Review Article

Acromioclavicular Joint Injuries: Evidence-based Treatment

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Abstract

Injuries to the acromioclavicular (AC) joint are common in the athletic patient population. Most AC joint injuries occur in young males, typically from a direct fall onto the superior aspect of the shoulder when the arm is adducted. Numerous publications describing joint anatomy and biomechanics, surgical techniques for reconstruction, and rehabilitation protocols are available to guide treatment strategies for injuries to the AC joint. Treatment is typically nonsurgical for type I and II injuries and surgical for type IV and VI injuries. Controversy surrounds the indications for nonsurgical versus surgical treatment of type III and V injuries. Multiple surgical techniques have been described, including coracoclavicular (CC) screw fixation, coracoacromial ligament transfer, and numerous methods of CC ligament reconstruction. Anatomic CC ligament reconstruction can be performed either open or arthroscopically, with and without graft augmentation. This article will discuss clinically relevant anatomy and biomechanical properties of the AC joint and will review decision-making principles and treatment options for common AC joint injuries. An updated summary of clinical outcomes after AC joint treatment will also be presented.

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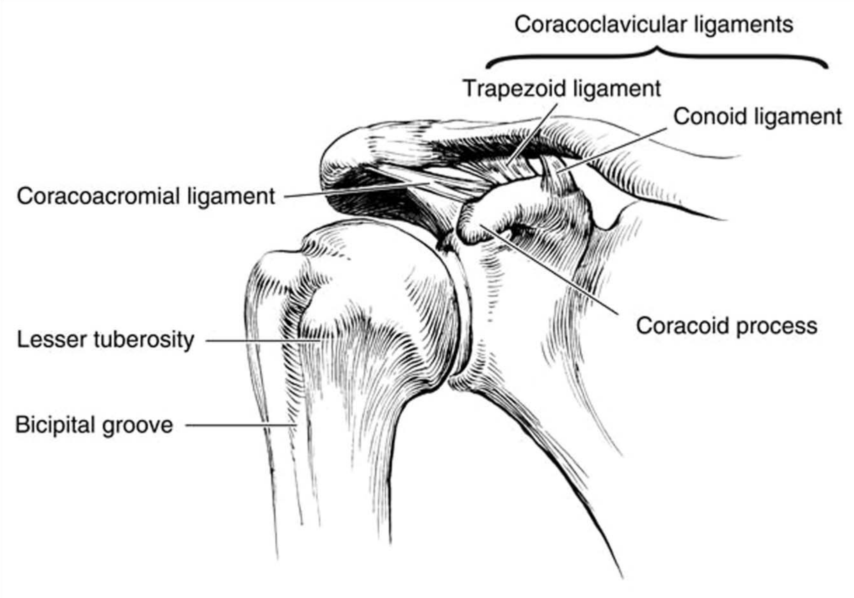
Most acromioclavicular (AC) joint injuries occur in young athletes, often resulting from a direct fall onto the superior aspect of the shoulder when the arm is adducted.[1] More than 60 surgical procedures have been described for the management of AC joint injuries, with hundreds of biomechanical and anatomic studies supporting their utilization. Treatment is typically nonsurgical for Rockwood type I and II injuries and surgical for type IV and VI injuries. Controversy surrounds the indications for nonsurgical versus surgical treatment of type III and V injuries.[1,2] This article will provide an overview of the clinically relevant anatomy and biomechanics of the AC joint and will review treatment considerations for AC joint injuries.

Anatomy

The AC joint is a diarthrodial joint comprising the distal, flattened end of the clavicle and the medial aspect of the acromion process of the scapula[2] (Figure 1). The clavicle articulates with the acromion via the medial facet, which is orientated posterolateral, whereas the articular surface of the acromion faces anteromedial.[3] On average, the AC joint is approximately 9 mm in length from superior to inferior and 19 mm in depth from anterior to posterior.

The AC joint relies on both dynamic and static stabilizers. Static stabilizers include the capsule and its associated ligaments, including the superior, inferior, anterior, and posterior AC ligaments. The AC ligaments originate

Figure 1



Schematic drawing demonstrating the anatomy of 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 (Reproduced with permission from Simovitch R, Sanders B, Ozbaydar M, Lavery K, Warner JJ: Acromioclavicular joint injuries: diagnosis and management. *J Am Acad Orthop Surg* 2009;17:207-219.)

Figure 2

A **B**

Anatomic dissection depicting (**A**) the locations of the conoid and trapezoid ligaments (coracoclavicular, or CC, ligaments); the CC ligaments resist superior-inferior and anterior-posterior motions and (**B**) the gross anatomy of the acromioclavicular joint. Courtesy of Jorge Chahla, MD PhD.

from the anteromedial edge of the acromion and attach to the lateral aspect of the clavicle. The coracoclavicular (CC) ligaments, while not directly attached to the acromion, serve to further stabilize the AC joint. The CC ligaments include the conoid ligament medially and the trapezoid ligament laterally[4] (Figure 2). The conoid ligament originates at the base of the coracoid process of the scapula and attaches on the conoid tubercle located on the most posterior aspect of the clavicle, where the middle third of the clavicle curves into the lateral third. The trapezoid ligament originates from the superior aspect of the coracoid process and attaches to the trapezoid ridge anterolateral across the inferior surface of the clavicle, lateral to the conoid insertion.[3] As noted by Rios and colleagues, the distance from the lateral edge of the clavicle to the medial edge of the conoid tuberosity is 47.2 ± 4.6 mm in males and 42.8 ± 5.6 mm in females, whereas the distance to the center of the trapezoid tuberosity is 25.4 ± 3.7 mm in males and 22.9 ± 3.7 mm in females[5] (Table 1).

Biomechanics

Numerous studies have investigated the biomechanical properties of the AC joint. The clavicle rotates approximately 5° to 8° relative to the acromion as a result of simultaneous scapuloclavicular motion.[6] In a study of 12 human cadaver shoulders, Fukuda et al[4] evaluated the contributions of the AC and CC ligaments to joint stability under stress loading. The authors reported that the AC ligaments serve primarily to resist posterior translation of the clavicle and posterior axial rotation, regardless of the degree of joint displacement. The conoid ligament was shown to primarily resist anterior and superior translation of the clavicle, whereas the trapezoid ligament had lesser contributions with movement of the clavicle horizontally and vertically, except when the clavicle underwent axial compression toward the acromion. Importantly, although vertical stability is mediated mainly by the CC ligaments, Dawson et al[7] demonstrated that the AC ligaments provide notable stabilization in an anterior-posterior direction.

The AC joint capsule, particularly the posterosuperior capsule, is important in resisting excessive posterior translation, as noted in a cadaver study conducted by Klimkiewicz et al.[8] The authors' data suggest that overly

Table 1

Anatomy of the Ligaments Involved in Stabilizing the AC Joint

Ligament	Origin	Attachment	Function	Notes
AC	Anteromedial edge of the acromion	Lateral aspect of the clavicle	Provides horizontal stability	Flattened tissue that joins superior surface of the AC joint capsule
Superior				
Posterior				
Anterior				
Trapezoid (CC)	Upper coracoid process	Oblique ridge on the inferior clavicle	Provides vertical stability (less than the conoid ligament)	Broad, thin, and quadrilateral; lateral to conoid
Conoid (CC)	Base of the coracoid process	Conoid tubercle on the inferior clavicle	Provides vertical stability (more than the trapezoid ligament)	Dense and conical; medial to trapezoid
CA	Lateral border of the coracoid	Anterior and inferior surface of the acromion just anterior to the clavicular articular surface	Forms part of the coracoacromial arch preventing superior migration of the humeral head	Strong, dense, triangular band

AC = acromioclavicular, CA = coracoacromial, CC = coracoclavicular

aggressive distal clavicle excision with disruption of the posterosuperior capsule may result in increased posterior clavicle translation, creating iatrogenic AC joint instability. Others have reinforced these findings, with Renfree and Wright[3] reporting that distal clavicle resection of as little as 2.3 mm in women and 2.6 mm in men can completely release the AC ligament attachment points, thus destabilizing the AC joint.

Classification System

The original classification systems describing AC joint injuries were put forth by Tossy et al[9] and Allman[10] included three grades. The Rockwood Classification built on this, separating grade III injuries into grades III to VI based on the degree and direction of displacement of the distal aspect of the clavicle[11] (Table 2). The Rockwood Classification system is essentially based off of the severity of injuries to the AC and CC ligaments, and it is important to remember when classifying these injuries that the normal CC distance is approximately 1.1 to 1.3 cm.[12] Notably, in 2014, the ISAKOS Upper Extremity Committee published a consensus statement on the classification of AC joint injuries and suggested subdividing grade III injuries into type IIIA (stable) and type IIIB (unstable).[13] The committee stated that type IIIB lesions continue to cause pain, weakness, decreased flexion and abduction, and scapular dyskinesis and may warrant earlier surgical stabilization compared with type IIIA lesions. Specialized diagnostic imaging, including dynamic axillary radiographs demonstrating notable horizontal plane instability, can be used to identify these unstable type IIIB lesions.[14]

Patient Evaluation

History

AC joint injuries may be the result of direct or indirect trauma. Most commonly, patients describe falling directly onto the superolateral aspect of the shoulder with the arm in an adducted position. In the setting of indirect trauma, patients will describe falling onto an outstretched hand, resulting in pain localized to the AC joint.[1] Patients will often complain of painful shoulder motion and the presence of a deformity, particularly in type V and IV injuries.

Physical Examination

Physical examination should begin with a visual inspection of both shoulders, noting any asymmetry between the injured and uninjured shoulders, which most often appears as a "bump" because of superior translation of the distal clavicle relative to the acromion. The shoulder should be inspected while hanging unsupported at the side to accentuate any potential deformities owing to the weight of the arm. The sternoclavicular joint, glenohumeral joint, and cervical spine should be assessed in all patients with AC joint injuries to rule out concomitant injuries. A thorough neurovascular assessment

Table 2

Summary of the Rockwood Classification System for AC Joint Injuries

Type	AC Ligament Injury	CC Ligament Injury	Deltotrapezial Fascia	Clinical Findings	Radiographic Findings
I	Intact	Intact	Intact	AC tenderness; no obvious visible deformity	Normal
II	Ruptured	Incomplete injury	Mild injury	Pain with motion, clavicle unstable in the horizontal plane possibly displaced A/P	Lateral end of the clavicle slightly elevated. Stress views approximately 25% separation
III	Ruptured	Ruptured	Mild to moderate injury	Clavicle unstable in both horizontal and vertical planes, extremity adducted, and acromion depressed relative to the clavicle Clavicle appears "high-riding"	Plain radiographs and stress radiographs abnormal—25%-100% separation. In reality, the acromion and upper extremity are displaced inferior to the lateral clavicle
IV	Ruptured	Ruptured	Injured as the clavicle is posteriorly displaced	Possible skin tenting and posterior fullness; AC joint irreducible on PE	Clavicle displaced posteriorly on axillary view, possibly penetrating the trapezius muscle
V	Ruptured	Ruptured	Injured and stripped off clavicle	More severe vertical incongruity than III injury, shoulder with severe droop; if shoulder shrug does not reduce, then type V injury	100% to 300% increase in the clavicle-to-acromion distance
VI	Ruptured	Mild injury, usually intact	Possible injury	Rare inferior dislocation of the distal clavicle for high-energy hyperabduction, ER injury; accompanied by other severe injuries; transient paresthesias; always evaluate for neurovascular injury	Clavicle lodged behind the intact conjoined tendon

AC = acromioclavicular, A/P = anterior/posterior, CC = coracoclavicular, ER = external rotation, PE = physical examination

should always be done to evaluate for brachial plexus and/or vascular injuries.

Tenderness to palpation directly over the AC joint is the most common examination finding in patients with AC joint injuries; however, numerous special examination maneuvers have also been described. The crossed-arm adduction and active compression tests are two well-described tests, with the cross-arm adduction test yielding the highest sensitivity and the active compression test yielding the highest specificity.[15] Additional commonly used provocative maneuvers for AC joint pathology include forced passive internal rotation behind the back, forced adduction with internal rotation (Hawkins-Kennedy sign), and the horizontal resisted extension test.[16]

The physical examination is critical in differentiating a type III from a type V injury, which has important implications for clinical decision making. These injuries can be distinguished based on the integrity of the deltotrapezial fascia, which can be evaluated by having the patient shrug their shoulders. This motion will reduce type III injuries, but will not reduce type V injuries. Horizontal stability of the AC joint can be assessed with the examiner placing their thumb and index finger on either side of the midshaft of the clavicle and the opposite hand on the acromion for stabilization and then slowly shucking the clavicle anteriorly and posteriorly.[2]

Imaging Studies

Diagnostic workup should begin with a standard trauma series of

Table 3

Summary of the Main Diagnostic Imaging Modalities for Acromioclavicular Joint Injuries and Clinical Notes Regarding Their Utilization

Modality	Clinical Utility	Notes
Radiograph	A/P: evaluates vertical CC displacement	Tauber protocol (Zanca, axillary, and dynamic lateral views): performed in the arm abducted to 90°, radiograph point at the axilla first in 0° of flexion and then in 60° of flexion
	Axillary: evaluates A/P displacement (type IV injuries)	The Tauber protocol affords better visualization of dynamic horizontal stability
	Zanca: cephalic tilt angle (10°-15°) for alternative view (helpful to get bilateral views)	Stress radiographs uncommonly used because of pain
MRI	More detailed visualization of ligamentous and soft-tissue structures	The authors have demonstrated incongruence between MRI and radiographic interpretations often with MRI demonstrated less significant injury

A/P = anterior/posterior, CC = coracoclavicular

radiographs.[17] Additional specialized views including anterior-posterior stress views and Zanca views are helpful (Table 3). As noted by Minkus et al,[18] the modified bilateral Alexander views can be helpful to quantify dynamic posterior translation in patients with AC joint instability. In some cases, MRI can be useful to evaluate for any additional intra- and/or extra-articular glenohumeral joint pathology (Table 3). Concomitant pathology associated with AC joint injuries can be variable and includes glenohumeral joint pathology in 15% to 50% of patients with high-grade AC joint separations.[19,20]

Treatment Options

The treatment of AC joint injuries is based on the injury severity (grade) and chronicity. Treatment is typically nonsurgical for type I and II injuries and surgical for type IV and VI injuries. The indications for surgery for type III and V injuries remain controversial.

Type I and II Injuries

Nonsurgical treatment is recommended for nearly all patients with type I and II AC joint injuries.[1,21] Type I injuries can often be managed with immobilization in a simple sling for 1 to 3 weeks, whereas a longer course of sling immobilization may be necessary for type II injuries. Other nonsurgical treatment modalities include nonsteroidal anti-inflammatories, activity modification, physical therapy, and cryotherapy. Physical therapy can be initiated within the first 2 weeks to improve range of motion, after which time gentle strengthening exercises can be introduced.[1,21] Contact sports and heavy lifting are typically avoided for 1 month, but return to full activities can take as long as 2 to 3 months. In a study of 134 patients with an average 6.3-year follow-up, Park and colleagues found that patients with type I injuries were immobilized in a sling for an average of 19.5 days, with symptoms lasting approximately 6 weeks. Patients with type II injuries were immobilized for an average 27 days, with symptoms also lasting approximately 6 weeks.[22] In some cases, patients with type I and II AC joint injuries may not experience complete resolution of symptoms within 2 to 3 months (Table 4). As noted by Mikek, up to half of patients with type I and II injuries can experience some amount of shoulder pain or dysfunction 10 years after injury.[23] For patients with recalcitrant shoulder pain, distal clavicle excision may be helpful in patients with type II injuries.[24]

Type III Injuries

The optimal management of type III AC joint injuries continues to be controversial. Although very few level I or II studies are available to guide clinical and surgical decision making, multiple lower-level studies have been published favoring nonsurgical approaches.[25,26] In addition, several studies on physician preferences for the management of these injuries have been published.[27] In 2006, Nissen and Chatterjee[27] described their findings from a mail-in survey sent to all members of the American Orthopaedic Society for Sports Medicine and Accreditation Council for Graduate Medical Education orthopaedic residency program directors assessing management preferences for type III injuries. The authors found that 81% of American Orthopaedic Society for Sports Medicine respondents and 86% of residency program directors preferred

Table 4

Summary of Clinical Outcomes of Nonsurgical Management of Type I and II ACJ Injuries

Authors	Methods	Results
Mouhsine et al.[29]	33 patients with acute type I and II injuries treated with ice, analgesics, and sling immobilization at an average 6.3-yr follow-up	9 patients (27%) progressed to undergo surgical intervention.
	29 patients (85%) were athletes.	Of the remaining 24 patients, 17 (52%) remained asymptomatic at final follow-up.
Shaw et al.[30]	47 patients with grades I or II (Allman) injuries treated with analgesics and broad-arm sling immobilization	40% of patients reported significant pain at 6-mo follow-up.
		20% reported restricted ROM at 6 mo.
		Positive correlation found between symptoms at 6 mo and those persisting beyond 1 yr ($P < 0.01$)
Mitek[23]	23 patients with type I or II injuries evaluated at an average 10.2-yr follow-up after nonsurgical treatment	52% reported at least occasional symptoms
		Constant score ($P < 0.001$), SST ($P < 0.002$), and UCLA Shoulder Scale ($P < 0.001$) were all significantly lower in injured shoulder compared with contralateral.
		Demonstrates potential for ACJ injuries to have long-term effects

ACJ = acromioclavicular joint, ROM = range of motion, SST = Simple Shoulder Test, UCLA = University of California, Los Angeles

nonsurgical management for uncomplicated type III AC joint injuries.

Nonsurgical management of type III injuries uses the same approach as described previously for type I and II injuries, although the duration of sling immobilization is likely to be longer, approaching 3 to 4 weeks.[23,28-30] In a series of 44 patients with type III AC joint injuries managed nonsurgically, Dias et al[31] reported good-to-excellent outcomes in all but one patient at 5 years after injury. Although 82% of patients in their cohort had an obvious deformity at the AC joint and 55% had lingering AC joint symptoms, these variables did not result in any functional deficits or limitations. More recently, Schlegel et al[32] reported 25 patients with type III AC joint injuries treated in a sling with early progressive motion. The authors found no limitations of shoulder motion and no appreciable strength differences between the injured and uninjured shoulders in 20 of the 25 patients at 1 year after injury. In 2016, Petri et al[17] compared clinical outcomes in a series of patients who progressed to surgery after initial nonsurgical management of type III AC joint injuries to patients who did not require surgery. Twenty-nine of 41 patients in their cohort were successfully managed with nonsurgical treatment, whereas 12 patients (30%) progressed to surgical intervention for persistent symptoms at a median of 42 days after initiation of nonsurgical therapy. The authors found no significant differences in follow-up outcome scores between the two cohorts; however, the cohort that underwent surgical intervention did have decreased Single Assessment Numeric Evaluation and Short Form-12 Physical Component Scores compared with patients treated nonsurgically.

Some authors have advocated for surgical management of acute type III injuries, especially in younger, active patients who place higher demand on their shoulder girdles with overhead sports.[26] In a recent review evaluating surgical versus nonsurgical management for these injuries, Smith et al[33] found that surgical management resulted in a markedly better cosmetic result, but was also associated with a greater duration of sick leave compared with nonsurgical management. Notably, no significant differences in postintervention strength, pain, ability to throw overhead, or incidence of AC joint arthritis were identified between the two groups.

In a different systematic review, Beitzel et al[34] analyzed 14 articles comprising 706 patients with type III AC joint injuries, with an average follow-up of 67 months for patients undergoing surgical management and 58 months for patients undergoing nonsurgical treatment. The authors reported favorable clinical outcomes in 88% of the patients treated surgically and in 86% of the patients managed nonsurgically. The authors found that patients managed nonsurgically had quicker recoveries, allowing them to return to work and/or sport faster than those managed surgically.

Type IV, V, and VI Injuries

Surgical intervention is almost always recommended for patients with Rockwood type IV and VI injuries. As noted in the previous section, similar to type III injuries, controversy remains with respect to type V injuries. Many factors must be considered when deciding on surgical versus nonsurgical management for these injuries, including the status of the surrounding skin and soft tissue, medical comorbidities, and expectations/goals of the patient, including any desire to return to contact sports.

The Canadian Orthopaedic Trauma Society[35] recently conducted a multicenter randomized clinical trial evaluating surgical versus nonsurgical management of type III, IV, and V AC joint separations. Their cohort contained 83 patients, 40 of whom were randomized to surgical intervention with hook plate fixation. The authors found no significant differences between the groups in Disabilities of the Arm, Shoulder, and Hand or Constant scores at both 1 and 2 years after injury; however, scores were better in the nonsurgical cohort at earlier time points (6 weeks, 3 months, and 6 months [Constant score only at 6 months]). In addition, the authors reported 14 complications (seven major and seven minor) in the surgical cohort, with only three complications (two major and one minor) in the nonsurgical group.

Notably, several authors have also discussed the utilization of nonsurgical treatment for management of type V injuries. Dunphy et al[36] evaluated 22 patients with type V AC joint injuries after nonsurgical management. At the time of final radiographic follow-up (average 7.7 months), the average CC distance had decreased 7.2 ± 4.2 mm, and further, at the time of final clinical follow-up (average 34.3 months), 77% of patients were working, with 41% in manual labor positions. At final clinical follow-up, American Shoulder and Elbow Surgeons scores and Disabilities of the Arm, Shoulder, and Hand scores were 63 and 28, respectively. The authors concluded that nonsurgical management of type V injuries can allow patients to return to activities of daily living and return to work, despite lower patient-reported outcome scores.

Surgical Techniques

More than 60 surgical techniques for the management of appropriately indicated patients with AC joint injuries have been described; however, the superiority of a single technique has not been clearly defined to this point. A summary of these techniques is provided in Table 5. For acute, unstable AC joint injuries, the AC joint can be stabilized via repair and reconstruction techniques. For the management of chronic, symptomatic AC joint injuries, reconstruction techniques are preferred because the soft tissues are typically not amenable to direct repair. When analyzing investigations comparing different techniques, it is widely accepted that nonanatomic reconstructions are biomechanically inferior to anatomic reconstructions.[37] Importantly, despite these biomechanical findings, pending the specific technique used, anatomic reconstruction does pose a clinically relevant increase in clavicle (and potentially coracoid) fracture risk, which must be taken into account when considering treatment options, particularly for collision athletes.

Open Reduction and Internal Fixation

Historically, surgical management of AC joint separations involved open reduction and internal fixation with a variety of different fixation constructs, including screws, pins, sutures, wires, plates, and hook plates. Hook plates evolved into a more popular method of fixation because of complications seen with Kirschner wires and pins,[38,39] but typically require removal at 8 to 16 weeks after placement. Because of the risk of complications after open reduction and internal fixation, particularly with pin fixation, alternative management options have been developed as described in the following sections.

Coracoacromial Ligament Transfer (Weaver-Dunn) ± Distal Clavicle Excision

Weaver and Dunn[40] initially described their technique for surgical stabilization of the AC joint in 1972. Their technique involves excising the distal end of the clavicle, release of the coracoacromial (CA) ligament from its acromial attachment, and transfer of the CA ligament to the superior aspect of the remaining distal end of the clavicle. Biomechanically, this repair construct is substantially weaker compared with native CC ligament strength, and clinically, failure rates as high as 30% have been described.[41,42]

Modified Weaver-Dunn

Because of the high failure rates associated with the Weaver-Dunn technique, many surgeons have described modifications to the Weaver-Dunn technique to improve the reduction of the AC joint in an effort to improve overall stability, particularly during the early stages of healing.[43] Among the many Weaver-Dunn modifications, one common technique involves the detachment of CA ligament from the acromion with or without a bony attachment, followed by transfer to the clavicle with augmentation of a suture loop for further protection of the healing

Table 5

Summary of Commonly Described Surgical Techniques for ACJ Stabilization

Surgical Techniques	Advantages	Disadvantages	Complications
Primary open repair	Good visualization	Highly invasive	Frequently develop arthritis
Open reduction and internal fixation	Solid reduction	Larger incision	Implant migration
			Acromion osteolysis or fracture
			Persistent pain
Weaver-Dunn	Anatomic reduction	Relatively weak stabilization of the distal clavicle	Retearing of ligaments
DCE (distal 2 cm)	Improved integrity of CC ligaments over primary open repair	Inferior CC ligaments strength to normal	Clavicular fractures
CA ligament transfer to the clavicle			Distal clavicle hypertrophy
Repair CC ligaments			Persistent pain
Repair Deltotrapezial fascia			
Modified Weaver-Dunn (augmentation of CC interval)	Anatomic reduction	Potential for graft ruptures, clavicular fractures	Same as Weaver-Dunn
Suture loop	Improved protection of CA and CC ligaments		
Cerclage	Improved strength and stability of repair comparable to normal anatomy		
Allograft	Numerous augmentation options available		
Autograft			
Synthetics			
Arthroscopic reconstruction	Minimally invasive	Less than ideal visualization at time	Same as Weaver-Dunn
	Improved ability to diagnose concomitant pathology	Some approaches are nonanatomic, resulting in weaker biomechanics.	

CA = coracoacromial, CC = coracoclavicular, DCE = distal clavicle excision

ligament.[2] Others have described augmentation of the transposed CA ligament with cerclage wires, transposed screw fixation, and synthetic materials. Another technique involves reconstructing the CA ligament using a semitendinosus tendon autograft in concert with distal clavicle excision.[44] In a cadaver study of 42 shoulders randomly assigned to arthroscopic AC joint reconstruction, anatomic CC reconstruction, or a modified Weaver-Dunn procedure, Mazzocca et al[41] found that the modified Weaver-Dunn procedure resulted in markedly greater laxity compared with the other two groups. Notably, no differences were found in load to failure or superior migration after superior cyclic loading of 70 N for 3,000 cycles.

Anatomic Coracoclavicular Reconstruction

A variety of surgical techniques aimed at restoring the CC ligaments as close as possible to their native anatomic locations have been described. Jones et al[45] initially described an open technique in which two tunnels in the distal clavicle were created at the footprints of the conoid and trapezoid ligaments, allowing for anatomic recreation with tendon grafts through each tunnel and either around or through the coracoid. Both autograft and allograft (typically semitendinosus) tissues can be used for these techniques. The grafts can be secured with interference screws or cortical buttons along the clavicle (Figure 3 to 5; Video 1, Supplemental Digital Content 1, http://links.lww.com/JAAOS/A291).

Nonanatomic Coracoclavicular Reconstruction

As described previously, nonanatomic AC joint reconstructions are considered biomechanically inferior compared with anatomic reconstructions.[37] Despite these biomechanical findings, nonanatomic reconstructions can be advantageous as the risk of postoperative clavicle fracture is reduced as less drill holes (in some cases, no drill holes) are used. Nonanatomic AC joint reconstruction can be performed via either arthroscopic or open techniques and typically uses a tissue graft looped under the coracoid and tied over the top of the clavicle (or placed through a single drill hole) to create a sling construct.

Arthroscopic and Arthroscopic-Assisted Techniques

A variety of arthroscopic and arthroscopic-assisted techniques have been described for the treatment of unstable AC joint injuries. Although these techniques are associated with reduced surgical site morbidity and an improved ability to diagnose and manage concomitant glenohumeral and subacromial joint pathology, some of these approaches are nonanatomic and thus may not restore native joint kinematics. In 2005, LaFosse and colleagues described an all-arthroscopic CA ligamentoplasty technique for the treatment of AC joint separations.[46] Specifically, the authors describe dissecting the CA ligament from the undersurface of the acromion and reattaching it to the inferior aspect of the clavicle via transosseous suture fixation, with possible wire or screw augmentation for further stability. Boileau et al[47] described an all-

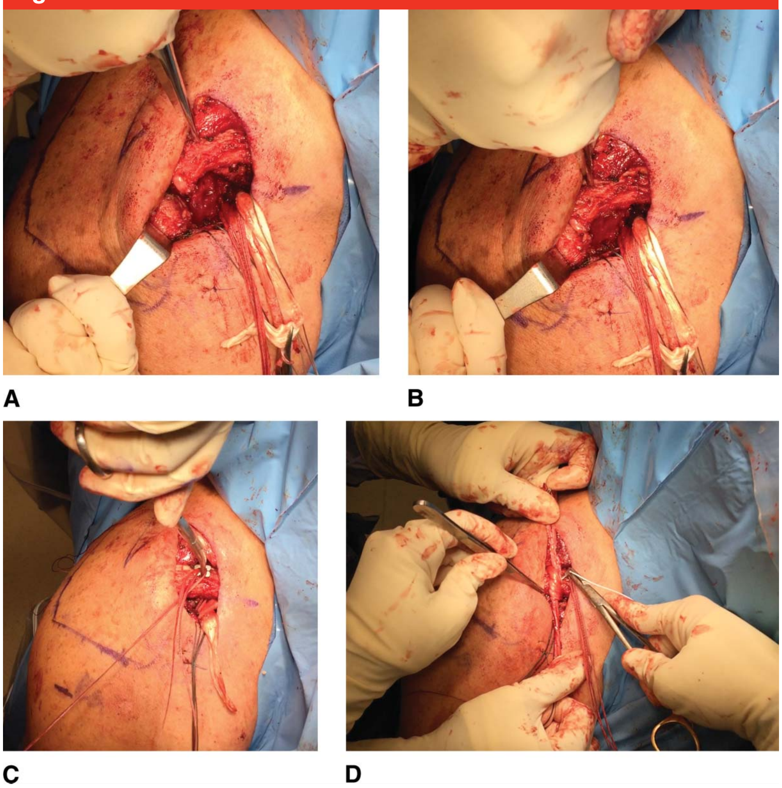
Figure 3

Preoperative radiograph of a 40-year-old man with a right grade III acromioclavicular joint separation who presented with chronic right shoulder pain after a previous injury sustained by falling from a bike.

Figure 5

Postoperative radiograph of a 40-year-old man after undergoing acromioclavicular joint reconstruction with a suture-button construct and semitendinosus allograft

Figure 4



Intraoperative photographs taken during acromioclavicular joint reconstruction of a 40-year-old man with a suture-button construct and semitendinosus allograft including **A,** joint appearance before reduction, **B,** joint appearance after reduction, **C,** placement of suture button device and graft passage, and **D,** suturing of graft after graft passage.

Table 6

Summary of Common Failure Mechanisms for Surgical Techniques and Offered Solutions

Surgical Technique	Reasons for Failure	Solutions
Primary AC and CC fixation	Pin and implant migration	Do NOT use smooth pins
	Suture pullout	Bend pins if they are necessary to case
	Implant pullout	Remove migrating pins promptly
	Coracoid and clavicular fracture	
Weaver-Dunn	Laxity of the repair over time (loss of reduction)	Revise anatomic CC reconstruction with graft (many options exist)
	Persistent pain, weakness, and instability	Revision CA ligament transfer has also been described
Anatomic reconstructions	Clavicular failure (fracture through a drill hole)	Consider nonsurgical management if minimal displacement of clavicle fracture
	Midsubstance graft failures	Consider revision anatomic fixation with allografts and possible temporary ACJ pin fixation
	Coracoid fractures	Consider alterative fixation with anchors or buttons
Arthroscopic techniques	Suture breakage	Revision anatomic fixation with or without allograft augmentation
	Button pullout through the coracoid	Consider alternative fixation with suture anchors

AC = acromioclavicular, CA = coracoacromial, CC = coracoclavicular, ACJ = acromioclavicular joint

arthroscopic technique for CC ligament reconstruction in 10 patients with Rockwood type III or IV AC joint injuries in which the CA ligament is rerouted with a bone block harvested from the tip of the acromion into a socket at the distal clavicle. The authors augmented their reconstruction with two titanium buttons connected in a four-strand configuration. Tauber et al[48] recently described an arthroscopically assisted triple-bundle autologous semitendinosus graft reconstruction of the CC ligaments. The technique is described as "triple" bundle because it not only reconstructs the native conoid and trapezoid ligaments as separate ligamentous structures but also reconstructs the AC ligament with a third bundle.

Other arthroscopic and arthroscopic-assisted techniques using high-strength nonabsorbable suture with button constructs, with or without graft augmentation, have also been described.[49] Biomechanical studies have demonstrated comparable load strength between a commercially available suture-button construct (two-system TightRope device; Arthrex) and that of the native CC ligaments.[50]

The Role of Acromioclavicular Ligament Repair

In addition to the techniques described in the previous sections, direct AC ligament repair has also been described, typically as an adjunct to CC ligament reconstruction. The proposed advantage of direct AC ligament repair, regardless of the specific technique chosen, is a reduction in horizontal AC joint instability after surgery, although clinical outcomes after direct AC ligament repair are unknown.[51-53] Described techniques for direct AC ligament repair use tendon grafts or high-strength nonabsorbable suture or suture-tape material.[51-53]

Complications

Complications can result from both surgical and nonsurgical management of AC joint injuries, with higher complication rates and more serious complications occurring after surgical intervention. Complications described after nonsurgical management include the late development of AC joint arthrosis, persistent AC joint instability, cosmetic deformity, and distal clavicle osteolysis.[1,2] After surgical management, complications include infection, neurovascular damage, and especially with early surgical techniques involving smooth pins and wires, implant migration resulting in neurovascular and/or cardiopulmonary injury.[38,39] Other complications include failed reconstruction (coracoid fracture, graft ruptures, and clavicle fractures), suture granulomas, implant pain, adhesive capsulitis, and implant failure.[54]

Although most patients experience good-to-excellent outcomes after AC joint reconstruction, failures unfortunately do occur. Clavert et al[55] conducted a prospective multicenter study to evaluate types of failure

Table 7

Summary of Recent Clinical Outcomes Studies for ACJ Treatment Techniques

Authors	Methods	Results
Assaghir[58]	56 patients with Rockwood type III-V acute injuries treated with anatomic repair of clavicular muscle and ligament attachments with CC lag screw fixation (76.6-mo follow-up)	Good-to-excellent long-term clinical outcomes in 94.6% (ASES, UCLA, and DASH scores)
		CC distance not significantly different than the contralateral side
Bostrom Windhamre et al.[59]	Compare W-D augmented with the PDS loop suture (n = 23) to W-D with a temporary hook plate (n = 24)	Constant score 10 points lower in the hook plate group (*P* = 0.21)
	Minimum 1-yr follow-up	The hook plate group had more painful movement on the VAS (*P* = 0.003).
Canadian Orthopaedic Trauma Society[35]	RCT of surgical repair with hook plate fixation (n = 40) versus nonsurgical treatment (n = 43) for acute (<28 d) ACJ injuries.	DASH scores better in the nonsurgical group at 6 wk (*P* = 0.014), 3 mo (P = 0.005) but not at 6 mo or 1 yr
	Follow-up to 24 mo	Constant scores better in the nonsurgical group at 6 wk, 3 mo, and 6 mo (*P* = 0.0001)
		The surgical group had 14 complications, whereas the nonsurgical group had 3.
Venjakob et al.[60]	23 patients undergoing anatomic two suture-button fixation for acute ACJ injury	96% were satisfied or very satisfied.
	Average 58-mo follow-up	VAS (0.3 ± 0.6) and Constant scores (91.5 ± 4.7) improved markedly to baseline levels.
		8 radiographic failures and 4 CC distance overcorrections
Carofino and Mazzocca[61]	17 patients treated with anatomic CC ligament reconstruction with ST allografts	The ASES score increased from 52 to 92 (*P* < 0.001).
	Average 21-mo follow-up	The Constant score increased from 66.6 to 94.7 (*P* < 0.001).
		Average SANE score 94.4
		3 failures in series: 1 due to loss of reduction
Faggiani et al.[62]	16 patients with acute ACJ injuries: half treated with the MINAR mini-open procedure and half with the arthroscopic Dog Bone Button (Arthrex)	Objective aspect of the Constant score significantly better in the arthroscopic technique (*P* < 0.001)
	Average follow-up 13 mo	Constant score, Oxford Shoulder Score, and SST all improved from baseline
		Arthroscopic group RTS better than mini-open (*P* < 0.05)
Tauber et al.[48]	26 patients with chronic high-grade ACJ injuries treated with autologous hamstring grafts arthroscopically	The Constant score improved in both groups (*P* < 0.009).

(*continued*)

AC = acromioclavicular, ACJ = acromioclavicular joint, ASES = American Shoulder Elbow Surgeons, CC = coracoclavicular, DASH = Disabilities of the Arm, Shoulder, and Hand, MINAR = Minimally Invasive Reconstruction of the Acromioclavicular Joint, PDS = polydioxanone suture, RCT = randomized controlled trial, RTS = return to sport, RTW = return to work, SANE = Single Assessment Numerical Evaluation, SST = Simple Shoulder Test, ST = semitendinosus, UCLA = University of California, Los Angeles, VAS = visual analog scale, W-D = Weaver-Dunn

Table 7 (*continued*)

Summary of Recent Clinical Outcomes Studies for ACJ Treatment Techniques

Authors	Methods	Results
	12 patients under anatomic triple-bundle CC reconstruction; 14 single-bundle CC reconstruction; used AC GraftRope system	No intergroup difference in the Constant score
	Average follow-up 29 mo	Taft score significantly better in the triple-bundle group (*P* = 0.018)
		No radiographic difference in the CC distance between groups
		Triple bundle had superior horizontal stability (*P* = 0.011).

AC = acromioclavicular, ACJ = acromioclavicular joint, ASES = American Shoulder Elbow Surgeons, CC = coracoclavicular, DASH = Disabilities of the Arm, Shoulder, and Hand, MINAR = Minimally Invasive Reconstruction of the Acromioclavicular Joint, PDS = polydioxanone suture, RCT = randomized controlled trial, RTS = return to sport, RTW = return to work, SANE = Single Assessment Numerical Evaluation, SST = Simple Shoulder Test, ST = semitendinosus, UCLA = University of California, Los Angeles, VAS = visual analog scale, W-D = Weaver-Dunn

after arthroscopic primary anatomic CC ligament reconstruction with cortical button fixation in 116 patients with a minimum 1-year follow-up. The authors reported 32 clinical failures (defined as Constant score <85) and 48 radiographic failures (defined by 50% loss of reduction on an AP radiograph). Notably, no significant association was found between age, sex, body mass index, professional activity, delay to surgery, type of injury, and length of immobilization in predicting clinical failures; however, higher body mass index and delay to surgery (1.6 versus 1.2 weeks) were shown to be associated with a higher incidence of radiographic failure. Recently, Spencer et al[37] compared rates of revision surgery and radiographic failure in four different AC joint surgical techniques: modified Weaver-Dunn (N = 26), allograft fixed through coracoid and clavicular tunnels (N = 17), allograft loop CC fixation (N = 69), and combined allograft loop with cortical button fixation (N = 42). The authors reported an overall radiographic failure rate of 21.4%, with the patients undergoing combined allograft loop with cortical button fixation having the lowest overall failure rate at 4.8% (*P* = 0.001). Solutions for managing failed AC joint reconstruction failures depend on technique used for the index reconstruction and the mechanism of failure. In the setting of coracoid fracture, salvage reconstruction with hook plate fixation has been described.[56] More recently, Virk et al[57] have described a coracoid bypass procedure. A complete analysis of common reasons for repair failure and offered solutions can be found in Table 6.[35,48,58-62]

Rehabilitation

After surgical stabilization of the AC joint, the shoulder is typically kept immobilized in a sling for 2 to 4 weeks, at which time patients may begin passive motion below the level of the shoulder under the supervision of a physical therapist. Strengthening is permitted once full motion is achieved, typically initiated between 6 and 8 weeks after surgery. Return-to-sport guidelines following the surgical management of AC joint injuries depend in large part on the initial injury severity and type of surgical stabilization performed. Return to contact sports is typically not permitted for a minimum of 4 to 6 months after surgery.

Clinical Outcomes

Using modern surgical techniques/implants and with appropriate indications, clinical outcomes after AC joint stabilization are generally good to excellent, with low overall failure rates and high return-to-sport rates. A summary of recently reported clinical outcomes studies is provided in Table 7.

Summary

Despite increases in biomechanical and outcomes research over the past several decades, controversy continues to exist regarding optimal treatment strategies for type III and V injuries. Multiple surgical techniques are available, each with associated advantages, disadvantages, and potential complications. Surgical decision-making must be conducted on an individual basis, with the patient's injury severity, desire to return to sport/activity, and willingness to comply with the postoperative rehabilitation protocol all taken into consideration. Given recent advances in surgical techniques and implants, additional research analyzing the biomechanical properties and clinical outcomes, complications, and failures rates is warranted.

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