The Thoracic Spine and Rib Cage: Musculoskeletal Evaluation and Treatment

Timothy W. Flynn, P.T., M.S., O.C.S.

Instructor of Continuing Medical Education, College of Osteopathic Medicine, Michigan State University, East Lansing, Michigan; Doctoral Candidate, Center for Locomotion Studies, Pennsylvania State University, State College, Pennsylvania

Foreword by

Philip E. Greenman, D.O., F.A.A.O.

Professor of Osteopathic Manipulative Medicine and Professor of Physical Medicine and Rehabilitation, Michigan State University, East Lansing, Michigan

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Chapter 10

Myofascial Considerations in Somatic Dysfunction of the Thorax

Jeffrey J. Ellis and Gregory S. Johnson

Somatic dysfunction is defined as impaired or altered function of related components of the somatic (body framework) system; that is, the skeletal, arthrodial, and myofascial structures and related vascular, lymphatic, and neural elements [1]. The specific identification and timely amelioration of this dysfunction has been the challenge and goal of manual medicine since its inception.

Somatic dysfunction of the thoracic spine and rib cage is ubiquitous in nature with respect to patients complaining of spinal pain and produces a myriad of subjective and objective findings that challenge the clinician to arrive at a concise and accurate diagnosis. In fact, the thoracic vertebral column has been termed "one of the elusive frontiers in spine research" [2]. Recognition of the neuromusculoskeletal and biomechanical attributes and potentials of this region is very helpful in formulating appropriate treatment protocols as well as prognoses. As concepts of vertebral and rib cage motion, both normal and abnormal, are challenged, and even redefined by some [2, 3], increasing attention is being paid to the "driving force" behind this movement—the myofascial system and its potential role in creating and perpetuating somatic dysfunction [4–9].

Long recognized as a potential source of pain in biomechanical somatic dysfunction of the vertebral column [9–15], numerous terms and classifications have been proposed as designates for primary myofascial dysfunction (MFD), including muscular rheumatism [16–18], myalgia [19–21], interstitial myofibrositis [22], myofascial pain syndrome [23], myofaciitis [24–27], and fibrositis [28]. More recently, the myofascial system has received attention because of its causative or primary role in creating biomechanical sources of somatic dysfunction as opposed to its being intrinsically the direct source of pain [5, 6, 29–31].

Myofascial structures are those tissues that are either musculoskeletal (in this case) or connective in makeup and origin. The interrelationship between these tissues and the mechanical dysfunction that can be directly linked to their aberrant function demands the closest attention.

In the thoracic spine and rib cage, structural lesions can be defined through biomechanical nomenclature and include non-neutral type II, FRS (flexed, rotated, and side-bent) or ERS (extended, rotated, and side-bent) dysfunctions of a single vertebral segment; type I, neutral vertebral dysfunctions; and structural, torsional, and respiratory rib cage lesions. The myofascial system frequently provides insight into the identification and causation of underlying somatic dysfunction and presenting symptomatology. Myofascial structures may be observed from four specific perspectives with respect to thoracic spine and rib cage somatic dysfunction (Table 10.1).

First, their diagnostic value should be considered. In the presence of aberrant positional and motion dysfunction of the vertebral column or rib cage, adjacent myofascial structures will often have tissue texture abnormalities. These findings have been de-

Table 10.1. The Role of Myofascial Tissue in the Evaluation, Pathogenesis, and Treatment of Structural Somatic Dysfunction of the Thorax

Diagnostic role
Facilitated segment
Tissue texture abnormality
Primary motion restrictor
Cause of structural dysfunction
Use in MET/PNF
Primary activation force
Source of entrapment/tunnel syndrome
Myofascial/fiber-osseous tunnels

scribed in the osteopathic literature as being consistent with the presence of a "facilitated segment" [1, 32–37]. Korr [34], Mitchell et al. [35], Greenman [1], and others have described the myofascial changes that represent a facilitated segment, including hypertonicity, increased temperature, hyperesthesia, and concomitant fascial dysfunction of the immediate surrounding tissues. These changes are commonly present in the muscles of a single segment of the vertebral column (including the transversospinalis groups located in the anatomic groove between the transverse and spinous process) and of the rib cage (including the levator costae and intercostal muscles). These changes may, however, be analogous to an "idiot light" on a car (e.g., the oil gauge), which when lit, although meriting attention, belies a problem elsewhere. Tissue texture abnormalities in these regions often reflect underlying biomechanical dysfunction and should warrant further investigation. Undue preoccupation with these "lights" and the correlative subjective complaints that accompany biomechanical dysfunction elsewhere, frequently misguide and detract the clinician from formulating an appropriate diagnosis and implementing proper treatment. However, in the presence of a chronic facilitated segment, compensatory myofascial dysfunction may develop, become symptomatic, and warrant treatment in combination with the primary source of dysfunction.

Second, myofascial structures should be recognized for their potential role as primary motion restrictors in somatic dysfunction [7, 38–40]. In the presence of aberrant myokinematics of the thorax with respect to increased muscle tone, deficient muscle play/accessory mobility, changes in strength or neuromuscular responsiveness, and subsequent alteration in functional excursion/length, motion dysfunction of the related articular structures may result. This diminished functional capacity of the correlative articular structures (thoracic vertebral and rib segments) provides the environment for aberrant arthrokinematics, precipitating the occurrence of a cascade of possible chronic, degenerative changes [41].

In addition, because of the initial myofascial dysfunction, the neuromuscular system commonly functions inefficiently and is unable to provide the proper motor control and intrinsic stabilization necessary to protect and produce efficient function at these related segments [42]. This furthers the degenerative cascade through the repeated trauma of inefficient and improper movement patterns, both segmentally (arthrokinematically) and as an entire kinetic chain (osteokinematically).

Third, myofascial tissues are the operational focus during corrective treatment procedures such as muscle energy technique (MET) and proprioceptive neuromuscular facilitation (PNF) techniques. Lever principles (short and long) are used during METs to localize and normalize articular structures. These techniques, however, require tremendous specificity and rely on the presence of normal kinematics of related myofascial tissues for appropriate localization and to be efficacious. Normalization of MFD of these tissues may be required before their utilization in MET.

Finally, consideration must be given to the role myofascial tissues play in entrapment or tunnel syndromes of the neurovascular structures that pass through or reside in the thorax [13, 43, 44]. As they emerge from their origin in the spinal cord and until they reach their effector organs, nerves must pass through bony, fibrous, osteofibrous, and fibromuscular tunnels, where they risk potential compression, damage, and impairment of their end function [45]. Careful assessment of related myofascial tissues in combination with specifically selected neural tension tests [43, 44] will allow specific identification and isolation of causative myofascial dysfunction.

The purpose of this chapter is to recognize the varied influence and diagnostic information the myofascial tissues of the thorax can provide in managing somatic dysfunction of this region. In particular, the reader will be exposed to:

1. The relevant anatomic and biomechanical attributes of the myofascial structures of the thoracic spine and rib cage.

2. An enumeration and correlation of the specific myofascial structures that characterize nonresponsiveness to treatment, or recurrence in thoracic spine and rib cage articular (position/motion) dysfunctions.
3. An algorithmic methodology for evaluating and enumerating specific myofascial structural dysfunction.
4. An organized framework, methodology, and principles for treating myofascial dysfunction.
5. Relevant case studies that demonstrate the effectiveness of addressing myofascial dysfunction in the presence of movement dysfunction of the thoracic spine and rib cage.

Myofascial Tissue

The body is composed of four primary soft tissues: epithelial, muscle, nerve, and connective [46–48]. The interrelationship of muscle and connective tissue (i.e., myofascial tissue) provides for both normal biomechanics, which support static and dynamic activities (9), and pathomechanics in the dysfunctional state.

Connective tissue chiefly comprises ligaments and tendons (regular or dense) as well as aponeuroses, fascia, synovial membranes, joint capsules, and intrinsic elements of muscle (dense and loose irregular) [47, 48]. Continuous throughout the entire body, the fascial system interconnects with tendons, aponeuroses, ligaments, capsules, peripheral nerves, and intrinsic elements of muscle [49].

Connective Tissue: Fibrous Component

Connective tissue may be organized into two distinct components: fibrous and nonfibrous. The fibrous components consist primarily of collagen and elastin fibers. Irregular and regular connective tissues are distinguished by the periodicity and direction of fibers within each. Irregular connective tissue is recognized by its multidirectional fiber orientation, which provides the necessary strength, in all directions, required for structures such as capsules, aponeuroses, synovial membranes, and fascia. Regular connective tissue is distinguished by a uniplanar or linear fiber orientation, which provides the tensile strength required by ligaments and tendons [46–48, 50].

Connective Tissue: Nonfibrous Component

The nonfibrous portion of connective tissue consists primarily of amorphous ground substance, which is a viscous gel composed of long chains of carbohydrate molecules called mucopolysaccharides, known as glycosaminoglycan (GAG), bound to a protein and water (60–70% of net content). Collectively termed proteoglycan aggregate [48, 51], the nonfibrous portion of connective tissue plays a key role in providing a lubricous state in which collagen and elastin fibers can coexist and thrive. In addition, the proteoglycan aggregate provides appropriate spacing, described as critical fiber distance (CFD), between the fibrous elements and is necessary for normal mobility.

Viscoelastic Properties of Connective Tissue

Collagen fibers are relatively inextensible; however, they have the biomechanical attribute of being able to withstand high tensile forces [47, 48]. Fascia is composed of wavy, multidirectional, multiplanar collagen fibers and elastin fibers and is therefore highly extensible as well as strong. Force, or the load applied to the tissue, is defined as *stress*, whereas the tissue deformation realized is termed *strain* [48, 52]. This stress/strain relationship (Fig. 10.1) depicts the viscoelastic response connective tissue undergoes when force is applied and includes the initial toe region elastic, plastic, and, finally, failure ranges. This collagenous elongation or deformation is known as *creep* and occurs through the process of hysteresis (Fig. 10.2) [52–54].

It is through these physiologic and biomechanical properties that soft-tissue mobilization techniques are purported to demonstrate their efficacy. Collagen has in fact been found to realign, strengthen, and orient its fibroblasts and the resulting newly synthesized fibers in response to the type, amount, duration, and frequency of the stress applied [55–57]. In short, newly deposited collagen fibers become oriented in the direction of stress [58–61]. This process of remodeling in accordance with stresses imposed is known as Wolf's Law of C.T. [55–58] and will be a prime consideration in our attempts to influence the connective tissue system with myofascial mobilization technique.

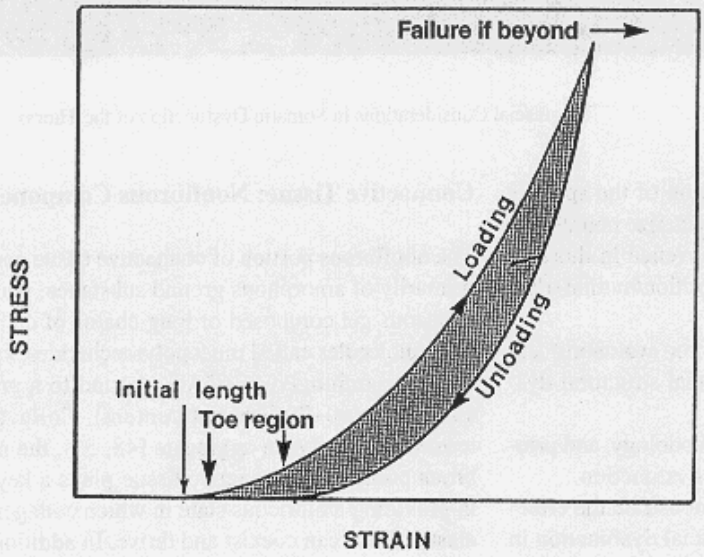

Figure 10.1. Stress/strain curve. This curve demonstrates the viscoelastic behavior and resulting deformation of connective tissue to externally applied stress. (Reprinted with permission from N Bogduk N, LT Twomey. Clinical Anatomy of the Lumbar Spine. New York: Churchill Livingstone, 1987.)

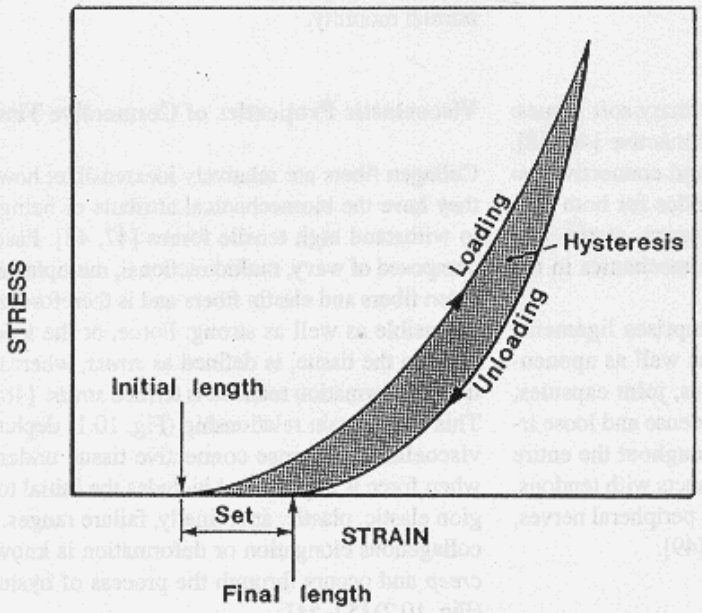

Figure 10.2. Hysteresis. This curve demonstrates tissue deformation with loading and the permanent length changes realized after stress is removed "set." (Reprinted with permission from N Bogduk, LT Twomey. Clinical Anatomy of the Lumbar Spine. New York: Churchill Livingstone, 1987.)

Effects of Immobilization

The effects of immobilization of articular capsules have been well documented [48, 50, 62–64], and the information provided may be extrapolated for use in observing what occurs to other connective tissues including fascia. The chief effects of immobilization are summarized in Table 10.2.

These changes equate to stiffer, harder tissues, a reduction in muscle play and functional elongation, and an overall diminution in fascial mobility secondary to biomechanical aberrancies. Myofascial mobilization efforts are directed at normalizing these aberrancies while keeping in mind the histologic and biochemical reasons for this presentation.

Table 10.2. Effects of Immobilization on Connective Tissue

Reduction in glycosaminoglycan (especially hyaluronic acid, which maintains a high affinity for H_2O
Subsequent reduction in H_2O
Thixotropic state according to dehydration
Increased tissue rigidity and stiffness
Production of abnormal cross-link formation
Decreased and altered spacing between collagen fibers (decreased critical fiber resistance)
Diminished fiber glide
Fatty infiltrate within spaces, which potentially matures to become scar tissue
Random orientation and deposition of newly synthesized collagen fibers

Muscle

Three types of muscles are found in the human body: cardiac muscle; smooth (nonstriated or involuntary) muscle, which lines the hollow internal organs; and skeletal (striated or voluntary) muscle, which attaches to the skeleton via tendons, causes movement to occur and accounts for 40–45% of total body weight [52].

Performing both static and dynamic activities, skeletal muscle, which will be our focus, consists of two basic components: muscle fibers (the contractile component), and connective tissue (the noncontractile component) [52]. The fiber, the structural unit of skeletal muscle, is virtually sheathed in connective tissue, first as a single fiber covered with loose endomysium, then as various sized bundles or fascicles covered with dense perimysium, and finally as muscle bellies covered with epimysium [47].

An intimate relationship exists between the contractile and noncontractile elements of skeletal muscle. The contractile portion provides force production, relaxation, and extensibility, whereas the noncontractile portions provide for space, the lubrication of the contractile elements, and the elasticity required by muscle for appropriate broadening, lengthening, and muscle play.

Numerous authors have written about the histologic and biomechanical effects of trauma and immobilization in the form of microscopic and macroscopic changes to the myofascial unit [63, 65–67]. These dysfunctions include alteration of tone (secondary to impaired peripheral and central innervation); hypertonicity with localized trigger points (contraction) [14]; diminution of motor recruitment and control [39, 41, 68]; a decrease in functional excursion/muscle length secondary to sarcomere loss [62, 66, 67, 69, 70]; diminished accessory motion of connective tissue elements (contracture); and decreased muscle play. It is these microscopic and macroscopic changes that combine to create abnormal tension vectors and levers that alter the normal homeostatic balance that exists in the biokinetic chain.

Myofascial Dysfunction: Contracture/Contraction/Cohesion-Congestion (Fluidochemical)

In the consideration of motion dysfunction of the thoracic spine and rib cage, as well as the entire vertebral column, careful attention must be placed on defining the causative or contributory barriers to normal movement. Three theoretical models for the manifestation of MFD are contracture, contraction, and cohesion-congestion. Elements of each of these categories are presented in Table 10.3.

Table 10.3. Theoretical Models for the Manifestation of Myofascial Dysfunction

Contracture	Contraction	Cohesion-Congestion
Inert/noncontractile	Muscle contraction	Fluidochemical
Capsular/fascial fibrotic	Muscle holding	Edematous/dehydrated
Abrupt/firm end-feel	Hypertonicity/spasm	Boggy/stiff/reactive
Chronic	Acute/distress	Acute/chronic

Contracture

Contracture describes those myofascial structures (particularly connective tissues) that have undergone some degree of fibrotic alteration that makes their end-feel stiffer, harder, and less resilient or elastic, with associated shortening [5, 14, 58]. This may be secondary to various and numerous biomechanical and biochemical causes but yields as its end result specific characteristics including microscopic cross-linking of collagen fibers with diminution of fiber glide; alterations in tissue creep capacities [71]; alterations in tissue layer mobility, resulting in adhesion to underlying myofascial or osseous structures [29]; a change in mobility of intramuscular septum; and posttraumatic scarring. This definition of contracture should be distinguished from other works that classify "contracture" as the sustained intrinsic activation of the contractile mechanism of muscle fibers [72].

Contraction

The classification *contraction* may be used synonymously with spasm and is defined as increased tension with or without shortening of a muscle caused by involuntary motor nerve activity that cannot be stopped by voluntary relaxation [73]. This hypertonicity is usually associated with an increased level of tissue reactivity to palpation and often correlates with articular dysfunction at the same level. The tissue end-feel encountered is described as reactive, firm, painful, and frequently accompanied by increased tissue temperature. In addition, there may be localized signs of inflammation including swelling or edema.

Cohesion-Congestion

Webster's New Collegiate Dictionary [74] defines cohesion as "the act or process of sticking together tightly" and congestion as "to bring together, to concentrate in a small or narrow space." "This category includes macro- and microcirculatory changes affecting fluidochemical transport and exchange (such as altered chemical exchange on a cellular level, impaired lymphatic flow, vascular stasis or ischemia, etc.), and considers various chemical substances which may influence myofascial tissue such as metabolites, electrolytes, hormones, neurotransmitters, neurogenic and nonneurogenic pain mediators, etc." [71]. This category includes those fluidochemical changes related to a diminution in tissue hydration that may go on to provide the foundation for biomechanical dysfunction as a sequela to ground substance dehydration and resulting changes within the fibrous and nonfibrous elements of connective tissue. It also, however, encompasses those situations in which there is an overabundance of tissue hydration with resulting biomechanical alteration.

Myofascial Anatomy of the Thorax

The myofascial tissues of the thorax, although multipurpose, maintain the distinction of providing one overriding function—respiration (Table 10.4). Together, the various tissues of the thoracic wall constitute a strong yet delicately regulated pump or bellows, providing the rigidity capable of resisting surrounding pressure, the mobility that allows active expansion and aspiration of air, and a resilience that imparts properties of elastic recoil [46]. In addition, these muscles act in an orchestrated fashion with the back musculature of the thoracolumbar and cervicothoracic regions to initiate and control functional movements of the thoracic spine and rib cage.

Understanding the anatomic topography and myokinematics of all of these muscles allows their normal and dysfunctional states to be more easily identified and managed. In addition, the pathomechanics of this region secondary to aberrant muscle function may be more commonly attributed to specific dysfunctional myofascial tissues as their anatomic presentation is understood. These muscles are listed topographically and in accordance with their function in Tables 10.4 through 10.10 (for further details, see Chapter 1).

Table 10.4. Muscles of the Thorax

Diaphragm
Intercostales externi
Intercostales interni
Intracostales
Triangularis sterni
Levatores costarum

Source: Adapted from H Gray. Anatomy, Descriptive and Surgical. Philadelphia: Running Press, 1974.

Table 10.5. Topographical/Layer Orientation of the Back Muscles of the Cervical, Thoracic, and Lumbar Spine

First Layer	Second Layer	Third Layer	Fourth Layer	Fifth Layer
Trapezius	Levator anguli scapulae	Serratus posticus superior	Sacral and lumbar regions:	Semispinalis dorsi
Latissimus dorsi	Rhomboideus minor	Serratus posticus inferior	Erector spinae	Semispinalis colli
	Rhomboideus major	Splenius capitis	Dorsal region:	Multifidus spinae
		Splenius colli	Ilio-costalis	Rotatores spinae
			Musculus accessorius ad iliocostalem	Supraspinales
			Longissimus dorsi	Interspinales
			Spinalis dorsi	Extensor coccygis
			Cervical region:	Intertransversales
			Cervicalis ascendens	Rectus capitis posticus major
			Transversalis cervicis	Rectus capitis posticus minor
			Trachelo-mastoid	Obliquus capitis inferior
			Complexus	Obliquus capitis superior
			Biventer cervicis	
			Spinalis colli	

Source: Adapted from H Gray. Anatomy, Descriptive and Surgical. Philadelphia: Running Press, 1974.

The musculature of the back (cervicothoracic, thoracolumbar) must receive equal consideration because it exerts a significant influence on the overall static and dynamic posturing of the thoracic spine and rib cage. Although the postvertebral muscles show little if any rhythmic activity in quiet respiration, their chief function is primarily postural, maintaining erect posture against gravity. Dysfunction of these tissues (i.e., increased muscle tone, decreased play, alteration in strength or neuromuscular responsiveness, or changes in functional excursion) may produce significant postural changes and resultant dysfunction of the rib cage [75]. These muscles may be identified topographically from a larger perspective (see Table 10.5).

Muscles of respiration may also play a key role in the structural, torsional, or respiratory rib dysfunctions (see Chapter 8). These muscles have been categorized as primary and accessory muscles of inspiration and primary and accessory muscles of expiration (see Tables 10.6, 10.7) [11, 76].

Finally, the muscles of the abdomen must be considered because they exert influence on and support for the thoracolumbar region and the rib cage. These muscles are topographically divided into superficial and deep groups (see Table 10.8).

Although not discussed in this text, additional consideration should also be given to the muscles of the upper extremities, particularly the rotator cuff musculature, because dysfunction of the upper extremity can directly affect the scapula and clavicle and indirectly the rib cage and thoracic spine. Each muscle group of the thorax, back, abdomen, and upper extremity and their related fascial attachments should be considered in somatic dysfunction of this region.

Table 10.6. Muscles of Inspiration

Primary
Diaphragm
Levator costarum
External intercostals
Internal intercostals (anterior)
Accessory
Scaleni
Sternocleidomastoid
Trapezius
Serratus anterior and posterior superior
Pectoralis major and minor
Latissimus dorsi
Thoracic spine extensors
Subclavius

Source: Adapted from HO Kendall, FP Kendall, DA Boynton. Posture and Pain. Huntington, NY: Robert E. Krieger, 1977.

Table 10.7. Muscles of Expiration

Primary
Abdominal muscles
Internal oblique, external oblique, rectus abdominis
Transversus abdominis
Internal intercostals, posterior
Transversus thoracis
Accessory
Latissimus dorsi
Serratus posterior inferior
Quadratus lumborum
Iliocostalis lumborum

Source: Adapted from HO Kendall, FP Kendall, DA Boynton. Posture and Pain. Huntington, NY: Robert E. Krieger, 1977.

Table 10.8. Abdominal Muscles

Superficial
Obliquus externus
Obliquus internus
Transversus abdominis
Rectus abdominis
Deep
Psoas major
Psoas minor
Iliacus
Quadratus lumborum

Source: Adapted from H Gray. Anatomy, Descriptive and Surgical. Philadelphia: Running Press, 1974.

Pathomechanics and Sequelae of Myofascial Dysfunction

Kinetic Chain Principles

A kinetic chain is a series of interconnecting segments that affects the position, movement, potential for movement and shock absorption, and attenuation of forces that are transmitted through those segments. Intimately linked and supportive of the skeletal structures, the myofascial tissues play a key role in the way this chain functions.

Myofascial Joints "Above and Below"

The axiom that thorough assessment of an individual articulation demands examination of the immediate articulations above and below the dysfunctional articulation [63] is equally germane to the soft-tissue system. Through a series of direct and indirect attachments or junctions, all myofascial tissues maintain an interrelationship that allows biomechanical influence on one another. Dysfunction in one myofascial structure may have a profound effect on the functional ability of a distant, but related, second myofascial structure.

Gratz's Functional Joint

Gratz defined the space that exists within and between these junctions as well as all structures of the human body as "functional joints" [77]. He went on to define a functional joint as "a space built for motion." From a functional and biomechanical basis, the mobility provided by the presence of this "space" [77] has been designated "muscle play" [29]. This concept will be critical in understanding the subtle yet profound impact that loss of accessory motion within the myofascial structures can have on the entire kinetic chain. The aberrance, or loss of normal "functional joint mobility" as defined by Gratz, should prompt one to consider the mechanical interface that exists between virtually all structures in the body. From a microscopic, cellular perspective to a macroscopic observation of structures such as muscle bellies, fascial sheaths, and underlying bony structures, the available spacing and mechanical interface relationship that exists must be considered, especially when attempting to restore normal mobility to the kinetic chain.

Myofascial Dysfunction in Primary and Compensatory Vertebral and Rib Dysfunction

Of primary importance in determining and sequencing treatment is whether presenting myofascial dysfunction represents the primary cause of a movement dysfunction or is a component of compensatory dysfunction. Primary sources of movement dysfunctions of the vertebral column, classified as type II non-neutral FRS or ERS dysfunctions (see Chapter 8), and of the rib cage, classified as structural, torsional, or respiratory, represent the causative agents of both aberrant position and motion of the involved motion segment. In the vertebral column, unisegmental muscles have been implicated as the possible source of

Table 10.9. Proposed Myofascial Sources of Thoracic Spine and Rib Cage Motion Dysfunction

Myofascial Structure	Potential Structural Dysfunction
Anterior scalenes	Superior subluxation of the first rib segment Exhalation restriction
Medial scalenes	Superior subluxation of the first rib segment Exhalation restriction
Posterior scalenes	Superior subluxation of the second rib Exhalation restriction
Pectoralis minor	Exhalation restriction External torsion
Transversospinalis muscles	Type II FRS/ERS dysfunction
Respiratory diaphragm	Inhalation restriction
Quadratus lumborum	Inhalation restriction 12th rib structural dysfuntion
Serratus posterior superior	Internal torsion ribs 2–4
Serratus posterior inferior	External torsion ribs 9–12
Latissimus dorsi	Exhalation restriction more frequent than inhalation restriction Lateral bucket-bail
Serratus anterior	Upper fibers: Inhalation restriction Lower fibers: Exhalation restriction, lateral bucket-bail
Internal intercostals (anterior)	Exhalation restriction
External intercostals	Exhalation restriction
Abdominals	Inhalation restriction
Iliocostalis lumborum	External torsion

myofascial dysfunction in primary movement dysfunction. These include the transversospinalis, multifidus, and rotatores muscles [1, 3, 7, 36, 78]. In the rib cage, the anterior and medial scalenes, the levatores costarum, the intercostals, the pectoralis minor, the serratus posterior superior and inferior, the serratus anterior, and the latissimus dorsi muscle groups are common sources of primary movement dysfunction. Specifically, these muscles may contribute to primary vertebral or rib dysfunction by compensatorily shortening (secondary to increased tone-contraction or connective tissue shortening contracture), thereby producing a significant impact on the possibility of structural correction through MET or mobilization efforts alone. Table 10.9 provides a list of muscles and their possible myokinematic influence on thoracic spine and rib cage dysfunction. It must be remembered, however, that the respective tone and length of a muscle do not constitute the only considerations for possible dysfunction; the entire surrounding fascial structures must be considered as well.

In response to type II non-neutral vertebral dysfunction of the thoracic spine and structural rib cage dysfunction, compensatory responses of the vertebral column, described as type I neutral dysfunctions, are expected (see Chapter 8). Spanning three or more vertebral levels with osteokinematic sidebending to one side and concurrent rotation to the opposite side, myofascial dysfunction with adaptive shortening often occurs concomitantly. This is particularly true in cases of chronicity (Fig. 10.3).

These myofascial adaptations frequently include aberrant muscle play and functional excursion/length on the concave side of the type I curve and alteration of neuromuscular responsiveness/strength on the convex side. These compensatory changes typically include multisegmental muscles such as the iliocostalis and longissimus groups. Changes in muscle length, tone, play, or accessory motion responsible for the causation or perpetuation of type I vertebral dysfunctions must be addressed because they often contribute to nonresponsive or recurrent lesions elsewhere in the kinetic chain.

Although type I dysfunction often correlates with concomitant myofascial dysfunction in this region, it may also be related to and demands differentiation from at least 13 other possible causes (see Table 10.10).

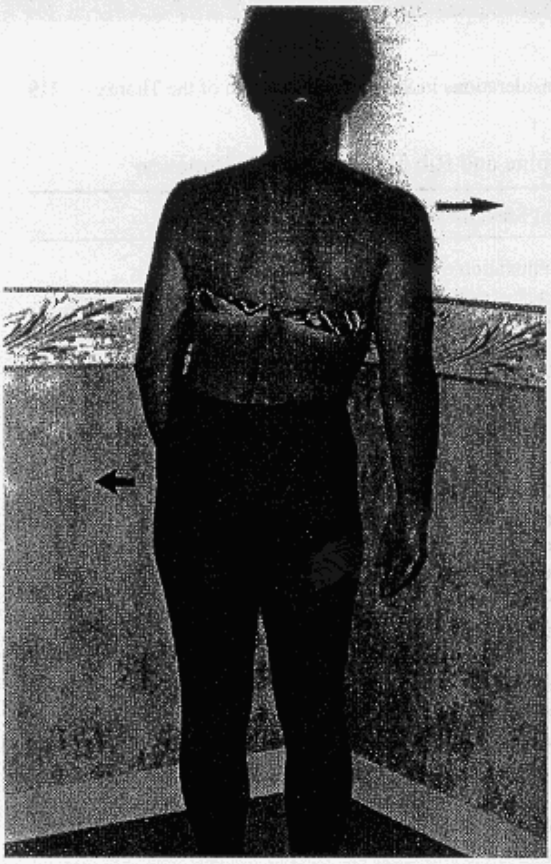

Figure 10.3. Type I neutral dysfunction of the thoracolumbar spine with thoracic sidebending to the left and concurrent rotation to the right.

Sequencing Treatment Strategies

Of paramount importance in determining treatment strategies are the identification and amelioration of myofascial sources of primary movement dysfunction. In the acute phase, these will typically be related to those sources of dysfunction classified as contraction, cohesion-congestion, or both (see Table 10.3) and will be most evident at or immediately adjacent to the dysfunctional vertebral or rib dysfunction. Correction of these dysfunctions should yield immediate changes in both position and motion characteristics of the involved motion segment. In addition, when these dysfunctions are present in the acute phase and are not associated with longstanding myofascial changes, compensatory myofascial dysfunctions (i.e., increased tone, muscle holding, superficial fascial dysfunction) will also normalize.

Equally important, however, is the identification of myofascial dysfunction associated with chronic, compensatory vertebral dysfunction (type I neutral dysfunction), which is often classified as "contracture" in nature (see Table 10.3). Because they are accompanied by adaptive myofascial changes, particularly alteration in muscle length/elongation and play/accessory mobility, failure to address these aberrancies may allow for poor correction of osteokinematic movement dysfunctions (i.e., type II non-neutral vertebral dysfunction or structural rib dysfunction). In addition, failure to normalize the myofascial structures associated with

Table 10.10. Thirteen Causes for the Presence of Type I, Neutral Dysfunction of the Vertebral Column, with Sidebending and Rotation Opposite

Type II nonneutral, vertebral dysfunction (FRS/ERS) below the type I dysfunction
Type II nonneutral, vertebral dysfunction (FRS/ERS) above the type I dysfunction
Subcranial dysfunction (particularly at the O/A articulation)
Rib cage dysfunction (structural or torsional)
MFD of the abdomen
Idiopathic scoliosis
Sacral base unleveling (sacroiliac joint dysfunction)
Innominate or iliosacral dysfunction
Structural leg length assymetries
Functional leg length assymetries (rearfoot pronation/supination deformities)
Adverse neural tension signs, upper extremity
Adverse neural tension signs, lower extremity
Visceral dysfunction

Source: JJ Ellis. LPI—Lumbo-Pelvic Integration, A Course Manual. Patchogue, NY: 1990.

compensatory vertebral dysfunction may provide the "environment" for primary movement dysfunctions to recur (i.e., recurrent tendencies).

Myofascial Assessment: CHARTS Methodology of Evaluation

Evaluation of somatic dysfunction of the thoracic spine and rib cage requires careful attention to detail. The use of an algorithmic approach will help the clinician avoid overlooking the smallest yet perhaps most significant of details. One such approach is the CHARTS methodology of evaluation [6] (Table 10.11). This system builds on the osteopathic evaluative acronym ART, which stands for *a*symmetry of bony landmarks, *r*ange of motion/mobility alteration, and *t*issue texture abnormalities [1, 36, 79]. In the CHARTS model, chief complaints, history (particularly recent biomechanical and systems review), and special tests (e.g., radiologic, blood analysis) are added for thoroughness and precision in arriving at a diagnosis. (See Chapters 3–7 for a thorough discussion of history and special tests.) In addition, tissue texture abnormalities, "T," have been embellished in keeping with this chapter's emphasis of the importance of this area.

Table 10.11. CHARTS Methodology of Evaluation

C: Chief complaint
H: Histories
Family history
Social/recreational history
Past medical history
Pharmacologic history
Current history/presenting dysfunction
A: Asymmetries of bony landmarks
Orthostatic postural assessment
Specific spinal/costal/extremity landmarks
R: Range of motion/mobility testing
Osteokinematic spinal/costal/extremity ROM
Arthrokinematic spinal/costal/extremity ROM
Special mobility testing
T: Tissue texture/tension/tonal abnormalities
Skin/fascial layer assessment
Muscle play/accessory mobility
Bony contour assessment
Functional excursion/length
Neuromuscular control/functional strength
S: Special tests
Neurologic screen
Vertebrobasilar clearance testing
Ligamentous integrity testing
Gait assessment
Radiologic screen
Laboratory profiles
Functional capacity/work hardening screen

Source: JJ Ellis. LPI—Lumbo-Pelvic Integration, A Course Manual. Patchogue, NY: 1990.

Evaluation and General Screening Procedures

Evaluation of myofascial tissues, "T" within the CHARTS methodology, requires consideration of several specific characteristics. These elements are assessed through static, dynamic, and physiologic movement patterns using a layer approach, which assesses tissues from the most superficial to the deepest—i.e., those inserting into bony contours (Table 10.12).

Static Postural Assessment

Static evaluation takes place with the patient standing, seated, prone, supine, and on all fours (quadruped). The evaluative process begins at the moment of initial visual contact with the patient. A keen sense of observation as the patient walks to the evaluative suite and then throughout the static postural screen will yield much information regarding static and dynamic postures, reactivity levels, muscle guarding/holding, gait deviations, tolerance to certain functional postures (e.g., sitting, standing), and perhaps appropriateness and psychological state. Ideally, the practitioner should provide an environment suitable for patient comfort and privacy, while allowing for unobstructed visual observation from a distance of 8–12 feet. Evaluation suites should be carpeted, adequately heated to allow disrobing, and have lighting arranged to avoid unnecessary shadowing or glare.

The static postural examination often yields valuable information regarding underlying osseous/articular structures as well as asymmetries and aberrancies within myofascial structures. This may directly correlate with altered motion and positional dysfunction within the thoracic vertebral column and

Table 10.12. Myofascial Assessment

- A. General screening procedures
  - 1. Static postural assessment
    - a. Skeletal observation
    - b. Soft tissue observation
  - 2. Dynamic postural assessment
    - a. Vertical compression testing (VCT)
  - 3. Physiologic movement patterns
    - a. Thoracic movement patterns
    - b. Upper extremity movements
    - c. Respiratory movements
    - d. Functional movement patterns (FMP)
- B. Skin and superficial fascial assessment
  - 1. Palpation
  - 2. Soft-tissue contours
  - 3. Skin condition
  - 4. Skin mobility
  - 5. Scar tissue
  - 6. Superficial/deep fascia
- C. Bony contours
  - 1. Thoracic spine
    - a. Vertebral segments
  - 2. Rib cage
    - a. Sternum
      - i. Manubrium
      - ii. Body
      - iii. Xiphoid
    - b. Clavicle
    - c. Rib segments 1–12
  - 3. Scapula
- D. Muscle assessment
  - 1. Muscle tone
  - 2. Muscle play/accessory
  - 3. Muscle length/functional
  - 4. Neuromuscular control

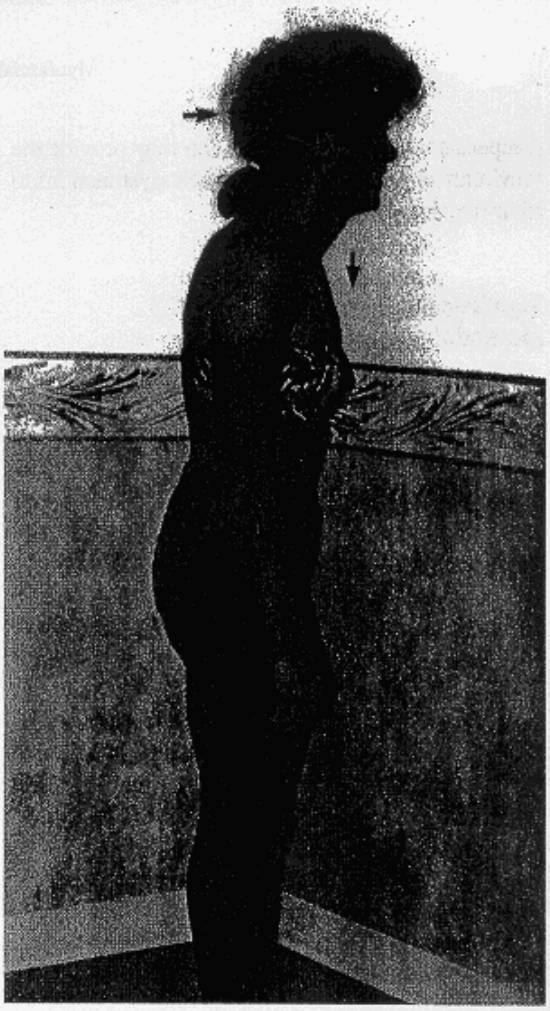

Figure 10.4. Forward head postural dysfunction with accompanying bilaterally protracted shoulders, depressed sternum, and thoracic kyphosis.

the rib cage. An example of this is a patient with forward head posture (FHP), bilaterally protracted shoulders with one greater than the other (the right shoulder in this example), a depressed sternum, and myofascial dysfunction of the pectoralis minor/major muscle complex (right greater than left) (Fig. 10.4).

This aberrant condition of the myofascial structures may be the primary cause of the resulting respiratory, exhalation dysfunction of the third, fourth, and fifth ribs on the right (see Chapter 8). In addition, asymmetric myofascial tightness may directly correlate with type I dysfunction in the thoracic spine.

Skeletal Observation

Beginning with posterior, anterior, and, finally, lateral views, static postural assessment should proceed in a caudal to cranial direction and include careful inspection of both skeletal and soft-tissue structures. Skeletal structures are evaluated with respect to symmetry from side to side and should include observation of aberrant position, spacing, size, and relative support. Anterior and posterior perspectives will provide information regarding skeletal and soft-tissue deviations of the craniovertebral structures, rib cage,

pelvis, and extremities in the coronal plane. Lateral shifts, type I dysfunctions, relative torsional and rotational patterns of the rib cage, pelvis and upper and lower extremities will be visualized in these postures. Lateral perspectives will yield information regarding sagittal deviations and include forward head posture (FHP), excessive cervicothoracic angulation ("dowager's deformity") or diminished, or absent cervical lordosis, sternal and sternomanubrial positions, shoulder posturing (protracted, retracted), rib cage resting position (exhalation, inhalation pattern), thoracolumbar and lumbopelvic angles, and genu recurvatum and/or flexion deformities.

The thoracic spine should have a smooth, uninterrupted curve reflecting a sagittal kyphosis with little or no coronal shift or lateral displacement. Sharp breaks or angulation in this contour often correlate with areas of focal hypermobility [80] and may present with increased muscle hypertonicity in the immediate surrounding tissues. In addition, these areas may reflect the presence of type II vertebral dysfunction or occur at transitional zones between two groups of type I vertebral dysfunction. Flattened areas within the thoracic sagittal kyphosis may relate to areas of hypomobility. Lateral deviations or alteration in the coronal plane may reflect the presence of type I multisegmental dysfunction.

In addition, inspection and side-to-side comparison of the individual relationships of rib segments (including spacing and superior, inferior, anterolateral and posterolateral contours), the scapula, and the clavicle should be considered. Asymmetric contours of the rib cage may yield valuable information regarding underlying somatic dysfunction (respiratory, torsional, or structural) in this region.

Soft-Tissues Observation

Soft tissues are also observed in the static postural screen from the posterior, anterior, and lateral perspectives. Beginning with a global view, the general patterns, types, and contours of soft tissues should be assessed. Initial impressions will often provide the direction of soft-tissue evaluation as central areas of dysfunction are discovered. Soft-tissue dysfunction of the thoracic spine and rib cage often has a proclivity for spiral and diagonal patterns, which course from a central, focal location of somatic dysfunction. These dysfunctions may zig-zag throughout the kinetic chain and provide a visual and palpatory link to primary sites of dysfunction. Observations should focus on several characteristics of the soft-tissue system including general contours, girth, muscle mass and development, symmetry from side to side, and three-dimensional relationships including depth, width, height, and length. Specifically, soft-tissue structures are evaluated for the presence of bands, restrictions, adhesions, and depressions within the superficial and deep fascial tissues. These characteristics may yield valuable information regarding underlying or adjacent osseous and articular somatic dysfunction as well as the functional characteristics and movement potential they possess. The presence of asymmetric contours or muscular development may provide valuable information regarding aberrant patterns of use, habitual postures, prior trauma, or improper training emphasis. Bands, contours, adhesions, and restrictions in the superficial tissues, often appearing as depressions or puckering of the dermis or epidermis, may direct attention to the possibility of aberrant superficial and deep fascial tissues, which often accompany or are responsible for underlying vertebral and rib cage dysfunction.

In addition, the examiner should look for and evaluate areas of focal neuromuscular activity or muscle holding because of their role as protective or pain avoidance mechanisms, or as part of aberrant postural or segmental mechanics. This is commonly seen in the scapulocostal region in the presence of forward head posture with abnormal muscle holding/neuromuscular activity of the levator scapulae muscle. In the chronic dysfunctional state, several aberrant static and dynamic dysfunctions may be seen in the sequelae that result from this abnormal muscle holding. These findings include cranial tilt to the ipsilateral side of increased muscle activity, elevated ipsilateral shoulder girdle, altered scapulocostal posturing with possible suprascapular and dorsal scapular nerve entrapment syndrome [43, 81], upper rib cage dysfunction, and upper thoracic spine dysfunction (Fig. 10.5).

Dynamic Postural Assessment

Vertical Compression Testing

Vertical compression testing (VCT) [29] is used to further assess the position, integrity, and force atten-

Figure 10.5. Myofascial dysfunction of the right levator scapulae muscle with increased muscle holding (contraction) secondary to postural dysfunction including forward head posture, protracted shoulders, cranial side tilting, and depressed sternum.

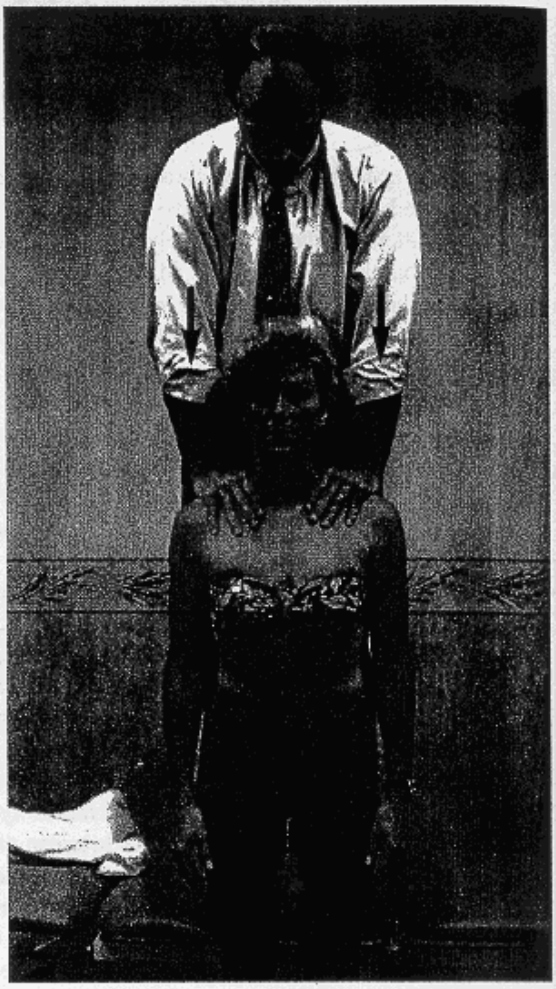

Figure 10.6. Vertical compression testing in the standing posture to assess postural dysfunction including the presence of type I and II vertebral dysfunctions.

uation characteristics of the vertebral column, pelvis, and lower extremities in various weight-bearing postures (i.e., standing and sitting). Aberrant positional dysfunction of the spine (i.e., type I and II) is both palpated and visually magnified through the vertical compression test. In addition, this testing procedure provides kinesthetic feedback to the patient regarding aberrant positional and motion dysfunction by emphasizing malalignment and then serving as positive feedback after correction and retesting. This often proves invaluable in enlisting the patient's support, understanding, and participation in a rehabilitation program.

The VCT is performed with the patient both standing and sitting and is accomplished by applying a gently increasing vertical compressive load through the shoulders and rib cage in a cranial-to-caudal direction (Figs. 10.6 and 10.7). This load may vary from ounces to several pounds as the clinician localizes to various levels of the vertebral column and lower extremity.

Vertical Compression Testing with Somatic Dysfunction

Observation of buckling, shearing, torsion, translation, or exaggeration of type I rotoscoliosis and increases in thoracolumbar kypholordosis should be noted (Fig. 10.8).

Sharp, acute apexes may indicate areas of focal hypermobility/instability and warrant further inves-

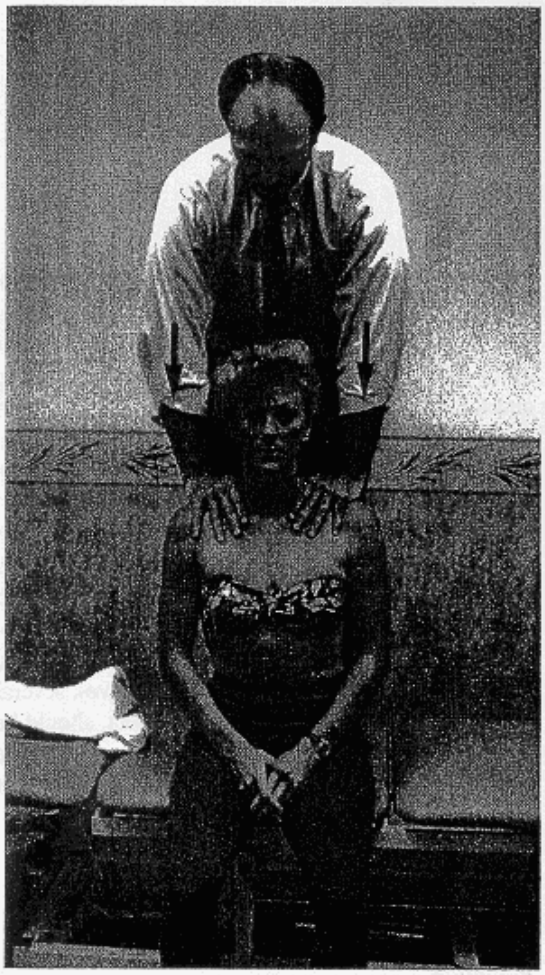

Figure 10.7. Vertical compression testing in the seated posture.

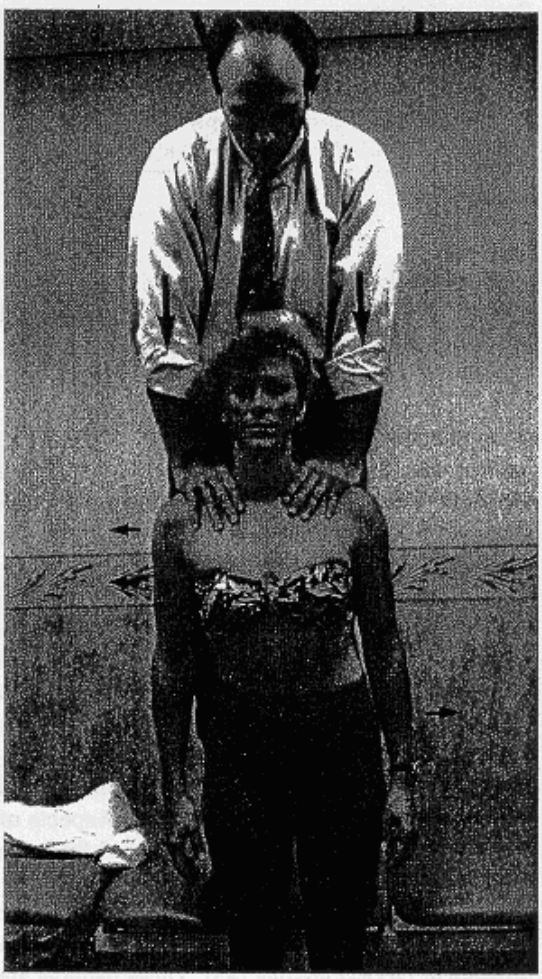

Figure 10.8. Vertical compression testing with shearing to the right secondary to the presence of a type I neutral dysfunction.

tigation (e.g., passive intevertebral motion testing [PIVMT], spring/translational testing and radiologic motion testing). These areas may also be related to type II non-neutral FRS/ERS vertebral dysfunctions and are frequently accompanied by tissue texture abnormalities (including increased muscle tone and decreased muscle play). Finally, these areas may occur at transitional zones in the vertebral column (i.e., cervicothoracic, thoracolumbar, and lumbosacral junctions) or at a rotoscoliotic curve. Left untreated, these areas may become sites of aberrant static and dynamic postural mechanics, resulting in neuromuscular imbalances with altered patterns of functional movement and, ultimately, focal areas of degenerative articular changes.

Although the emphasis of this diagnostic test is objective observation, the patient should also be encouraged to provide subjective feedback regarding symptoms during the procedure. Patients with a history of being "load sensitive" should be evaluated with caution, as this test may be provocational to them.

Physiologic Movement Testing

Dynamic postures used in assessing active range-of-motion (AROM)/combined movement testing include physiologic AROM of the thoracic spine in all planes (i.e., flexion, extension, side-bending, and rotation), AROM of the upper extremities, and respi-

Table 10.13. Observations During Active/Passive, Physiologic Motion Testing, and Functional Movement Patterns (FMP)

Excursion of movement
Quality of movement
Barriers to movement
Coordination of movement
Freedom of movement (both articular and soft tissue)
Substitutions to normal movement patterns
Subjective complaints before, during, and following

Table 10.14. Functional Movement Patterns (FMPs)

Pelvic clock
Unilateral hip rotation in various positions
Quadruped (arch/sag)
Unilateral lower extremity extension in prone
Lower trunk rotation in prone
Diagonal breathing
Sidelying arm circles

ratory patterns of breathing. Combined movement patterns are also performed and include lateral glide/translatory shear and quadrant patterns (i.e., combined flexion, side-bending, and concurrent rotation to the same side followed by extension, side-bending, and concurrent rotation to the same side). Assessment should include observation of both arthrokinematic and myokinematic function throughout each particular movement and should focus on several components (Table 10.13).

Functional movement patterns (FMPs) are defined as any functional motion that may be used to evaluate function, functional capacity, integration of movement segments, differentiation of individual segments, and sequencing of motion including both passive and active ranges of motion [4, 30]. In addition, motor recruitment and neuromuscular control can be assessed throughout the FMP. Aspects of these evaluative movements are derived from the proprioceptive neuromuscular facilitation (PNF) diagonal movement patterns [38, 82] and from the work of Feldenkrais and his Awareness Through Movement (ATM) lessons [83]. These patterns are applicable to both the spine and extremities and are listed in Table 10.14.

Once dysfunctions are identified, treatment is administered during the performance of a portion of or throughout the entire FMP. An example of an FMP, sidelying arm circle, is a pattern that is appropriate for both patients with a cervicothoracic upper quarter dysfunction, and patients with a lumbopelvic lower quarter dysfunction. This pattern is accomplished as follows:

With the patient in the sidelying position, the trunk is stabilized by the inferior hand holding the superior leg while movement occurs through the superior arm scribing the widest circle possible around the axis of the shoulder. In the efficient state, the hand maintains contact with the floor throughout the full arc of motion. This occurs through the orchestrated movement of the shoulder, shoulder girdle, rib cage, and thoracic and lumbar spine. In the presence of restrictions in any of the articulations or soft tissues of this region, hand contact to the floor will be altered, as will the synchronous motion throughout the arc. The practitioner should observe and palpate for specific motion and dysfunctional tissue barriers. Treatment is begun while the patient performs the FMP, moving in and out of the restricted range while soft-tissue mobilization is concurrently performed. During physiologic movement patterns (both passive and active), several variables, including response to treatment, should be observed while concurrently palpating the respective tissues for additional points of restriction and aberrant motion (Fig. 10.9).

Skin Assessment

Palpation

Whereas the observational evaluation is used to identify myofascial structures that may be dysfunctional and contributing to symptomatology, manual palpation is the primary modality used to assess the condition of the myofascial tissues. Developing and refining one's skill in palpation is paramount in both the successful evaluation and the treatment of somatic dysfunction. Specific distinctions of myofascial dysfunction are identified most commonly via digital compression, shear, and specifically appropriated tension on soft tissues. Firm yet gentle pressure should be directed with a specific tissue depth in mind and with a three-dimensional perspective.

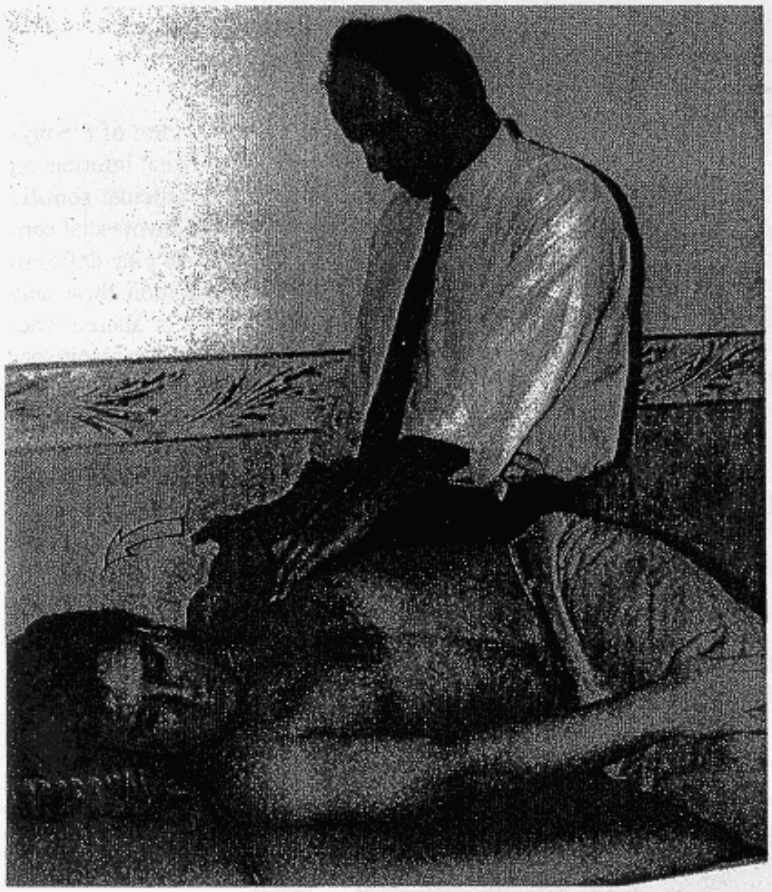

Figure 10.9. Functional movement pattern—arm circles. Performed in a right sidelying position with the inferior arm supporting the superior knee while the superior arm and shoulder are evaluated in a 360-degree circular motion. Myofascial structures are palpated during the entire pattern.

Subtle alterations in tone, excursion, end-feel, fibrous content, contours, reactivity, elasticity, recoil, and response to active contraction and passive lengthening should be assessed. Although emphasis should be placed on objective variables, the patient's subjective response to palpation may also provide insight into biomechanical dysfunction and the relative level of reactivity. Numerous contacts may be used during palpation and include the finger tips, finger pads, thumb, open palm, knuckles, heel of hand, elbow, and forearm. Specifically, the evaluation of myofascial somatic dysfunction of the thoracic spine and rib cage should include careful attention to the components listed in Table 10.15. These elements must be evaluated in both static and dynamic postures (including physiologic, combined movement, and functional movement patterns) and correlated with associated articular dysfunction.

Table 10.15. Elements of Emphasis During Myofascial Examination

Skin mobility
Superficial/deep fascia
Bony contours
Muscle play (accessory mobility)
Muscle tone (hypertonicity/trigger points)
Muscle length/functional excursion
Functional strength/neuromuscular responsiveness

Evaluation of the myofascial tissues should logically begin with the most superficial tissues and progress inward toward deeper layers. The most superficial tissues include the outer epidermis of ectodermal origin and the deeper dermis of mesodermal origin [8]. The superficial epidermis, the dermis, and the superficial fascia are continuous with the deeper fascia and underlying structures via direct attachment to the basement membrane [47]. Arbitrary compartmentalization of the fascia has been pro-

Table 10.16. Fascial Layers

Dermis/epidermis
Superficial fascial layer
Potential space (between superficial and deep fascial layers)
Deep fascial layer
Subserrous fascia (over body cavities)

Source: Adapted from RF Becker. The Meaning of Fascia and Fascial Continuity. New York: Insight Publishing, 1975.

posed based on anatomic disposition and function [84] and is provided in Table 10.16. The recognition of these layers may assist the practitioner in appreciating the various and varying depths of restrictions during both the evaluation and treatment of MFD.

The skin and superficial tissues of the thorax are assessed with a combination of open palmar and digital contacts (Figs. 10.10 and 10.11) for:

1. Soft-tissue contours, symmetry, bulk, draping, and proportions.
2. Skin condition.
3. Skin mobility, excursion, and recoil.
4. Superficial and deep fascia.
5. Scar tissue mobility, extensibility, and adherence to underlying and surrounding structures.

Contact

Soft-Tissue Contours, Symmetry, Bulk, Draping, Proportions

Visual as well as palpatory evaluation of the myofascial structures will often yield vital information regarding the underlying bony or articular somatic dysfunction. Puckered or adherent myofascial contours commonly accompany muscle play deficiencies and tonal abnormalities. In addition, these may correlate with areas of diminished or altered function such as in the case of long-standing respiratory rib cage dysfunction. This is particularly true of the "key rib" (see Chapter 8). Changes in symmetry, bulk, and proportions frequently occur concurrently with tonal or strength deficiencies and may also reveal chronic, compensatory patterns of movement or function. Observation of how myofascial tissue drapes over its underlying osseous and articular structures may also yield information regarding its relative viability and movement potential in addition to the functional capacity of the immediate associated articular structures.

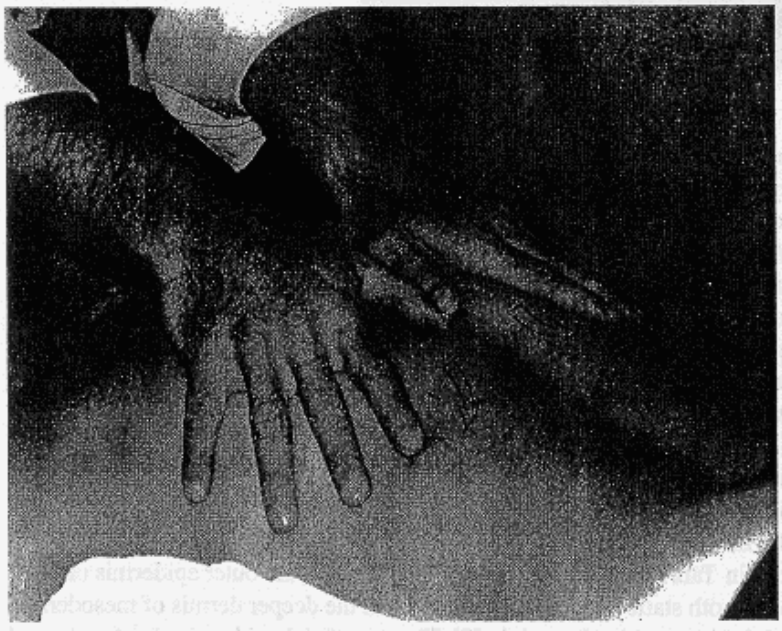

Figure 10.10. Open palmar contact for evaluation of superficial tissues.

Skin Condition

Light palpation of the skin and superficial fascia will reveal much regarding the health and vitality of the tissues being assessed. Tissues should be palpated for their relative dryness, moistness, warmth, coolness, or flaking. Textural abnormalities such as dry, shiny, smooth, or flaking skin will often accompany chronic conditions such as psoriasis, seborrhea, and scleroderma. Elevated skin temperatures with commensurate increases in skin moisture may indicate an active inflammatory process, whereas cool skin temperatures may accompany chronic tissue or articular dysfunction.

Skin blemishes, rashes, moles, and nodules should also be identified. Particular scrutiny should ensue if these alterations are of recent onset, are progressive in nature, or demonstrate adhesions to underlying structures. Subcutaneous nodules or fatty lipomas are common; however, they should be monitored for their role in creating aberrant myofascial kinematics.

Skin Mobility, Excursion, and Recoil

With the patient positioned in the prone and supine positions on an imaginary clock face (i.e., 12 o'clock cranially, 6 o'clock caudally), objective criteria for defining directions of fascial dysfunction are provided. Beginning with a light, open palmar contact, with the hands placed on either side of the vertebral column, tissues are evaluated in a multidirectional fashion with side-to-side comparison. This process is continued in a cranial-to-caudal direction from the cervicothoracic junction to the thoracolumbar junction. Note that complete assessment of the thorax should always include inspection of the craniovertebral and upper/lower quarter regions as well; however, this will not be elaborated on in this chapter.

Tissue excursion, end-feel, and recoil of myofascial tissues after digital deformation should be evaluated. Firm, hard, arresting end-feels with diminished recoil often accompany collagenous restrictions with associated alteration in nonfibrous elements (i.e., glycosaminoglycan depletion, dehydration, and resulting thixotropy). These tissue characteristics are consistent with those categorized as contracture and/or cohesion-congestion (see Table 10.3).

A variety of techniques are used to assess changes in the dermis, epidermis, and superficial tissues, including general skin sliding/shearing, finger gliding, and specific-point skin sliding [29] (Figs. 10.12, 10.13, and 10.14). These three techniques allow the examiner to:

1. Identify a "general region" of fascial dysfunction (i.e., left upper posterior quadrant versus right) with general skin sliding/shearing.

Figure 10.11. Digital contact for evaluation of superficial tissues.

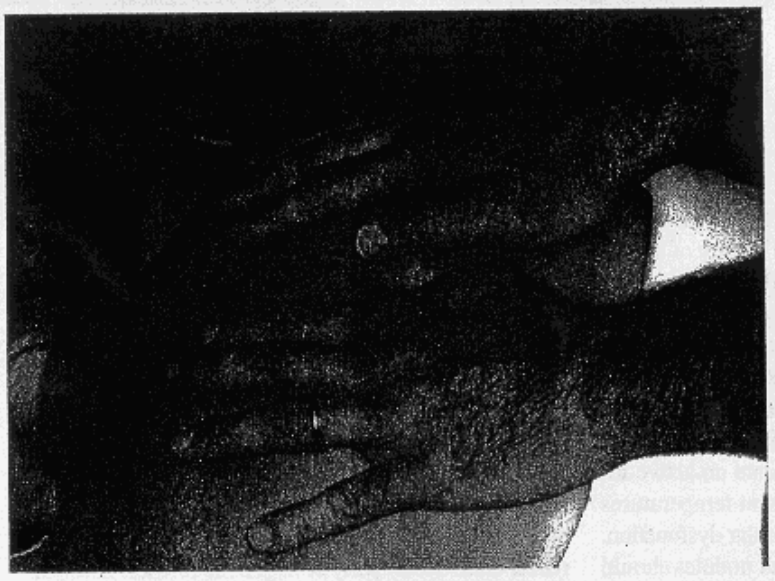

Figure 10.12. General skin slide. Used to localize a "general region," or quadrant, of myofascial dysfunction.

Figure 10.13. Finger glide. Used to localize a "specific site," or epicenter, of myofascial dysfunction.

2. Identify a specific spot or "epicenter" of the restriction within that region with finger gliding.
3. Identify a specific direction of fascial restriction within the restrictive barrier with specific skin sliding.

Superficial and Deep Fascia

Distinguishing between superficial and deep fascial restrictions is vital in establishing and directing appropriate treatment. This is accomplished through a combination of palpatory finesse, angle of inclination of the palpating contact, and varying pressures. Palpatory experience and the skill and tacit information derived through repetition cannot be replaced with even the most eloquent of technical explanations. Determining the existence of myofascial barriers, their direction of restriction, and their exact location in the fascial planes requires much practice. The identification of "depth" is achieved via the angle of inclination the palpating digit or contact as-

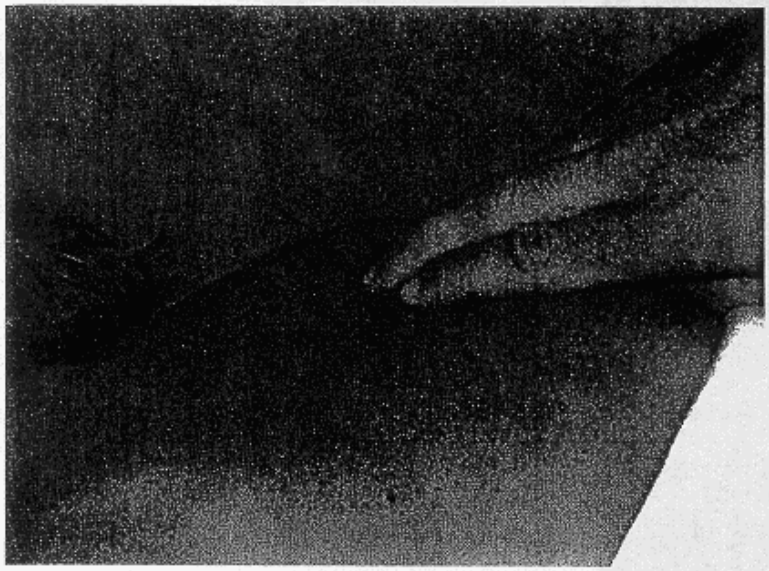

Figure 10.14. Specific skin slide. Used to localize and determine the specific depth and direction of a myofascial dysfunction.

sumes. The more horizontal the contact, the more superficial the tissue being palpated. Shearing tissues in this fashion most often identifies restrictions in the dermis and epidermis. Changing the angle of inclination to a more vertical orientation will allow for greater depth (Figs. 10.15 and 10.16).

In addition, gradually increasing the force used in palpation will provide greater depth. This option, however, should be used last, especially by a novice or inexperienced practitioner. Perceiving that additional force will provide greater proprioceptive feedback is one of the most frequent mistakes in manual medicine. Firm yet gentle compression/palpation will in fact yield the most information and give the least extraneous feedback. Force is, however, an option for depth, and is used to reach deeper fascial structures such as those existing between the septae of the muscle bellies.

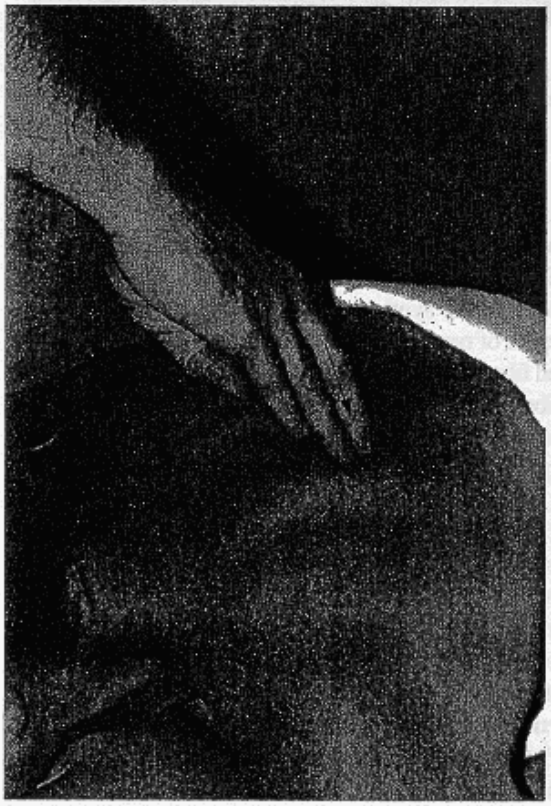

Figure 10.15. Vertical angle of inclination of the mobilizing hand to achieve greater tissue depth and treat deeper structures.

Scar Tissue

Scar tissue formation results from major or minor trauma to tissues with similar histologic consequences, albeit differing in severity. Macrotrauma to myofascial tissues may include surgical incisions, traumatic lacerations, and punctures as well as intrinsic muscle and fascial tears. Microtrauma includes repetitive myofascial strain patterns and habituated postures with aberrant function. In both cases an inflammatory process or

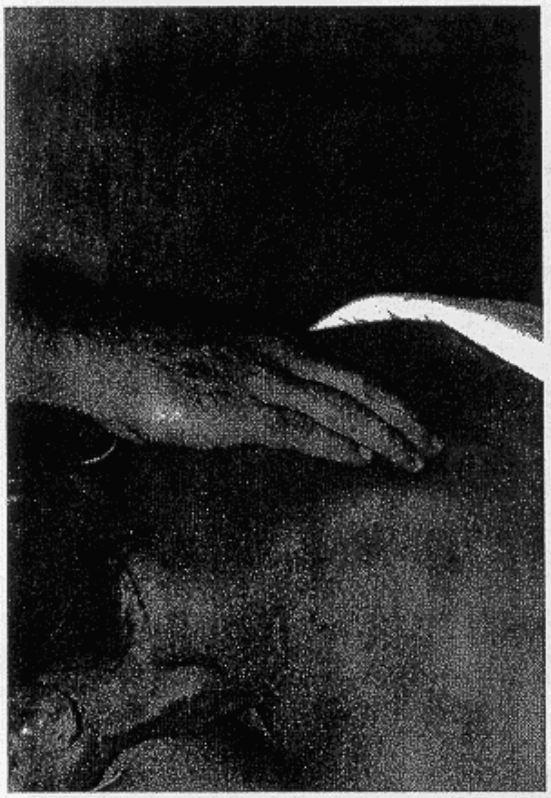

Figure 10.16. Horizontal angle of inclination of the mobilizing hand to achieve access to more superficial tissues.

phase, usually lasting 1–6 days, is followed by a postinflammatory, fibroblastic phase lasting 6–21 days [5, 63, 85]. It is during this fibroblastic phase that a proliferation of newly synthesized collagen fibers occurs with a degree of randomness. "Crosslinking" of normal collagen fibers may occur, dramatically reducing the normal "fiber glide" and therefore the mobility of the implicated tissues. Hollingshead [50] remarked that aberrance of myofascial mobility secondary to scar tissue formation ". . . may be a major factor in altering the biomechanics of the whole kinetic chain, placing strain on all related structures." This strain or altered biomechanics can have profound effects on the subtle arthrokinematics of the rib cage and thoracic vertebra and may be implicated in the primary motion restriction present in respiratory/structural lesions and type II non-neutral and type I neutral vertebral lesions. In addition, abnormal patterns of stress caused by adherent and inextensible scar tissue may contribute to chronic inflammatory disorders and perpetuate symptomatology [62–64]. Remodeling of these newly synthesized fibers in an organized, mobile framework is critical to regaining extensibility and dynamic function at the associated motion segments as well as the entire kinetic chain.

Scar tissue is assessed by appreciating and observing:

1. Stage of healing/reactivity.
2. Intrinsic mobility of the scar (in all planes).
3. Dissociation from adjacent and underlying structures.
4. Influence of scar tissue on osteokinematic motion patterns of related articular segments.

As with skin mobility, assessment is accomplished by shearing tissues in multiplanar directions to determine barriers to movement, directions of those barriers, and quality of end-feel.

Assessment of Bony Contours

The assessment of myofascial tissues as they insert and anchor into the periosteum of the spine and extremities provides information regarding the deepest myofascial structures. The significance of these structures has been noted, since a "great deal of spinal pain may well be felt where muscle, tendon, ligament and capsule are attached to sensitive periosteum of the spine" [86].

Bony contours are evaluated via digital palpation, which proceeds along the osseous structure in a parallel or longitudinal manner. Restrictive barriers, increased tone, and adhesions between adjoining structures are noted as attention is given to the depth and direction of the tissue barrier evaluated. As with superficial tissues, increased depth is accomplished by increasing the angle of vertical inclination of the palpating digit or by increasing force. Table 10.17 identifies the key bony contours that should be evaluated in the thoracic spine and rib cage.

The assessment of bony contours also provides vital information regarding the positional dysfunction of those osseous structures. Aberrance of myofascial tissue and the related position of associated osseous structures should be correlated with motion testing (see CHARTS Method of Evaluation). This is particularly applicable in the rib cage, where structural rib dysfunction will most commonly appear with positional alterations as well as accompa-

Table 10.17. Assessment of Bony Contours

I. Supine
  A. Sternum
    1. Manubrium
    2. Body
    3. Xiphoid
    4. Sternoclavicular joints
    5. Sternorib joints
    6. Costochondral joints
    7. Anterior ribs 1–12
  B. Clavicle
    1. Superior, inferior, anterior
II. Sidelying
  A. Scapula/lateral aspect
  B. Humerus
  C. Lateral ribs
  D. Iliac crest
III. Prone
  A. Vertebral column
    1. Spinous process
    2. Posterior arch
    3. Transverse process
  B. Posterior ribs
  C. Scapula/posteromedial aspect

nying myofascial dysfunction or tissue texture abnormalities. Bony contour, myofascial abnormalities in this region commonly include the intercostal muscles circumferentially, the thoracic fibers of the iliocostalis lumborum muscle posteriorly (especially at its insertion into the rib angle) [53], and the soft-tissue attachments at the posterior costotransverse and the anterior sternocostal articulations of a dysfunctional rib or ribs (Fig. 10.17).

Laterally, the attachment of the latissimus dorsi and serratus anterior muscles become common sites of bony contour abnormalities, especially in the presence of respiratory exhalation dysfunctions. This is particularly common on the superior surface of the key rib (see Chapter 8) or with chronic laterally elevated lesions. Anteriorly, the sternum, sternal manubrial, and costochondral junctions should be carefully assessed (Fig. 10.18).

Other common areas of bony contour abnormalities include the inferior border of the clavicle (with structural or respiratory dysfunction of the first rib), the inferior border of the costochondral arch (with

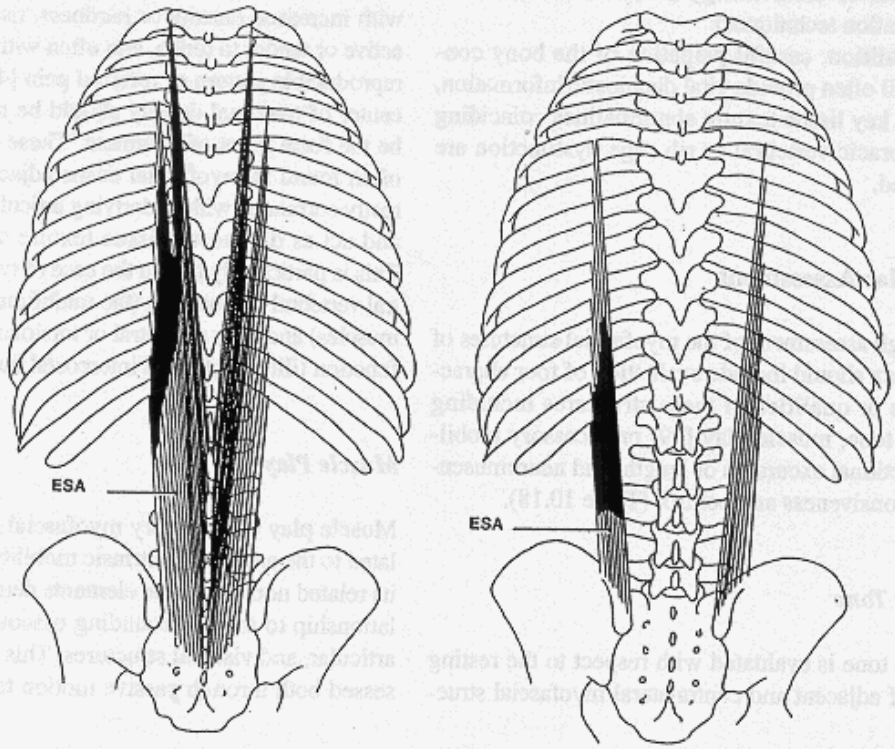

Figure 10.17. Attachment of the iliocostalis lumborum muscles to the rib angle. (ESA = erector spinae aponeurosis.) (Reprinted with permission from N Bogduk, LT Twomey. Clinical Anatomy of the Lumbar Spine. New York: Churchill Livingstone, 1987.)

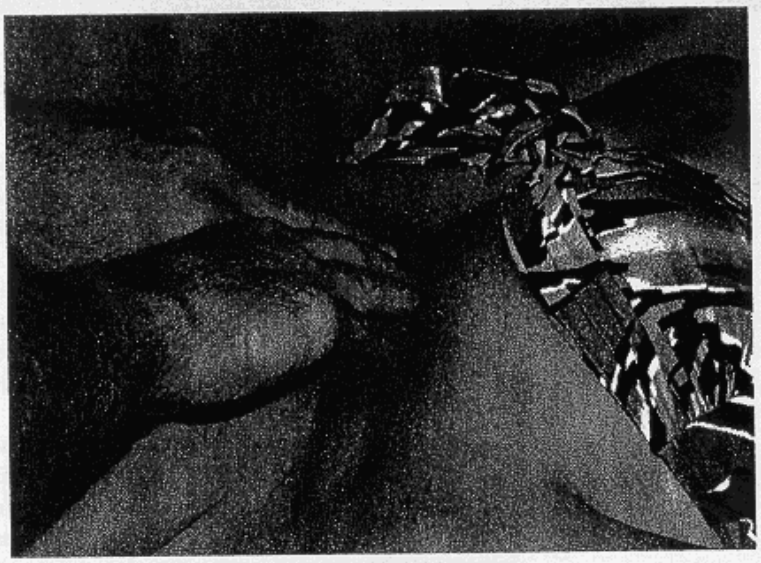

Figure 10.18. Bony contour assessment of the sternomanubrial junction.

respiratory inhalation dysfunction), and the existing groove formed between the spinous and transverse processes (i.e., the posterior arch/lamina of the thoracic spine) in the presence of type II, non-neutral vertebral dysfunction. Left untreated, this myofascial dysfunction may contribute to nonresponsive rib cage and/or vertebral dysfunction, especially when treated with an approach relying predominantly on an articulation-driven methodology (i.e., joint mobilization, manipulation techniques).

In addition, careful palpation of the bony contours will often provide vital diagnostic information, because key tissue texture abnormalities coinciding with thoracic vertebral or rib cage dysfunction are identified.

Muscular Assessment

Thorough assessment of the myofascial structures of the thorax should include evaluation of four characteristics or qualities of these structures including muscle tone, muscle play [29] or accessory mobility, functional excursion or length, and neuromuscular responsiveness and control (Table 10.18).

Table 10.18. Muscle Assessment

Muscle tone
Muscle play/accessory mobility
Muscle length/functional excursion
Neuromuscular responsiveness and control

Muscle Tone

Muscle tone is evaluated with respect to the resting tonus of adjacent and contralateral myofascial structures. Aberrance of muscle tone typically presents with increased density or hardness, tissue that is reactive or tender to touch, and often with a typical and reproducible pattern of referred pain [4, 14]. An epicenter of maximal density should be noted and will be the focal point of treatment. These epicenters are often found in myofascial tissue adjacent to and directly correlated with underlying articular dysfunction and act as diagnostic tissue texture abnormalities. This is particularly true in the case of type II non-neutral vertebral dysfunction (the multifidus and rotatores muscles) and with structural or torsional rib cage dysfunction (iliocostalis and intercostal muscles).

Muscle Play

Muscle play or accessory myofascial mobility is related to the amount of intrinsic mobility a muscle and its related noncontractile elements demonstrate in relationship to their surrounding osseous, myofascial, articular, and visceral structures. This mobility is assessed both through passive motion testing and dur-

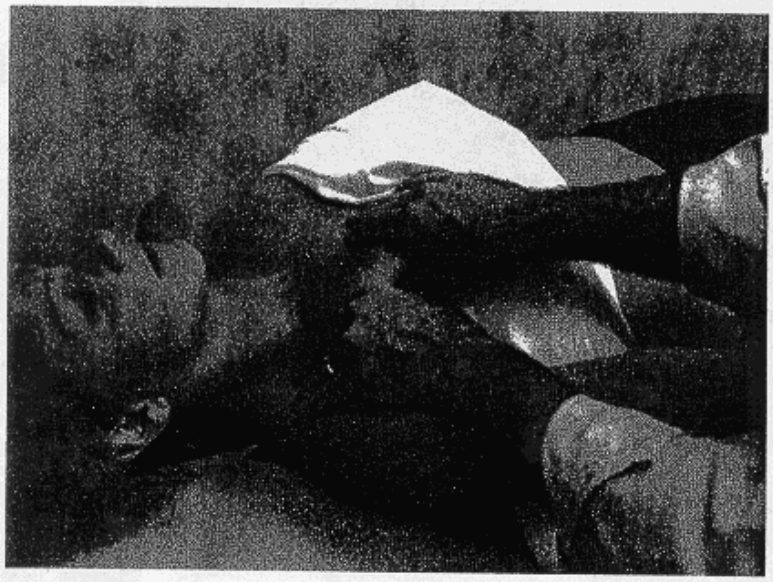

Figure 10.19. Perpendicular deformation of the pectoralis minor muscle with bilateral thumb contact to evaluate medial-lateral, lateral-medial muscle play.

ing functional movement patterns of excursion or lengthening, as well as during the shortening and broadening of fibers associated with muscle contraction. Passive motion testing is accomplished through perpendicularly directed forces (thumbs or tips of digits) described as a perpendicular/transverse deformation, and through "strumming techniques," which assess mobility in two planes [29] (Fig. 10.19).

The ability to shear muscles freely from their adjacent and underlying structures, as well as the ability to move in an uninterrupted fashion through the septae of muscle groups, is evaluated with these techniques. Specific sites, depths, directions, and degrees of restrictions should also be noted. In addition, related thoracic and costal segments and their mobility should be considered, because muscle play restrictions frequently accompany and precipitate somatic dysfunction in these regions. This is commonly seen in the rib cage between the pectoralis major, the pectoralis minor, and underlying costal segments 3, 4, and 5. Aberrant muscle play between the pectoralis major and minor muscles, or between the deeper pectoralis minor muscle and the rib cage, creates abnormal tension in the costal segments and commonly provides an environment for respiratory rib cage dysfunction. Other specific key muscle groups of the thorax that require careful assessment for muscle play abnormalities are provided in Table 10.19.

Table 10.19. Muscle of Emphasis in Muscle Play Assessment of the Thorax: Muscle Play/Accessory Mobility

Spinalis/longissimus/iliocostalis
Pectoralis major/minor complex
Rotator cuff muscles
Serratus anterior/posterior (superior/inferior)
Latissimus dorsi
Trapezius/levator scapulae
Intercostals
Respiratory diaphragm
Quadratus lumborum
Abdominals
Psoas major/minor

Functional Excursion

Functional excursion is the ability of an individual muscle to lengthen as it concomitantly narrows, as well as its ability to broaden as it simultaneously shortens. The importance of balance and symmetry with respect to excursion and length of agonist and antagonist muscle groups has been clearly identified in patients suffering from low back pain [87–89]. Tightness or diminished functional excursion in paired muscle groups (i.e., bilateral hip flexors, hamstrings, paraspinal muscle groups) are viewed as potentially contributory to aberrant static posture and