4 Examination of Range of Motion Scapulothoracic, Acromioclavicular, and Scapulothoracic Joints

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4.1 Scapulothoracic Joints

Keeping in mind that the shoulder is a ring of a very complex kinetic chain, it is evident that it is important to assess a patient's posture and core stability so as to tailor the right sequence of goals to be obtained over the course of functional shoulder movement.

As Kibler explains [1, 2], the various body segments play specific roles in the kinetic chain activation sequence. The muscles, the joints of the hips, pelvis, and spine ("the core") are centrally located and can perform many of the dynamic stabilizing functions that the body requires if the distal segments are to perform their specific tasks. Thus "core stability" provides proximal stability for distal limb mobility and function.

When assessing core stability and strength, it is important to evaluate the muscles working in an eccentric, load-absorbing function, the body segments in a closed-chain situation, and the resultant movements in the three planes of trunk motion. In the standing balance test, the patient is asked to stand on one leg and is given no further verbal cue. A positive test result, known as the Trendelenburg sign, is when the hip drops on the unsupported side. This indicates inability to control the posture and suggests proximal core weakness.

The scapula is anatomically and biomechanically intimately involved with shoulder function.

A primary role of the scapula is that it is integral to the glenohumeral articulation, which kinematically is a ball-and-socket configuration.

The second role of the scapula is to provide motion along the thoracic wall, retract (externally rotate) and laterally protract (internally rotate) around the thoracic cage, to maintain a normal position in relation to the humerus.

The third role that the scapula plays in shoulder function is elevation of the acromion, to clear the acromion from the moving rotator cuff to decrease impingement and coracoacromial arch compression [3, 4].

Although rotator cuff fatigue may cause superior humeral head migration to trigger subacromial impingement in this position [5], lower

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trapezius and serratus anterior muscle fatigue also may contribute to impingement by decreasing acromial elevation [6].

Finally, the scapula is a link in proximal-to-distal sequencing of velocity, energy, and forces of shoulder function [5, 7, 8].

For most activities, sequencing begins at the ground, and individual body segments (links) are coordinated by muscle activation and body position to generate, summate, and transfer force through these segments to the terminal link. This sequence is termed the kinetic chain [5, 7, 9].

The scapula has to be considered pivotal in transferring large forces and high energy from the legs, back, and trunk to the delivery point, the arm, and the hand [7, 10], thereby allowing more force to be generated in activities such as throwing than could be done by the arm musculature alone. The scapula, serving as a link, also stabilizes the arm to more effectively absorb loads that may be generated through the long lever of the extended or elevated arm [11].

When, for different reasons, there is a breakage of the "kinetic chain," a clinical picture termed scapular dyskinesis can subjectively and objectively be described.

Scapular dyskinesis [12] is defined as observable alterations in the position of the scapula and the patterns of scapular motion in relation to the thoracic cage.

More commonly, the scapular stabilizing muscles (1) are directly injured from direct-blow trauma; (2) have microtrauma-induced strain in the muscles leading to muscle weakness; (3) become fatigued from repetitive tensile use; or (4) are inhibited by painful conditions around the shoulder. Muscle inhibition or weakness is quite common in glenohumeral pathology, whether from instability, labral pathology, or arthrosis [5, 6, 13, 14].

The serratus anterior and the lower trapezius muscles are the most susceptible to the effect of the inhibition, and they are more frequently involved in early phases of shoulder pathology [6, 15, 16].

Scapular evaluation, as previously described, includes distant contributions to normal scapular function and dyskinesis.

The evaluation of the scapula itself should be done mainly from the posterior aspect.

Abnormalities of winging, elevation, or rotation may first be examined in the resting position.

Pure serratus anterior muscle weakness resulting from nerve palsy will create a prominent superior medial border and depressed acromion, whereas pure trapezius muscle weakness resulting from nerve palsy will create a protracted inferior border and elevated acromion [17].

Motion and position should be examined in both the elevating and lowering phases of motion. Muscle weakness and mild scapular dyskinesis are more common in the lowering phase of arm movement.

An effective test for evaluating scapular muscle strength is an isometric pinch of the scapulas in retraction. Scapular muscle weakness may be present as a burning pain in less than 15 s, whereas the scapula normally may be held in this position for 15–20 s without burning pain or muscle weakness. Wall push-ups are effective for evaluating serratus anterior muscle strength.

The scapular assistance test evaluates scapular and acromial involvement in subacromial impingement.

In a patient with impingement symptoms with forward elevation or abduction, assistance for scapular elevation is provided by manually stabilizing the scapula and rotating the inferior border of the scapula as the arm moves. This procedure simulates the force-couple activity of the serratus anterior and lower trapezius muscles. Elimination or modification of the impingement symptoms indicates that these muscles should be a major focus in rehabilitation.

The scapular retraction test involves manually stabilizing the scapula in a retracted position on the thorax. This position confers a stable base of origin for the rotator cuff and often will improve tested rotator cuff strength. (That is, the apparent strength generated by isolated rotator cuff strength testing often improves by retesting in the scapula-retracted position.) The scapular retraction test also frequently demonstrates scapular and glenoid involvement in internal impingement lesions [18]. The positive posterior labral findings on modified Jobe relocation testing will be decreased with scapular retraction and removal of the glenoid from the excessively protracted impingement position.

4.2 Specific Strength Test for Scapulothoracic Muscles

4.2.1 Serratus Anterior

This muscle abducts the scapula, rotates the inferior angle laterally and the glenoid cavity cranially, and holds the medial border of the scapula firmly against the rib cage.

The patient is in a supine position: Abduction of the scapula, projecting the upper extremity anteriorly (upward from the table). *Movement of the scapula must be observed and the inferior angle palpated to ensure that the scapula is abducting*.

The examiner should press against the subject's fist, transmitting the pressure downward through the extremity to the scapula in the direction of the adducting scapula.

When the serratus is weak, the scapula tilts forward at the coracoid process and the inferior angle moves posteriorly and in the direction of the medial rotation. Because some type of substitution can occur, we advise you to perform the test in the sitting position. In this position, the test emphasizes the upward rotation action of the serratus in the abducted position.

4.2.2 Lower Trapezius Test

The muscle with upper and middle fibers adducts the scapula, especially with the medial fibers. It rotates the scapula so the glenoid cavity faces cranially; there is also the pressure of the scapula.

To test the lower trapezius the patient is prone, the arm is placed diagonally overhead, in line with lower fibers of the trapezius, the examiner presses the forearm in a downward direction toward the table. When the muscle is weak, the scapula rides upward and tilts forward with depression of the coracoid process.

4.2.3 Latissimus Dorsi

This muscle medially rotates, adducts, and extends the shoulder joint. The patient is prone in adduction and extension in medially rotated position, the examiner presses the forearm in the direction of abduction and slight flexion of the arm. Weakness interferes with activities that involve the adduction of the arm toward the body or of the body toward the arm.

4.2.4 Rhomboid Test

This muscle adducts and elevates the scapula and rotates it so the glenoid cavity faces caudally. The patient is prone, the position of the scapula is obtained by placing the shoulder in 90° abduction and in medial rotation to move the scapula into the test position. The examiner presses against the forearm in the downward direction toward the table. With the patient in the same position, but the arm in lateral rotation it is possible to test the middle fibers of the trapezius.

4.3 Acromioclavicular Joint

The accurate and complete exam of the acromioclavicular (AC) joint is based on in depth understanding of the functional anatomy of the AC joint. Static descriptions of the AC joint anatomy fail to provide the context for the most effective understanding of AC joint injuries. This requires a more functional description, relating the anatomy to how it facilitates, guides, and optimizes the three-dimensional mechanics of the clavicle, scapula, AC joint, and arm to create motions and forces to accomplish tasks.

Efficient upper limb mechanics requires coupled motions of the clavicle and acromion, with the AC joint acting as a stable articulation. The S-shaped clavicle acts as a (1) strut, maintaining length and stiffness [19, 20]; (2) crank handle, allowing large amounts of distal rotational arcs of motion for short amounts of proximal rotation [21–23]; and (3) the only bony attachment to the axial skeleton. The clavicle has minimal muscular attachments with so much of the clavicular long axis rotation, anterior/posterior motion, and elevation/depression occurring through the influence of scapular motion.

The AC joint is a relatively stiff structure, with strong posterior, superior, and anterior ligament components that are thicker on their acromial insertions than their clavicular insertions. Individual AC joint motions average 5° of acromial elevation and 8° of acromial rotation [24, 25]. A three-dimensional kinematic analysis of the AC joint demonstrated that the scapula rotated 35° on an axis (termed the "screw axis") that passed through the insertions of the AC and coracoclavicular (CC) ligaments, and that with abduction, the lateral clavicle translated 3.5 mm in the anterior/posterior direction and 1 mm in the superior direction [26]. This stiffness creates a strong link that allows rotational and elevation motions produced by the scapula or clavicle to be efficiently transmitted to the other bone of the articulation [27, 28]. Interruptions of the normal integrity of the AC and CC ligaments change the normal linkage between the scapula and the clavicle and can result in dyskinetic motion patterns during limb movement. In addition, indirect AC joint stability and stiffness is maintained by the CC ligaments.

In summary, intact AC joint anatomy is the basis for optimal arm and shoulder mechanics. It creates the most efficient screw axis and allows efficient scapulohumeral rhythm (SHR), the coupled sequenced motion of the scapula and humerus in all phases of arm motion.

Pathology involving the AC joint will create altered motions at the joint and in the surrounding structures and will affect the roles the AC joint plays in maintaining efficient SHR. The physical exam should be organized to identify the altered motions and functions. It should be able to identify not only the pathoanatomy (injury to the bones, ligaments, and joint) but also the effect of the pathoanatomy on the normal mechanics, creating pathomechanics.

The exam comprises visualization, palpation, provocative maneuvers, observation of motion, and corrective maneuvers that may alter the clinical symptoms. Table 4.1 summarizes the possible clinical and examination findings that may be seen.

Visualization should be accomplished by direct evaluation of the symptomatic joint and comparison, if possible, to the asymptomatic contralateral joint. The most common visualized alterations may include: (1) prominence of the distal clavicle due to a superior bone spur from arthritis; (2) an apparent superior position relative to the inferiorly and medially displaced acromion in low-grade or high-grade AC separations (Fig. 4.1); or (3) altered posture of the scapula and arm into protraction due to muscle weakness or imbalance. Any swelling or bruising, which

Table 4.1 Typical exam findings for acromioclavicular joint pathology

Pathology	Inspection	Palpation	Provocative maneuver	Observation	Corrective maneuver
Arthritis	Bone spur	Pain	(+)active compression (+)cross body adduction	Decreased arm motion, pain during flexion	(−)
Excessive distal clavicle excision	Joint deficit	Pain, bony deficit	(+)cross body adduction (+)anterior/posterior laxity	Pain to motion	Decreased with SRT
Low-grade AC separation	Clavicle prominence	Pain	(+)anterior/posterior laxity	Scapular protraction	Decreased with SRT
High-grade AC separation	Clavicle prominence	Pain	(+)anterior/posterior and inferior/superior laxity	Scapular protraction, decreased arm elevation	Decreased with SRT and joint reduction
Distal clavicle fracture	Swelling	Pain over bone	(+)cross body adduction	Decreased arm motion	(−)

(+) = positive; (−) = negative; AC = acromioclavicular; SRT = scapular retraction tests could indicate localized trauma, should be noted. Frequently, there will be minimal visual alterations.

Palpation often reveals the location of the symptomatic pathology. The clavicle should be palpated along its entire length from the sternoclavicular joint to the AC joint. Point tenderness along the bone, especially near the AC joint, will suggest bony injury. The acromion and its extension into the scapular spine as well as the coracoid process and CC ligament area can also be palpated. Finally, direct palpation of the AC joint, making sure that the palpation pressure is localized to the joint and not to the bone, can elicit pain that can confirm the joint is the actual source of some or all of the clinical symptoms. Palpating the AC joint directly can also be helpful in identifying clinically important AC joint pathology that may be associated with other shoulder pathology such as rotator cuff disease or impingement and will need to be addressed as part of the comprehensive treatment.

Fig. 4.1 Example of lost integrity of AC joint giving visual appearance of inferiorly position acromion relative to clavicle

Provocative maneuvers may be utilized to reproduce the clinical symptoms and provide information about the anatomic structures that may be involved. The clavicle and acromion may be grasped and mobilized (this maneuver is sometimes labeled the AC shear test [29, 30]) in several directions to load, unload, and shift the loads, and to place stress on the ligaments. Anterior/posterior testing assesses the integrity of the AC ligaments while inferior/superior testing assesses the integrity of the CC ligaments [19, 31]. Compression of the acromion into the clavicle may simulate load bearing and increase or reproduce the pain of an arthritic joint. Several types of horizontal adduction maneuvers of the arm in relation to the body have been described and advocated to produce the position of impingement of the acromion on the clavicle that occurs with increased motion of the arthritic (active compression test), slightly lax joint (cross body adduction test) or with compression against bone spurs (Paxinos test) [32–35] (Figs. 4.2, 4.3, and 4.4). These involve manual or active motion of the extended arm across the body, with a positive test being localized pain and/or crepitus at the joint and reproduction of the clinical symptoms. Ligamentous injury and resulting laxity can be identified by maneuvers that assess joint transla-

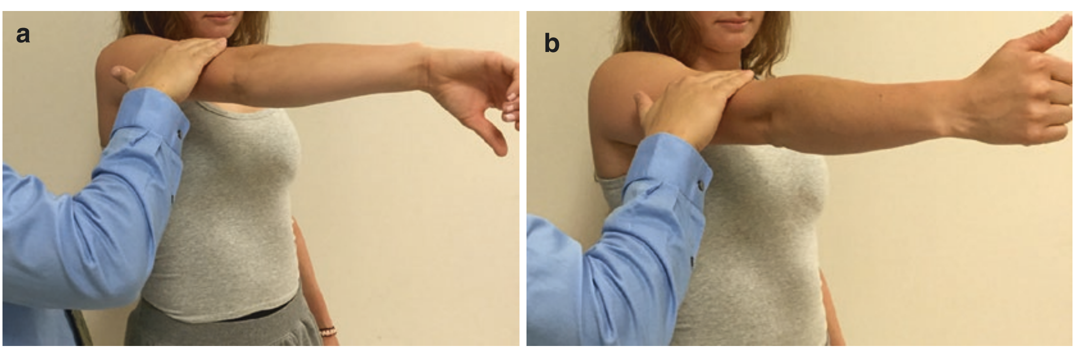

Fig. 4.2 Active compression test. Resistance is applied inferiorly to a patient's arm positioned in forward elevation, 10° of horizontal adduction, and internal rotation (**a**). The test is then repeated with the arm in external rotation (**b**). A positive test is determined as pain with resistance in both rotational positions

Fig. 4.3 Cross body adduction test. The arm is passively moved across the patient's body to determine if pain occurs at the AC joint

Fig. 4.4 Paxinos test. While grasping the posterior acromion and the middle aspect of the clavicle, pressure is applied to the acromion anterosuperiorly and to the clavicle inferiorly. Pain with pressure indicates a positive test

tion under an imposed load or motion. In low-grade (Rockwood/ISAKOS 1, 2, 3A) AC separations [36–38], with mainly AC ligament injuries, most of the demonstrated laxity will be in the horizontal direction, while in high-grade (Rockwood/ISAKOS 3B, 4, and 5) AC separations, the demonstrated laxity will be in the vertical as well as horizontal directions [36–38]. In addition, in the high-grade injuries, the cross body adduction maneuver will pull the acromion inferior and medial to the clavicle, resulting in

Fig. 4.5 Example of altered scapular positioning due to muscle weakness

the characteristic posture of clavicle prominence, even though the pathomechanical motion and resulting symptoms are due to abnormal acromial motion. Patients with excessive distal clavicle excision following arthroscopic or open surgery may demonstrate pain upon horizontal adduction and horizontal translation maneuvers, due to the bone shortening and ligament injuries.

The effect of AC joint pathology on SHR can be assessed by observation of the motions of the arm, scapula, and clavicle [39]. Limitation of arm motion in flexion and abduction may be seen in AC joint arthritis. In high-grade AC separations or type 2 distal clavicle fractures, the resulting pathomechanics may include excessive scapular protraction, which can be observed an asymmetrical scapular position at rest or medial border prominence upon arm motion in elevation and/or descent [40] (Fig. 4.5).

Corrective maneuvers can be helpful to indicate the effect of modifying the pathoanatomy or the symptoms and noting the change in the pathomechanics or function. This can give clues regarding how the alterations result in clinical dysfunction and suggest treatment options. Manual realignment and reduction of the AC joint, conferring joint stability, may decrease the joint symptoms and may improve the dynamic deficits in normal SHR. This can be accomplished directly by mobilizing the acromion and clavicle, or indirectly by mobilizing the scapula in relation to the stabilized clavicle in the Scapula Retraction Test (SRT) [41, 42]. In this test, the scapula is manually positioned in retraction and held in this position as arm motion or strength is measured or joint stability is tested. Change in symptoms of joint impingement, joint instability, arm impingement, arm strength, or SHR are positive results.

In summary, physical examination of the AC joint can result in specific information, enabling the accurate diagnosis of AC joint pathology and the effect on SHR mechanics, and provide guidelines for treatment.

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