The acromioclavicular (AC) joint is the articulation that anchors the clavicle to the scapula. The anatomy and design of the joint allow it to sustain a significant amount of force before disruption. There are many procedures and protocols that have been devised to treat the AC joint. Choosing the appropriate treatment is confusing due to the magnitude of research with conflicting outcomes. It is important to understand the biomechanics and anatomy of the joint to critically evaluate the existing studies. An understanding of these basic principles can then allow the orthopaedic surgeon to choose the appropriate treatment. This review defines and explains the anatomy and biomechanics of the AC joint.

ANATOMY

The acromioclavicular joint is a diarthrodial joint that has four degrees of freedom, allowing movement in the anterior/posterior and the superior/inferior planes. It is surrounded by a joint capsule with a synovial lining. Hyaline cartilage coats the articular surfaces and there is an intervening intraarticular meniscus type structure which has tremendous variation in size and shape. DePalma et al, Petersson, and Salter have demonstrated that with age this meniscal homologue undergoes rapid degeneration until it is no longer functional beyond the fourth decade. Its actual function in the joint is negligible.

The acromioclavicular joint is stabilized by both static and dynamic stabilizers. The static stabilizers include the acromioclavicular ligaments (superior, inferior, anterior, and posterior), the coracoclavicular ligaments (trapezoid and conoid), and the coracoacromial ligament. Dynamic stabilizers include the deltoid and trapezius muscles. All of the soft tissues at the acromioclavicular joint function in a synergistic, complex manner to provide AC joint stability.

The acromioclavicular joint capsule and the capsular ligaments are the primary restraints of the distal clavicle to anterior to posterior translation. The superior AC ligament is more substantial and thicker than the inferior AC ligament. The superior AC ligament attaches to the clavicle and its fibers interdigitate with the musculotendinous aponeurosis of the deltotrapezial fascia. These muscles add stability to the joint when they contract or stretch.

There have been few descriptions of the capsular anatomy of the AC joint. In a recent study by Renfree and coworkers, histologic sections revealed that the superior aspect of the AC capsule inserted onto the distal clavicle an average of 5.5 mm from the joint line. In an anatomical dissection study by Nicholson and coworkers, the AC capsule was dissected circumferentially from the inside out. The capsule was incised in line with the joint and was sharply dissected off the bone of the clavicle and acromion working from the underneath side of the capsule. Qualitatively the most identifiable and robust aspects were the superior and posterior portions of the capsule. The average insertional footprint increased from anterior to posterior on the distal clavicle. The capsule began an average of 0.3 mm from the joint line on the distal clavicle, and the superior posterior aspect of the capsule inserted an average of 13.5 mm from the joint line. The dimensions in this study were greater than those reported by Renfree. The authors speculated that this may be due to specimen preparation and methodology. It may also represent a thicker, deeper, shorter aspect to the superior AC capsule, with a thinner, broader, more extensive superficial capsular aspect to this structure.

The coracoclavicular ligaments’ main contribution is with vertical stability preventing superior and inferior translation of the clavicle. This complex is made up of two structures: the trapezoid and the conoid ligaments. As the name implies, the ligaments originate on the coracoid...
process of the scapula and insert on the undersurface of the distal clavicle. These two stout ligaments are responsible for suspending the scapula and the upper extremity from the undersurface of the clavicle. The trapezoid is anterior and lateral to the conoid, and both the trapezoid and conoid ligaments are posterior to the pectoralis minor attachment on the coracoid.

The trapezoid ligament insertion ends approximately 16 mm from the AC joint line. The conoid ligament insertion ends approximately 30 mm from the joint line. The trapezoid ligament was found to be thicker in all dimensions than the conoid ligament. The mean lengths of the ligaments from coracoid to clavicle were 19.3 and 19.4 mm for the trapezoid and conoid, respectively. Bearden et al reported a range of values for the coracoclavicular space of 1.1 to 1.3 cm. This distance becomes clinically important when differentiating incomplete versus complete acromioclavicular joint separations. The larger the distance between the coracoid and the clavicle the more likely that a complete dislocation has occurred. The coracoclavicular ligaments perform two major functions: (1) they mediate synchronous scapulohumeral motion by attaching the clavicle to the scapula and (2) they strengthen the acromioclavicular articulation.

BIOMECHANICS

ACROMIOCLAVICULAR JOINT MOTION

Rockwood et al have reported that there is approximately 5 to 8° of motion detected at the acromioclavicular joint with forward elevation and abduction to 180°. The clavicle rotates between 40 and 50° during full overhead elevation. This motion is combined with scapular rotation rather than through the acromioclavicular joint. This synchronous motion of the clavicle, rotating upward, and the scapula, rotating downward, during abduction and forward elevation was described by Codman as synchronous scapula clavicular rotation. This is coordinated by the coracoclavicular ligaments.

The motion of the acromioclavicular joint is important clinically. Procedures that either fuse the acromioclavicular joint or stabilize the clavicle to the scapula with a coracoclavicular screw still allow full forward elevation in abduction. This motion has allowed these screws and hardware to migrate as well as break over time.

ACROMIOCLAVICULAR CAPSULAR LIGAMENTS

Several biomechanical studies have illustrated the importance of ligaments in regard to AC joint stability. Klimkiewicz and coworkers performed cadaveric dissections to define the relative roles of the individual acromioclavicular capsular ligaments in preventing posterior translation of the distal clavicle in normal acromioclavicular joints. Each ligament was sectioned and the resultant clavicular translation was measured. Their results indicated that if the anterior and inferior ligaments are sectioned, there is no significant effect on posterior translation. However, if the posterior and superior ligaments are sectioned, there is a significant effect on clavicular translation. The superior and posterior capsular ligaments contribute 56 and 25%, respectively, of the force required to produce a given posterior displacement. Posterior horizontal instability of the distal clavicle can cause abutment of the posteroslateral portion of the clavicle into the spine of the scapula (Fig 3). Clinically, resistance to posterior translation is critical to avoid painful horizontal instability of the acromioclavicular joint with an abutment of the posteroslateral end of the clavicle on the spine of the scapula. The authors recommended procedures that spare the posterior and superior ligaments when removing the distal clavicle.

CORACOCLAVICULAR LIGAMENTS

Fakuda et al initially described the role of the coracoclavicular (CC) ligaments in AC joint stability. They reported that with small displacements the acromioclavicular ligaments are the primary restraints to posterior (89%) and superior (68%) translation of the clavicle. With larger displacement, the conoid ligament was found to be the primary restraint (62%) to superior translation. The trap-
ezoid ligament was found to be the primary restraint to compression of the acromioclavicular joint at both small and large displacements. Lee and coworkers further determined that the trapezoid ligament was the primary restraint to posterior displacement of the distal clavicle with an intact AC joint.5

Debski and coworkers provided further insight regarding the biomechanical properties of the CC ligaments.4 Under a 70-N load in the anterior, posterior, and superior directions, the clavicle translates 5.1, 5.6, and 4.2 mm, respectively (Fig 4). The in situ force in the superior AC ligament was greatest in response to an anterior load, whereas the in situ force was greatest in the conoid ligament in response to a superior load. With complete transsection of the AC ligaments, the in situ forces of the CC ligaments increased significantly when compared with an intact joint. Under a 70-N load, the conoid served as the primary restraint against anterior and superior loading, whereas the trapezoid functioned as the primary restraint against posterior loading.15 The difference in the contributions by the two ligaments is most likely due to their relative orientations.4 The authors attributed the difference between their results and those reported by others to the number of constraints placed on the resulting joint motion and the magnitude of load applied to the joint. In situ forces in each ligament are affected by coupled motions that occur during loading. This soft tissue force is redistributed during loading when a greater number of degrees of freedom of motion are allowed.15

The coracoclavicular ligaments should be considered for reconstruction to restore AC joint stability, especially for posterior distal clavicle instability.5 Under normal circumstances, distal clavicle resection would be unlikely to lead to failure of the coracoclavicular ligaments based on their structural properties.10,16 However, DCR performed in the face of a previous AC joint separation could compromise the previously stressed AC and CC ligaments, resulting in increased risk of distal clavicle instability postoperatively.17 The relative vertical orientation of the coracoclavicular ligaments prevents effective resistance against anterior-posterior translation.

**CORACOACROMIAL LIGAMENT**

The coracoacromial ligament is important as a secondary glenohumeral stabilizer preventing anterosuperior displacement of the humeral head in longstanding massive rotator cuff disease (cuff tear arthropathy). Disruption of this ligament commonly occurs with subacromial decompression, a procedure often performed in conjunction with distal clavicle resection. Biomechanical testing indicates that arthroscopic subacromial decompression alone does not significantly alter the mechanics of the AC joint during the application of an anterior, posterior, or superior load of 70 N to the distal clavicle.18

**TABLE 1. Summary of Biomechanical Studies Investigating the Structures Primarily Responsible for Resisting Displacement of the Distal Clavicle**

<table>
<thead>
<tr>
<th>Author</th>
<th>Direction of Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fukuda et al6</td>
<td>Conoid (large displacements)</td>
</tr>
<tr>
<td>Lee et al8</td>
<td>Inferior AC ligament</td>
</tr>
<tr>
<td>Debski et al15</td>
<td>Superior AC ligament (conoid with capsule transected)</td>
</tr>
<tr>
<td>Klimkiewicz et al14</td>
<td>Superior AC ligament</td>
</tr>
<tr>
<td>Salter et al17</td>
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Fig 3. Instability of the distal clavicle in the horizontal plane can result in abutment of the posterior clavicle into the anterior aspect of the scapular spine. (Reprinted with permission from Mazzocca et al.23)

Fig 4. The anterior view of a left shoulder demonstrates the coordinate system associated with forces applied to the distal clavicle during biomechanical testing. The X axis is an anterior force, the Y axis is a superior force, and the Z axis is a medial force. (Reprinted with permission from Debski et al.18)
DISTAL CLAVICLE RESECTION

Distal clavicle resection eliminates painful bony contact in the AC joint. As a result, unusually high loads (compression and translation) are transferred to the intact soft tissue structures. Branch and coworkers determined that only 5 mm of bone needs to be resected to ensure that no bone to bone contact occurs in postoperative range of motion. Furthermore, this study revealed that there was no difference in the three orthogonal axes of AC joint rotation (anterior–posterior, abduction–adduction, protraction–retraction) whether the superior or inferior acromioclavicular ligaments were cut before the removal of 5 mm of distal clavicle.20

A biomechanical study evaluating the effects of arthroscopic and open procedures for distal clavicle resection indicated that both procedures eliminate bony contact postoperatively. In this study, 0.5 to 1.0 cm of bone was removed arthroscopically and 1.5 to 2.0 cm of bone was removed by an open procedure. The average displacement was significantly greater for the surgically altered AC joints than the intact AC joints, although there was no significant difference in displacement between the surgically altered joints. Both procedures removed sufficient bone, and bony contact was prevented by the intact trapezoid and conoid ligaments.21

REFERENCES