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Acromioclavicular Joint Injuries: Diagnosis and Management

Abstract

Acromioclavicular joint injuries represent nearly half of all athletic shoulder injuries, often resulting from a fall onto the tip of the shoulder with the arm in adduction. Stability of this joint depends on the integrity of the acromioclavicular ligaments and capsule as well as the coracoclavicular ligaments and the trapezius and deltoid muscles. Along with clinical examination for tenderness and instability, radiographic examination is critical in the evaluation of acromioclavicular joint injuries. Nonsurgical treatment is indicated for type I and II injuries; surgery is almost always recommended for type IV, V, and VI injuries. Management of type III injuries remains controversial, with nonsurgical treatment favored in most instances and reconstruction of the acromioclavicular joint reserved for symptomatic instability. Recommended techniques for stabilization in cases of acute and late symptomatic instability include screw fixation of the coracoid process to the clavicle, coracoacromial ligament transfer, and coracoclavicular ligament reconstruction. Biomechanical studies have demonstrated that anatomic acromioclavicular joint reconstruction is the most effective treatment for persistent instability.

Acrmericoclavicular (AC) joint injuries represent 40% to 50% of athletic shoulder injuries. The treatment of AC instability has been an ongoing source of controversy. Long before a three-grade classification of the injury was developed by Tossy et al and Allman in the 1960s and then expanded by Rockwood in 1989, surgeons debated the method and timing of treatment. The greatest source of dispute has been the issue of nonsurgical management versus surgical reconstruction for complete dislocations.

In the mid 1970s, most residency program directors in the United States recommended surgical treatment for type III dislocations (ie, loss of contact between the clavicle and the acromion). However, by the early 1990s, 135 of 187 surgeons preferred nonsurgical treatment (72.2%). A series of comparative studies has supported this trend. Today, the tendency in management is toward minimal intervention. However, surgical management, most commonly in the form of coracoclavicular (CC) fixation and/or ligament reconstruction, is often undertaken after consideration of individual patient demands and injury chronicity.

Joint Anatomy and Biomechanics

The AC joint is a diarthrodial joint formed between the lateral end of the clavicle and the medial end of the
Figure 1

The acromioclavicular (AC) joint. Static stabilizers include the AC capsule and the coracoclavicular ligaments, consisting of the trapezoid ligament laterally and the conoid ligament medially.

The CC ligaments on the clavicle in a cadaveric study. The normal anatomic range of the distance between the coracoid process and the clavicle (CC interspace) is 1.1 to 1.3 cm. Fukuda et al demonstrated that the conoid ligament restrains vertical displacement to a greater extent than does the trapezoid ligament. They also concluded that the AC joint capsule contributes greater constraint at small loads and that the CC ligaments provide stability with greater displacements.

Dynamic stabilization of the AC joint relies on the origin part of the anterior deltoid muscle from the clavicle and the trapezius muscle through its fascial insertion over the acromion. The role of these muscles in AC joint stability must be appreciated during any AC joint surgical reconstruction.

Mechanism of Injury

An acute injury to the AC joint can occur through a direct or an indirect mechanism. Direct injury results from a direct force to the acromion with the shoulder adducted, resulting in movement of the acromion inferiorly and medially while the clavicle is stabilized by the sternoclavicular joint ligaments. This mechanism is involved in most injuries and is usually the result of a fall on the suprolateral portion of the shoulder. The force results in systematic failure of the stabilizing ligaments with the propagation of increasing force. Failure of the AC ligaments and capsule is followed by failure of the CC ligaments and deltrotrapezial fascia.

An indirect force can result in the same constellation of injury patterns but is generated by a fall on an outstretched arm or elbow with a superiorly directed force. Although injury to the AC and CC ligaments is the most common pathologic basis for
Table 1
Characterization of Acromioclavicular Joint Injuries by the Rockwood Classification

<table>
<thead>
<tr>
<th>Type</th>
<th>AC Ligaments</th>
<th>CC Ligaments</th>
<th>Deltopectoral Fascia</th>
<th>Radiographic CC Distance Increase</th>
<th>Radiographic AC Appearance</th>
<th>AC Joint Reducible</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Sprained</td>
<td>Intact</td>
<td>Intact</td>
<td>Normal (1.1 to 1.3 cm)</td>
<td>Normal</td>
<td>N/A</td>
</tr>
<tr>
<td>II</td>
<td>Disrupted</td>
<td>Sprained</td>
<td>Intact</td>
<td>&lt;25%</td>
<td>Widened</td>
<td>Yes</td>
</tr>
<tr>
<td>III</td>
<td>Disrupted</td>
<td>Disrupted</td>
<td>Disrupted</td>
<td>25%-100%</td>
<td>Widened</td>
<td>Yes</td>
</tr>
<tr>
<td>IV</td>
<td>Disrupted</td>
<td>Disrupted</td>
<td>Disrupted</td>
<td>Increased</td>
<td>Posterior clavicle displacement</td>
<td>No</td>
</tr>
<tr>
<td>V</td>
<td>Disrupted</td>
<td>Disrupted</td>
<td>Disrupted</td>
<td>100%-300%</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>VI</td>
<td>Disrupted</td>
<td>Intact</td>
<td>Disrupted</td>
<td>Decreased</td>
<td>N/A</td>
<td>No</td>
</tr>
</tbody>
</table>

* The type of AC injury can be discerned based on the pattern of ligament injury, AC joint position on radiographs, and whether the AC joint can be reduced on physical examination.

AC = acromioclavicular, CC = coracoclavicular, N/A = not applicable

complete AC joint dislocation and instability, AC dislocations can occur in the context of intra- and extraarticular fractures of the base of the coracoid process. Such an injury is considered equivalent to a CC rupture. Epiphyseal separation in children and young adults, as well as distal clavicle fractures, can result in the appearance of AC dislocation on radiographs; these are termed “pseudodislocations.”

**Classification**

The degree of injury to the AC joint is dependent on the amount of energy transferred to the acromion and clavicle and their ligamentous stabilizers. Tossy et al and Allman originally classified AC joint injuries into three grades. This classification system was subsequently modified by Rockwood into six types (Table 1).

In type I injury, there is no visible deformity. There may be some swelling and tenderness over the AC joint, but there is no tenderness over the CC interspace. Radiographs appear normal.

In type II injury, the distal clavicle is unstable horizontally and can be displaced anteriorly or posteriorly. Although there may be vertical instability, it is usually absent or minimal. In contrast to type I injuries, there is tenderness overlying the CC interspace. Radiographically, the AC joint is disrupted and may be widened, with a slight vertical displacement and concomitant increase in the CC interspace.

The distal clavicle is unstable vertically and horizontally in type III injury. Radiographically, the AC joint is disrupted, with the acromion displaced inferiorly relative to the clavicle. There is tenderness in the CC interspace. Pain is typically more severe in type III and higher injuries. The AC joint is reducible by an upward force placed on the ipsilateral elbow. Certain injury patterns mimic, but should be distinguished from, type III AC injuries. These variants include Salter-Harris injuries to the distal clavicular physis resulting from late closure of this physis (in persons aged 18 to 22 years), and AC dislocations associated with intact CC ligaments and a fracture of the coracoid process.

AC joint dislocation with the clavicle displaced posteriorly into or through the trapezius muscle identifies a type IV injury. Clinically, the anterior acromion may be prominent. Radiographically, the CC interspace is increased, and posterior translation of the lateral clavicle is seen on an axillary lateral view (Figure 2). The AC joint is irreducible on physical examination. The SC joint and brachial plexus should be evaluated in all AC injuries, but such evaluation is particularly important in type IV injuries, given the reports of bipolar clavicular dislocations (eg, synchronous AC and SC dislocation).

In a type V injury, in addition to disruption of all of the stabilizing ligaments (as in a type III or IV injury), the deltoid and trapezius muscles and fascia are more extensively detached from the clavicle. Clinically, the clavicle lies subcutaneously. Occasionally there is so much inferior displacement of the upper extremity that the patient develops symptoms from traction on the brachial plexus. The AC joint is irreducible.

The rare type VI injury represents a high-energy variant that usually occurs as a result of hyperabduction and external rotation. The distal clavicle typically comes to rest in a subacromial or subcoracoid position (Figure 3). Because this injury is usu-
Figure 2

A 33-year-old man presented with shoulder pain and an abrasion over the superior portion of the shoulder following a fall from a motorcycle. **A**, Anteroposterior radiograph with a 10° to 15° cephalic tilt demonstrating an increase in the coracoclavicular interspace distance (*). **B**, Axillary lateral radiograph demonstrating posterior displacement (posteriorly directed arrow), thereby distinguishing this as a type IV injury. The acromion (A) and the clavicle (C) are outlined.

Figure 3

Three-dimensional computed tomography scan demonstrating the subcoracoid variant of a type VI acromioclavicular dislocation.

Diagnosis

Clinical Findings

Injury to the AC joint should be suspected in any patient who has shoulder trauma with pain in the vicinity of the acromion and clavicle. During the clinical examination, the patient should be in the standing or sitting position without support for the injured arm. The weight of the arm pulling downward often makes the deformity more apparent.

On physical examination, findings related to the severity of the injury, such as local swelling, deformity, abrasion, or bruising, may be noted. The distal end of the clavicle is sometimes displaced enough to tent the skin. With AC injury, local tenderness is present on palpation over the AC joint as well as in the CC interspace. AC joint palpation provides guidance related to the degree and direction of the displacement of the clavicle compared with the acromion. The clavicle should also be carefully palpated to detect possible fractures. Disruption of the deltotrapezial fascia should be noted if present. Passive and active motion of the shoulder produces focal pain at the injured AC joint. This pain is often accentuated by abduction and cross-body adduction. The O'Brien active compression test for pain over the AC joint may be helpful.

The AC joint should next be assessed for stability. Evaluation of stability is difficult in the acute phase because of patient discomfort and guarding. In the subacute phase, after partial resolution of pain, horizontal and vertical instability can be detected. Because an AC joint injury occurs by inferior displacement of the scapula, determining whether the AC joint is reducible is done by stabilizing the clavicle with one hand and placing an upward force under the ipsilateral elbow with the other.
Treatment

Nonsurgical

Nonsurgical treatment is uniformly recommended for type I and type II injuries. Although multiple methods for clavicle reduction and immobilization have been described, most authors suggest a period of immobilization in a simple sling or shoulder immobilizer to remove stress from the injured CC and/or AC ligaments.\(^\text{14,29}\)

Generally, type I injuries can be treated by use of a simple sling for 7 to 10 days or until pain subsides. Type II injuries may require immobilization for as long as 2 weeks for resolution of symptoms. Once the shoulder pain has subsided, an early and gradual rehabilitation program is instituted, with the focus on passive- and active-assisted range of motion (ROM). After symmetric and painless shoulder ROM is achieved, an isometric strengthening program is begun. This is followed by isotonic strengthening with a gradual escalation of strengthening and endurance. Contact sports and heavy lifting should be avoided for 2 to 3 months to allow for ligament healing and avoid converting an incomplete injury to a complete type III injury.

Most studies support nonsurgical treatment of type III injuries, although this is controversial. Nonsurgical treatment is well accepted, but mid- and long-term outcomes should not be ignored. Several studies have demonstrated persistent disability in patients treated nonsurgically. Bergfeld et al\(^\text{10}\) evaluated United States Naval Academy midshipmen and found that 30% of patients with type I and 42% of patients with type II injuries reported minor symptoms such as clicking and pain with push-ups and dips. An additional 9% and 23% of patients with type I and II injuries, respectively, reported severe persistent pain and limitation of activities. Mouhsine et al\(^\text{11}\) reported similar results. Of patients with type I and II AC injuries treated nonsurgically, 27% developed chronic AC symptoms at a mean of 26 months after injury and subsequently required surgical intervention. Of the patients who chose later surgery, a significant proportion had activity-related pain and residual anteroposterior instability.

Bannister et al\(^\text{9}\) conducted a randomized, prospective, controlled trial comparing acute surgical treatment of Rockwood type III and V AC joint dislocations using a CC screw versus 2 weeks of immobilization in a sling. The same rehabilitation protocol was used in both groups. Patients were stratified according to the severity of AC joint displacement. Patients with AC displacement <2 cm fared better with nonsurgical treatment. Among only those patients with severe AC dislocation (≥2 cm displacement), 20% of the nonsurgical group had good or excellent results, while 70% of the surgically treated patients had good or excellent results. The authors concluded that nonsurgical treatment is appropriate for low-grade injuries but surgical treatment can be considered for young patients with severe injuries.

The most concerning sequelae of lower-energy injuries are the late development of AC joint osteoarthritis, exhibited in nearly 50% of patients with AC injury,\(^\text{30}\) and chronic instability. Current treatment options include arthroscopic distal clavicle resection,\(^\text{32}\) involving the removal of as little as 4 to 8 mm of bone, and open distal clavicle excision. However, no published prospective, randomized studies exist that compare both arthroscopic and open methods.

A meta-analysis by Phillips et al\(^\text{12}\) demonstrated that type III injuries have similar overall satisfactory out-
Table 2

Surgical Techniques for the Management of Acromioclavicular Joint Dislocation

<table>
<thead>
<tr>
<th>Technique</th>
<th>Method</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary acromioclavicular</td>
<td>Kirschner wires, hook-plate</td>
<td>Limited dissection</td>
</tr>
<tr>
<td>joint fixation</td>
<td></td>
<td>Risk of pin migration</td>
</tr>
<tr>
<td>Fixation between the</td>
<td>CC screw, suture loop</td>
<td>Screw requires staged removal</td>
</tr>
<tr>
<td>coracoid process and</td>
<td></td>
<td>Suture loop can be inserted arthroscopically</td>
</tr>
<tr>
<td>clavicle</td>
<td></td>
<td>Reserved for acute injuries</td>
</tr>
<tr>
<td>Dynamic muscle transfer</td>
<td>Coracoid transfer</td>
<td>Abandoned due to inferior long-term results</td>
</tr>
<tr>
<td>Ligament reconstruction</td>
<td>Autogenous hamstring,</td>
<td>Attempts to anatomically reestablish CC ligament anatomy</td>
</tr>
<tr>
<td></td>
<td>anterior tibialis allograft,</td>
<td>Provides biologic scaffold for revascularization</td>
</tr>
<tr>
<td></td>
<td>CA ligament transfer</td>
<td>Appropriate for acute and chronic reconstructions</td>
</tr>
</tbody>
</table>

CA = coracoacromial. CC = coracoclavicular

come rates whether managed nonsurgically or surgically. Patients treated nonsurgically returned to work and preinjury activities sooner and had more nearly normal strength and ROM at follow-up. Patients treated surgically had a higher complication rate. However, there was no standardization of surgical technique or nonsurgical treatment method among the studies reviewed. Wojtys and Nelson33 reviewed 22 patients with type III AC dislocations. They determined that laborers and athletes can recover adequate strength and endurance with nonsurgical treatment of type III injuries despite a slight decrease in both measures. However, they expressed concern that the decrease in endurance and strength, despite not being statistically significant, coupled with persistent pain and soreness, may be worth considering in developing a treatment plan for patients who depend on high levels of shoulder strength or endurance for a job or sport. Multiple other studies have demonstrated successful short- and mid-term clinical outcomes in patients with type III injuries treated nonsurgically.34-36

Proper and adequate rehabilitation may be critical to successful nonsurgical treatment of type III AC injuries. Glick et al.37 evaluated 35 unre-duced AC dislocations that were treated nonsurgically in a professional and competitive recreational athletic population. None of the patients was disabled. In addition, none of the patients who had a supervised rehabilitation program had reports of pain. These authors concluded that the predominant reason for persistent pain and disability after a type III AC injury treated nonsurgically was inadequate rehabilitation. This conclusion is supported by the assertion by Gurd38 that the shoulder can function normally despite an absent clavicle as long as the shoulder girdle muscles are strengthened and maintained. Thus, a structured active rehabilitation program that focuses on gaining strength of shoulder girdle muscles, including the deltoid, trapezius, sternocleidomastoid, and subclavius, as well as the rotator cuff and periscapular stabilizers, is indicated for patients who are treated nonsurgically.

Although there is no conclusive evidence of it in the literature, a relative indication for AC surgical stabilization after an acute type III injury may be young age or a job or sport that places high demands on the shoulder. In addition, chronic symptoms of instability and pain following a type III AC dislocation may warrant delayed surgical reconstruction. Recent reports of successful nonsurgical treatment of type III AC injuries in professional baseball players have challenged the relative indication of sport or job type in selecting a management protocol.39 Despite the success of nonsurgical treatment, late symptomatic sequelae can develop. Occasionally, distal clavicle osteolysis or a painful AC disk injury, akin to a meniscal tear, occurs acutely, or AC arthritis develops over time. When symptomatic, these conditions can be treated by steroid injection or distal clavicle resection with intra-articular disk excision, as described by Mumford,40 combined with a ligamentous reconstruction to establish stability.

Surgical

The case can be made for surgical management of some acute type III AC joint dislocations. However, acute type IV, V, and VI AC joint dislocations all require surgical intervention, although there is no consensus on which technique to use. Surgical techniques can be categorized into three main groups (Table 2), although all have the goal of obtaining and retaining anatomic AC joint reduction.
Primary Fixation of the Acromioclavicular Joint

Historically, primary fixation of the AC joint consisted of pin fixation using either smooth or threaded Kirschner wires after a closed or open reduction. However, this method has been abandoned, given the rare but catastrophic occurrence of pin migration; the pins have been found in the heart, lungs, and great vessels.41,42

An alternative technique commonly used in Europe is the hook-plate. After open reduction of the AC joint, the lateral end of the plate is inserted deep to the acromion and levered down on the clavicle to reduce the joint. It is secured to the clavicle with bicortical screws. Some surgeons combine hook-plate fixation with ligament reconstruction,43 while others use the hook-plate alone.44 The plate is removed at 8 weeks. This technique has been successful in treating AC dislocations and distal clavicle fractures.45 Sim et al,46 however, reported that 8 of 16 patients experienced complications (one bent plate, one plate dislocation, six infections).

Fixation Between the Coracoid Process and Clavicle

Bosworth47 popularized the use of a screw for CC fixation. The use of screws and suture loops has been described alone and in combination with ligament reconstruction. Rockwood et al48 recommended that a CC screw (Figure 4) be combined with ligament reconstruction in acute cases of AC dislocation. Through recent arthroscopic advances, CC fixation can now be accomplished by less invasive means.

Placement of synthetic loops between the coracoid process and clavicle have been described by several authors, most often in combination with a form of CC ligament reconstruction. The main advantage of this technique is that it does not require staged removal as do CC screws. Absorbable and nonabsorbable materials can be used. Morrison and Lemos49 demonstrated the importance of accurate positioning of a synthetic loop to allow for the most anatomic reduction possible. Potential complications of this technique include suture cutout. Good results have been reported with 6-mm polytetrafluoroethylene surgical tape as a secondary fixation combined with coracoacromial (CA) ligament transfer.50 However, cases of aseptic foreign-body reaction and clavicle osteolysis that resulted in failure have been reported.51,52

Coracoid Process Transfer

Transfer of the coracoid process was first described by Dewar and Barrington.49 It has been used for the treatment of acute and chronic injuries, with better results in younger patients. However, reports of residual joint aching led to the procedure’s being abandoned because of poor long-term outcomes.53

Ligament Reconstruction

Weaver and Dunn54 first described the use of the native CA ligament to reestablish AC joint stability (Figure 5). This technique has since been modified to include resection of the distal clavicle to avoid late degenerative changes at the AC joint. The CA ligament is detached from the deep surface of the acromion with or without a chip of bone and is then transferred to the clavicle. This construct can be augmented with a suture loop that provides protection while the reconstructed ligament heals. Recently, Lafosse et al55 described an all-arthroscopic technique for CA ligament transfer in the setting of acute or chronic AC dislocations.

An alternative technique for ligament reconstruction is the use of a semitendinosus tendon autograft. This technique is combined with re-
The modified Weaver-Dunn procedure. The coracoacromial ligament (A) is transferred to the clavicle to substitute for the ruptured coracoclavicular ligaments. A suture loop (B) can be used for augmentation.

Intraoperative photographs of a procedure to anatomically reconstruct the coracoclavicular ligaments through bone tunnels in the clavicle (C) using a semitendinosus allograft. A, A suture passer is passed from medial to lateral around the coracoid tip (*) and used to retrieve the anterior tibialis allograft around the coracoid process. B, The graft ends are pulled through two bone tunnels (arrows) in the clavicle to approximate the pull of the conoid and trapezoid ligaments.
coracoid process or potted in a coracoid bone socket. The graft is fixed with interference screws through two separate clavicle bone tunnels that approximate the normal anatomic location and orientation of the CC ligaments. We believe that this best replicates the injured anatomy. Biomechanical studies have demonstrated the superiority of this construct. We routinely resect the distal clavicle at the index operation. However, recent interest in the additional AC stability conferred by not resecting the distal clavicle and the clinical ramifications of doing so may be compelling. A possible shift in the treatment paradigm awaits further prospective clinical and well-designed biomechanical trials.

Distal Clavicle Resection
There has been some interest in primary or delayed excision of the distal clavicle (ie, Mumford procedure) in a symptomatic AC joint after dislocation. Although there has been success with this technique done open as well as arthroscopically, it must be reserved for patients in whom the CC ligaments are intact and there is no concomitant instability. When horizontal or vertical instability exists, results are compromised because this technique does not address instability and may accentuate it.15,24,53

Biomechanical Considerations
The goal of AC joint reconstruction, when indicated, is to achieve an anatomic reconstruction that best restores both the restraint to vertical as well as anteroposterior translation of the clavicle at the AC joint. Multiple studies have examined the biomechanical results of various reconstructive techniques (Table 3), and several conclusions can be drawn from them.16,56-63 A study by Jari et al54 suggests that surgical techniques that preserve the articulating surface of the clavicle at the AC joint lead to lower joint contact forces and are preferred.

CA ligament transfer, which has long been the most popular method for treating complete chronic AC dislocations, has just 25% of the strength of the intact CC complex and allows far greater primary and coupled translation than does the intact AC joint.61 Augmentation of this repair/reconstruction with various suture loops and suture anchors can increase the construct strength and ultimate load to failure while reducing primary and coupled translation. However, these constructs are biomechanically inferior to the native intact AC and CC capsuloligamentous unit. Screw fixation may also be considered. Although the bicortical Rockwood screw has the highest tensile strength and stiffness with the lowest elasticity, these properties may also be responsible for its high complication rate, including screw breakage and pullout.56

In a recent study of 42 cadaveric specimens, Mazzocca et al19 compared the stability conferred by three AC joint reconstruction techniques: CA ligament transfer and distal clavicle resection with suture loop augmentation, anatomic reconstruction with a double-bundled semitendinosus graft inserted into a coracoid bone socket, and arthroscopic reconstruction with suture and titanium screws (ie, suture loop and CC screw fixation). Only the anatomic CC reconstruction with tendon graft and suture augmentation provided anterior, posterior, and superior stability not statistically different from the intact state. The authors also recognized that a graft offers the advantage of a scaffold for revascularization compared with the arthroscopic suture loop, which does not and which can fatigue and fail over time with cyclic loading.

Costic et al17 demonstrated that the dislocated clavicle can lose up to 40% of its stiffness, which suggests that previous biomechanical models may be flawed, depending on how the clavicle and scapula were potted for testing.

Complications
Complications can occur as a result of nonsurgical and surgical treatment of AC joint dislocations. The most common complications associated with nonsurgical treatment are development of late arthrosis and persistent instability. Distal clavicle osteolysis also has been described.

Complications following surgical treatment of AC joint dislocations are related to the technique chosen. Hardware failure and migration resulting in injury to the great vessels have been described. In addition, aseptic foreign body reaction or infection may occur after the use of implants and synthetic suture. Depending on the choice of technique for surgical reconstruction, early or late fracture of the coracoid process or clavicle has been reported. In addition, any technique that passes a graft or synthetic material medial to the coracoid process poses a potential risk to the brachial plexus and axillary artery. Although reconstructive success is clinically predicated on alleviating pain and establishing AC stability, persistent pain and recurrent instability have been reported with all of the described techniques.

Postoperative Rehabilitation
After CC fixation with a metallic screw or suture construct for acute AC injuries, the shoulder is immobilized in a simple sling and cold therapy device. At 2 weeks, active and
### Table 3

<table>
<thead>
<tr>
<th>Study</th>
<th>Methodology</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mazzocca et al.</td>
<td>Biomechanical testing of 42 cadaveric shoulders for vertical and AP translation of the AC joint after three reconstructive techniques: modified Weaver-Dunn procedure, arthroscopic suture fixation, and anatomic CC reconstruction with semitendinosus graft</td>
<td>All three techniques establish comparable vertical stability and load to failure. Anatomic CC reconstruction that reconstructs both conoid and trapezoid ligaments allows the least AP translation of the three techniques and best approximates the intact state.</td>
</tr>
<tr>
<td>Jari et al.</td>
<td>Biomechanical comparison of the CA ligament transfer, CC sling, and Rockwood screw</td>
<td>Compared with the intact AC joint state, anterior, posterior, and superior translation increased 110%, 100%, and 360%, respectively, after the CA ligament transfer. With the CC sling, anterior translation increased by 110% and posterior translation by 330%. Primary translation was reduced with the Rockwood screw. A significant decrease in posterior translation was noted (60%) compared with the intact joint. Similar findings were noted for coupled translations (ie, AP). The Rockwood screw was the most rigid construct and was found to experience forces 30% and 170% greater than the intact AC joint in response to anterior and posterior loads, respectively.</td>
</tr>
<tr>
<td>Costic et al.</td>
<td>Biomechanical comparison of an intact AC joint with anatomic reconstruction using a semitendinosus graft</td>
<td>Stiffness and ultimate load to failure of the intact CC ligament state was significantly greater than for the anatomic reconstruction complex (P &lt; 0.05). Stiffness of the anatomic reconstruction complex (23.4 N/mm) was 40% of the stiffness of the intact CC complex (60.8 N/mm). Anatomic reconstruction complex had clinically insignificant elongation (&lt;3 mm) after cyclic loading. There is a 40% decrease in bending stiffness of the clavicle after dislocation that contributes to diminished stiffness of anatomic reconstruction.</td>
</tr>
<tr>
<td>Deshmukh et al.</td>
<td>Biomechanical comparison of the Weaver-Dunn procedure alone with the Weaver-Dunn procedure augmented by suture cerclage or suture anchor fixation</td>
<td>Average load to failure of the Weaver-Dunn procedure alone was 177 N compared with 319 N for augmentation with a variety of suture anchors or suture cerclage. The only failure during the 1,000-cycle fatigue test occurred with an unaugmented Weaver-Dunn procedure. The augmented Weaver-Dunn technique significantly better approximated the intact state of the AC joint for superior and AP laxity compared with the unaugmented Weaver-Dunn (P = 0.05). The mean superior and AP laxity for the augmented Weaver-Dunn technique was 7.6 mm and 26.9 mm, respectively, versus 3.1 mm and 8.8 mm, respectively, for the intact state. The authors found no significant difference in biomechanical properties depending on suture anchor choice for the augmentation technique.</td>
</tr>
<tr>
<td>Baker et al.</td>
<td>Biomechanical examination of varied placement of the drill hole for loop fixation of the clavicle after AC dislocation in 14 cadaveric shoulders</td>
<td>A more anterior drill hole in the clavicle allows more joint congruity and less anterior displacement of the clavicle with anterior loading. No method of loop fixation approached normal AC joint congruity.</td>
</tr>
<tr>
<td>Lee et al.</td>
<td>Biomechanical comparison of CA ligament transfer, Mersilene tape reconstruction, and ligament reconstruction with semitendinosus, gracilis, and long toe extensors</td>
<td>CA ligament transfer was the weakest construct. Mersilene tape reconstruction provided superior initial fixation strength compared with CA ligament transfer. Ultimate load to failure was equivalent among semitendinosus, gracilis, and long toe extensor grafts.</td>
</tr>
<tr>
<td>Wilson et al.</td>
<td>Biomechanical comparison of Weaver-Dunn reconstruction alone compared with Weaver-Dunn augmented with CC suture anchor fixation</td>
<td>AC joints were significantly more mobile after Weaver-Dunn reconstruction alone compared with the intact state (P &lt; 0.005). However, with suture anchor augmentation, the reconstructed state approached the intact state in terms of anterior, posterior, and superior translation.</td>
</tr>
</tbody>
</table>

ACS = acromioclavicular, AP = anteroposterior, CA = coracoacromial, CC = coracoclavicular
Table 3 (continued)

Biomechanical Comparison of Acromioclavicular Joint Reconstruction Techniques

<table>
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<tr>
<th>Study</th>
<th>Methodology</th>
<th>Results</th>
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<td>Breslow et al[61]</td>
<td>Biomechanical comparison of suture and suture anchors for the loop method of stabilizing the dislocated AC joint</td>
<td>After 10,000 cycles, laxity of the construct with suture loop was 1.32 ± 0.59 mm compared with 1.33 ± 0.94 mm for the suture anchor loop. The differences were not statistically significant.</td>
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<td>Harris et al[62]</td>
<td>Biomechanical comparison of tensile strength, tensile stiffness, and elongation at failure with five techniques in 19 cadaveric shoulders: CA transfer, CC sling with 8-mm polyester vascular prosthesis, 2 CC suture anchors, unicortical Bosworth screw, and bicortical Bosworth screw</td>
<td>CA ligament transfer demonstrated the weakest reconstruction initially. CC slings had high tensile strength but were very elastic and had the highest elongation at failure. CC screws provided the highest tensile strength and stiffness as well as least elasticity, but only with bicortical coracoid purchase</td>
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AC = acromioclavicular, AP = anteroposterior, CA = coracoacromial, CC = coracoclavicular

passive ROM is initiated and restricted to beneath the shoulder level. Doing so allows the patient to begin activities of daily living while avoiding lifting anything heavier than 5 pounds. Once the screw is removed at 2 to 3 months, full active and passive ROM is encouraged, with strengthening limited to light resistance for 6 to 8 weeks. Once full ROM and strength are obtained, return to athletic competition is permitted.

After AC joint reconstruction with an autogenous or allograft ligament reconstruction (e.g., semitendinosus graft, modified Weaver-Dunn), the arm is maintained in a simple sling. At 2 weeks, pendulum exercises are initiated, followed by light activities of daily living at 4 weeks. With further graft maturation at approximately 8 weeks, active and passive ROM is encouraged with a therapist, and light resistance can be initiated after 3 months. Once full ROM and strength are obtained, return to athletic competition or manual labor is permitted.

Summary

Significant recent advances have been made in the approach to AC joint injury. There is a consensus that type I and II AC joint injuries should be treated nonsurgically, while acute type IV, V, and VI injuries should be treated surgically. The correct algorithm for treating type III injuries is not known; most studies do not show a significant difference in the clinical outcome between nonsurgical and surgically treated patients. Although it has not been sufficiently demonstrated, it may be that a subset of overhead athletes and heavy laborers would benefit from surgical reconstruction of type III injuries. The idea that adequate rehabilitation is critical to a successful outcome of nonsurgical treatment of a type III injury is worthy of attention and further study. It is often the case that nonsurgical care translates into benign neglect, and perhaps inadequate rehabilitation has been responsible for some of the failures related to nonsurgical treatment.

References

Citation numbers printed in bold type indicate references published within the past 5 years.

10. Taft TN, Wilson FC, Oglesby JW:


