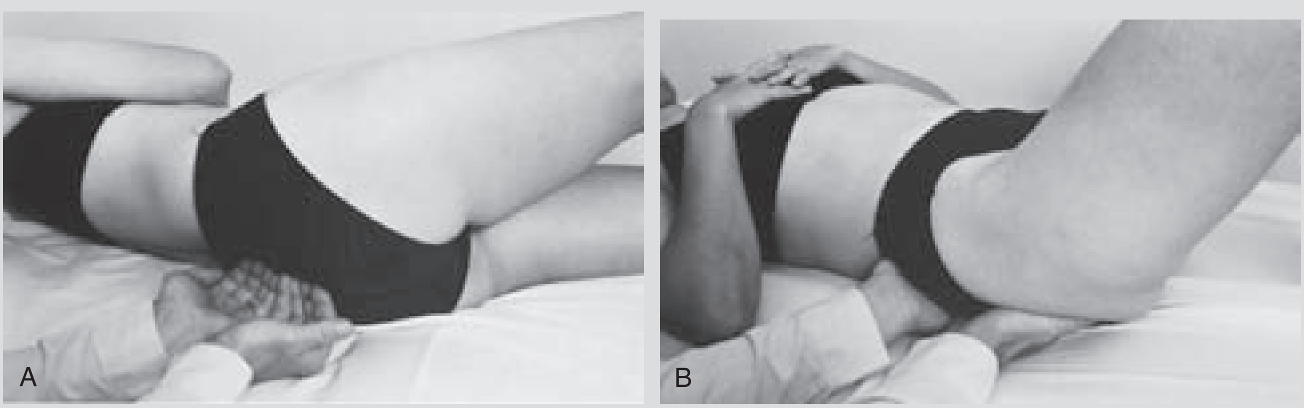

Figure 27-50 Fulcrum technique to mobilize the right sacral base. **A,** Finger position. **B,** Technique.

ated twice a week for the next 3 weeks to assist her transition to full-time employment. She was then seen for follow-up appointments every 3 to 4 weeks for 3 months.

At the end of 3 months she was discharged, with occasional peripheral symptoms secondary to excessive activity, but with the capacity to resolve and control these symptoms through self-management and a home program.

Case Study 2

The following case study illustrates the role that dysfunctional scar tissue can play in altering normal biomechanics and the results achieved with normalization.

The patient had right knee pain and dysfunction 1 year after anterior cruciate ligament (ACL) reconstructive surgery. She complained of lateral joint line and medial

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CASE STUDY—cont'd

Figure 27-51 Functional mobilization of the right innominate into anterior torsion and inflare.

intrapatellar pain after extended use. She also stated that she was having difficulty developing strength and muscular bulk in the quadriceps, especially the vastus medialis obliquus. The functional evaluation revealed that she was tracking medially, with difficulty moving her knee over the lateral aspect of her foot. It was noted that the lateral scar tissue developed significant tightness during knee tracking, with restricted posterior mobility.

Diagnostic classification: Musculoskeletal 4I: ACL tear with internal derangement 717.8

Treatment of the scar was initially applied in nonweight bearing and progressed to weight bearing, with the patient attempting to track over the middle toe. The primary treatment technique used was unlocking spirals (Figure 27-52, *A-B*).

After normalization of the scar tissue, there was a natural tendency to track over the second toe. In addition, the patient was able to perform dynamic quadriceps setting exercises of the vastus medialis. This confirmed the limitations on lower-extremity function produced by the scar tissue.

Figure 27-52 Scar tissue mobilization. **A,** Nonweight bearing. **B,** Weight bearing.

SUMMARY

The soft tissues of the body are often found to have inefficient mobility and tone, which precipitates and perpetuates many musculoskeletal symptoms. STM can play a valuable role in the treatment of these soft tissue dysfunctions. This treatment approach will achieve optimal results when used in conjunction with patient education, body mechanics training, a musculoskeletal conditioning program, and other manual therapy approaches (joint mobilization and neuromuscular education). A well-rounded and comprehensive conservative care program is required to return an individual to optimal function while avoiding nonconservative methods of management such as surgical intervention.

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