New insights in the treatment of acromioclavicular separation

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Abstract
A direct force on the superior aspect of the shoulder may cause acromioclavicular (AC) dislocation or separation. Severe dislocations can lead to chronic impairment, especially in the athlete and high-demand manual laborer. The dislocation is classified according to Rockwood. Types Ⅰ and Ⅱ are treated nonoperatively, while types Ⅳ, Ⅴ and Ⅵ are generally treated operatively. Controversy exists regarding the optimal treatment of type Ⅲ dislocations in the high-demand patient. Recent evidence suggests that these should be treated nonoperatively initially. Classic surgical techniques were associated with high complication rates, including recurrent dislocations and hardware breakage. In recent years, many new techniques have been introduced in order to improve the outcomes. Arthroscopic reconstruction or repair techniques have promising short-term results. This article aims to provide a current concepts review on the treatment of AC dislocations with emphasis on recent developments.

Key words: Acromioclavicular dislocation; Rockwood classification; Coracoclavicular ligament reconstruction; Hookplate; Arthroscopically assisted acromioclavicular reconstruction; Weaver and Dunn procedure; Conoid and trapezoid ligaments

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Core tip: Current literature suggests that the decision for treatment of type Ⅲ injuries should be made on a case-by-case basis, with an emphasis on initial nonoperative treatment. Early operative treatment for grades Ⅲ-Ⅵ dislocations may result in better functional and radiological outcomes than delayed surgery. There are numerous surgical techniques presented in the literature. The authors prefer an autograft tendon reconstruction of the coracoclavicular joint without bone tunnels in combination with direct suture fixation of the acromioclavicular joint. Arthroscopic techniques are evolving but there is currently
no evidence to support arthroscopic over open surgery.

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INTRODUCTION

The interest in acromioclavicular (AC) joint injuries dates back to the time of Hippocrates (460-377 BC) and Galen (129-199 AD). These ancestors already noted the difficulties in correctly diagnosing and treating this type of injury. Naturally, many developments have been made since then. New insights have led to the introduction of numerous treatment techniques during the past few decades. However, to date, much controversy still exists, and the optimal treatment is not available yet. Moreover, the best timing of surgery remains a topic of debate. This current concepts review aims to provide an up-to-date and evidence-based overview of relevant treatment options for AC joint dislocations, with special emphasis on most promising recent techniques.

Etiology

AC joint dislocations are common injuries among an athletic population. They account for approximately 12% of injuries of the shoulder girdle. The patient is typically male, < 30 years of age and involved in (contact) sports. The typical trauma mechanism is a force that depresses the shoulder girdle, such as occurs during a fall from a cycle or during a collision in contact sports. The force depresses the scapulohumeral complex (rather than the clavicle being elevated), resulting in tears of the AC ligament and the coracoclavicular (CC) ligaments. Associated shoulder injuries are present in 18% of patients with type III to V dislocations; superior labral anterior posterior (SLAP) lesions being the most common.

Anatomy

The AC joint is a diarthrodial joint, consisting of a thin cartilage surface and an interposed fibrocartilaginous meniscoid disk. The joint capsule or AC ligament (i.e., thickenings in the capsule) and the extracapsular CC ligaments provide static stability. Physiologic forces and the weight of the arm place significant translational forces in the vertical, anteroposterior and axial planes of the AC joint. Based on cadaveric studies, the AC ligaments contribute 20% to 50% of resistance to superior migration and 90% to anterior-posterior translation. The CC ligaments are formed by the conoid medially and the trapezoid laterally. They are the primary restraint to inferior and medial translation of the scapulohumeral complex in relation to the clavicle. The conoid ligament is attached proximally on the posteroomedial undersurface of the clavicle, typically 4.5 cm from the AC joint (47.2 mm in men and 42.8 mm in women). It tensions under loads that force the clavicle superiorly (or the acromion inferiorly). The trapezoid attaches proximally on the anterolateral aspect of the inferior clavicle, approximately 2.5 cm from the joint (25.4 mm in men and 22.9 mm in women). It tensions under medialization of the scapulohumeral complex, i.e., compression of the AC joint. The deltoid fascia provides dynamic stabilization to the AC joint, especially the anterolateral deltoid insertion.

Symptomatology

Patients commonly present with pain at the AC joint, following a trauma such as a fall on the shoulder. The pain is often accompanied by soft tissue swelling as well as a prominent lateral clavicle. Because of the pain, shoulder motion is reduced and patients are limited in their daily and athletic activities. Chronic instability of the AC joint can lead to tremendous impairment of shoulder function including muscle fatigue, scapular dyskinesia, subjective sensation of heaviness of the injured upper limb, and painful horizontal adduction.

DIAGNOSIS

The history and physical examination often provide clues to the diagnosis. The patient frequently reports a fall on the shoulder or a collision and has pain localized at the AC joint and often the trapezius muscle (pars ascendens). The patient may also note a swelling, which can be confirmed on physical examination. The patient is examined while standing or sitting. On inspection, a high lateral clavicle can be seen, compared to the uninjured side. The AC joint is tender on palpation. One should compare with the uninjured side. The shoulder range of motion is usually reduced because of the pain in the acute phase. The examiner should check the stability of the AC joint in the superior-inferior and anterior-posterior directions. For types III and V, the joint feels unstable when the lateral clavicle is depressed manually ("piano key" phenomena). The shoulder is passively adducted in the horizontal plain to test anterior-posterior stability (Figure 1). Chronopoulos et al. reported a sensitivity of 77% for the cross body adduction test, 72% for the AC resistance test and 41% for the active compression test; the combination of all 3 tests showed a specificity of 95%.

Standard radiographs of the shoulder are obtained, including a true anterior-posterior view, a scapular Y lateral view, an axillary view (or Velpeau view modification if unable to abduct the arm), and a Zanca view of the AC joint (performed by tilting the X-ray beam 10° to 35° toward the cephalic direction and using only 50% of the standard shoulder anteroposterior penetration strength) (Figure 2). It may be useful to obtain radiographs of the opposite side for comparison. A bilateral Zanca view visualizes the ipsilateral and contralateral AC joints on one
X-ray cassette, while the same orientation of the beam is maintained\(^9\) (Figure 2). In addition, a cross-body adduction radiograph may differentiate between a stable and unstable AC joint by assessment of the degree to which the clavicle overlaps the acromion\(^10\). The additional value of stress views with distal traction by weights on the arms is questionable. More precise imaging techniques, such as computed tomography or magnetic resonance imaging, are normally unnecessary, unless associated injuries are suspected.

The radiographic images are assessed on the relation between acromion and clavicle, as well as the CC distance, ideally comparing left and right. Associated injuries of the shoulder girdle must be ruled out.

**CLASSIFICATION**

Rockwood has made a classification that is used the most widely nowadays (Figure 3)\(^11,12\). In type I, neither AC nor CC ligaments are disrupted. In type II, the AC ligament is disrupted and the CC ligament is intact (50% vertical subluxation of the distal clavicle). In type III, both ligaments are disrupted. In type IV, the ligaments are disrupted and the distal end of the clavicle is displaced posteriorly into or through the trapezius muscle. An auxiliary radiographic view is particularly helpful in identifying type IV injuries. In type V, the ligaments and muscle attachments are disrupted, and the clavicle and acromion are widely separated. In type VI, the ligaments are disrupted, and the distal clavicle is dislocated inferior to the coracoid process and posterior to the conjoint tendon. Type VI lesions are extremely rare but do occur\(^13\). Reproducibility and interobserver reliability of the classification is only moderate and is likely limited by the inability of a classification based on plain radiographs to fully assess a soft tissue injury\(^14\).

In practice, the difference between type III and V can be subtle and confusing. There is no clear definition or consensus on how to differentiate between these types. A suggested definition is 25% to 100% superior displacement of the distal clavicle in type III dislocations and 100% to 300% displacement in type V\(^15,16\). Others describe more than 100% clavicle displacement in type III and more than 300% displacement in type V\(^7\). The CC distance can also be used to differentiate between the two types (CC distance 20% or 25% to 100% of contralateral side in type III; CC distance more than 100% of the contralateral side in type V)\(^7\).

The International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) Upper Extremity Committee has made a subdivision of type III dislocations in order to better identify patients who would benefit from surgery\(^15\). Type III A is defined as a stable AC joint with normal scapular function and no overriding of the clavicle on the cross-body adduction view. Type III B is defined as unstable with scapular dysfunction and an overriding clavicle on the cross-arm adduction view. However, it is unclear to what extent this subdivision predicts treatment outcomes.
TREATMENT

There is general agreement that types I and II injuries should be treated nonoperatively in all cases\(^2\). Most authors suggest that types IV, V and VI should be treated operatively\(^5,7\). In contrast, type III separations have caused much debate during the past decades. In the past, many type III lesions were treated surgically. However, it has turned out that there is no clear superior outcome after surgical treatment\(^17,18\). Operative treatment of type III is sometimes reserved for high-demand laborers and athletic patients\(^17\). Most surgeons now generally agree that nonoperative treatment is indicated initially in all patients with type III injuries; if unsuccessful, operative reconstruction of the AC and CC ligaments can be provided at a later stage\(^19,20\).

Nonoperative

Nonoperative treatment is indicated for types I and II dislocations and consists of temporary immobilization with a sling or collar and cuff for 1 to 3 wk. Early range-of-motion exercises are encouraged. Daily and athletic activities are resumed when the pain permits. Heavy lifting and contact sports are usually postponed until 6 wk. Unsatisfactory outcomes in conservative treatment may be explained by persistent instability, especially a horizontal component of instability\(^21\).

Open surgery

Numerous surgical repair or reconstruction techniques have been published. In 2013, the number of different surgical techniques described was 162\(^22\). These techniques can basically be grouped in four categories: (1) Fixation of the AC and/or CC with hardware including screws and K-wires; (2) hook plates; (3) fixation of the CC with suture buttons; and (4) reconstruction of the CC ligaments with autograft or allograft tendon\(^16\). Whichever construct is used, it needs to maintain the
reduction long enough for the biological healing process to be able to take place.

**Hardware fixation:** Previously, temporary trans-articular K-wire fixation of the AC joint has been used in combination with direct ligament repair. However, this technique has led to unsatisfactory outcomes, including K-wire breakage, migration and loss of reduction. Likewise, CC cerclage or screw fixation such as the Bosworth screw have led to unacceptable risk of screw breakage. Some remove the screw after 6 to 8 wk to avoid this complication. Even with adequate screw positioning, hardware failure and obligatory screw removal have decreased the popularity of this technique.

**Hook plate fixation:** The hook plate is a metal device that keeps the AC joint in a reduced position by hooking its tip under the acromion and fixing it to the clavicle with screws. It can be used alone or in conjunction with other methods of ligament repair.

The joint separation is either reduced and then the hook plate is positioned, or the hook plate is inserted with the hook under the posterior aspect of the acromion and then pushing the plate segment against the distal end of the shaft of the clavicle, in that way levering the clavicula downwards. Most of the time the 4-hole (shortest) hook plate can be used. Either the hook can be adjusted to the morphology of the acromion or the plate can be adjusted to the morphology of the distal clavicle.

The advantage of this technique is that it provides a strong and stable construct. There are case series that report acceptable results of hook plate fixation. A disadvantage is that the plate crowds the subacromial space, causing subacromial impingement, rotator cuff lesions, and even acromial stress fractures due to the hook. The hook makes a pinpoint contact with the undersurface of the acromion, which might explain why complications commonly occur after hook plate fixation. Furthermore, pain or discomfort is experienced because of the hardware. Because of these reasons, removal of the plate is routinely required after 3 to 4 mo, making a second operation necessary. This in turn can lead to loss of reduction.

The Canadian Orthopaedic Trauma Society recently completed a multicenter-randomized clinical trial involving hook plate fixation vs nonoperative treatment of 83 AC dislocations. Disability and Constant scores were better in the nonoperative group after 3 mo but the differences disappeared at 1 and 2 years. In contrast, radiographic reduction was better in the operative group at all time points but there were more complications and reoperations in this group. The necessity of implant removal, uncertain superiority over nonoperative management, and the higher incidence of complications are important considerations of hook plate fixation.

**Suture button CC fixation:** Suture buttons have been introduced as an alternative to simple suture fixation to anatomically repair the CC ligaments. These devices consist of two metal buttons that are connected by thick nonabsorbable sutures. The buttons are locked behind
the clavicle and coracoid drill holes and the sutures function as the CC ligaments\[16,26\]. Biomechanical studies have shown that suture buttons have comparable biomechanical strength as compared to the native ligaments\[26,27\].

The technique has the advantage of allowing minimally invasive implantation as well as sustaining some range of motion between clavicle and scapula. However, single CC suture button fixation has appeared to be biomechanically inferior to the native CC ligaments in vivo\[26\]. The single-button technique has resulted in high failure rates due to knot slippage, suture breakage, button migration, fractures\[28-30\] and large or misdirected drill holes\[31\] as well as failure to address the AC joint capsule\[31-33\]. Because of high rates of failure with the use of single buttons, the use of multiple suture buttons is now advocated to restore both the conoid and trapezoid ligaments (improving horizontal and vertical instability) and reduce the failure risk\[29\]. For example, Struhl and Wolfson\[34\] used a mini-open technique with a continuous loop double endobutton in combination with a lateral clavicle resection. Recently, these authors have added a figure-of-8 ultratape suture through drill holes in the acromion and clavicle to directly augment AC joint stability\[34\].

Suture button fixation has several advantages, particularly the ability for minimal soft tissue disruption and generally satisfactory outcomes. However, caution should be used as these constructs have been associated with remaining anterior-posterior instability and a risk of hardware issues\[35\]. Suture button fixation has higher shoulder function scores and lower postoperative pain when compared to hook plate fixation; however, there are higher complication rates\[26\].

**CC ligament reconstruction:** The Weaver and Dunn procedure was first described in 1972 and utilizes the native coracoacromial (CA) ligament in AC joint reconstructions. This technique involves the distal clavicle excision in combination with transfer of the CA ligament from the acromion to the distal clavicle remnant in an attempt to restore AC stability\[37\]. The procedure has been studied extensively, demonstrating up to a 30% failure rate and only approximately 25% biomechanical strength when compared to intact CC ligaments\[16,38\].

The modified procedure supplements the ligament transfer with a direct CC fixation or hook plate\[38,39\]. There are a few studies that reported inferior results of the modified procedure compared to anatomic CC ligament reconstruction technique using autogenous semitendinosus graft\[40-43\].

The utilization of autograft or allograft for the anatomic reconstruction of the CC ligament or semitendinosus autograft to reconstruct the anatomical CC ligament with that of reconstructions with CA ligament or free tendon grafts. They reported that tendon grafts had strengths equivalent to the native CC ligament strength, and were significantly stronger than the CA ligament reconstruction.

There are numerous techniques to reconstruct the CC ligaments. Mazzocca et al\[38,44\] used a semitendinosus autograft to reconstruct the anatomical configurations of the trapezoid and conoid ligaments, as well as the AC ligaments, without use of supplemental CC or AC stabilization. With this technique, the lateral 1 cm of the clavicle is excised. A soft-tissue tunnel is created under the coracoid. Two bony tunnels are drilled in the clavicle; one 4.5 cm from the AC joint (positioned slightly posteriorly to reconstruct the conoid ligament) and one 2.5 cm from the AC joint (positioned slightly anteriorly to reconstruct the trapezoid ligament). The graft is passed through the tunnels in a figure-of-eight fashion, and fixed proximally using interference screws while the AC joint is reduced with upper displacement of the scapulohumeral complex. Finally, the lateral limb of the graft is sutured to the acromion to reconstruct the AC ligament.

We use an autograft tendon reconstruction technique of the CC joint without bone tunnels in combination with direct suture fixation of the AC joint (Figure 4). The semitendinosus tendon is harvested. A Sabelhouw incision is made and the lateral clavicle is resected. A double nonabsorbable suture is passed through small drill holes in the lateral clavicle and the acromion for AC joint repair. The coracoid process is exposed through the deltopectoral interval. The semitendinosus tendon is directed under the coracoid and over the clavicle for CC joint repair (it is passed from the medial aspect of the coracoid to the posterior aspect of the clavicle to mimic the conoid ligament and from the lateral aspect of the coracoid to the anterior aspect of the clavicle to mimic the trapezoid ligament). The AC joint is reduced by elevation of the arm, the AC joint sutures are tightened, and the semitendinosus is secured with interrupted nonabsorbable sutures over the clavicle. Advantages of this technique without bone tunnels or interference screws are low costs, avoidance of iatrogenic fracture risk, no foreign body use (except for sutures), and the same biomechanical strength as anatomic repair with bone tunnels\[45\]. We have treated 23 patients with Rockwood type 4 or 5 lesions with use of this technique, of whom five were failures from elsewhere. All patients indicated that they would undergo the procedure again and were satisfied with the cosmetic outcome. They were able to participate in work and sports without restrictions. Two complications occurred; one patient had a temporary frozen shoulder and another had a recurrence due to a fall after 6 wk.

**Arthroscopic surgery**

Minimally invasive AC joint reconstruction and repair techniques have been developed since the introduction of arthroscopic shoulder surgery. Although arthroscopically assisted AC reconstruction should be used by skilled arthroscopists only, it has the possible advantages of the minimally invasive nature, direct visualization of
the reduction and placement of coracoid fixation, the possibility to address additional pathologies, and the deltoid-trapezial fascia can remain attached. A further advantage of arthroscopic treatment is a diagnostic glenohumeral arthroscopic evaluation. Concomitant injuries are common in AC joint dislocations and may occur in up to 20%-25% of patients.

Suture button fixation is typically used with arthroscopically assisted AC repair. Initially, one button was used for repair. Murena et al. described arthroscopic treatment of type III-IV acute AC dislocation with a double flip button. They found excellent clinical results in terms of Constant score (mean 97 points) and patient satisfaction, but a disappointing radiological result with a partial loss of reduction due to distal migration of the flip button within the upper third of the clavicle in one-fourth of the cases, at a mean follow-up of 31 mo. However, because of a high failure risk of one-button repair, either multiple suture buttons or augmentation techniques are used nowadays.

An example of a multiple suture button technique is that by Imhoff et al.: Anatomic CC ligament reconstruction utilizing double Tight Rope (Arthrex Inc., Naples, FL, Italy) suspensory fixation. This dual anatomic technique aims to reproduce the native conoid and trapezoid ligaments. The surgical procedure is begun with a diagnostic shoulder joint arthroscopy, followed by arthroscopic preparation of the coracoid undersurface through the rotator interval. After a guided superior skin incision and AC joint reduction, the conoid and trapezoideal tunnels are drilled with use of a drill guide system. The two TightRope devices are inserted through the tunnels and fixated. The longest follow-up case series of double suture button fixation in 23 patients reported a high satisfaction rate (96%) after 58 mo but eight radiographic failures were noted.

An example of augmentation in arthroscopic-assisted reconstruction of AC joint instability is the technique by DeBerardino et al.: CC ligament reconstruction with an allograft augmented GraftRope (Arthrex Inc., Naples, FL, Italy) system. This technique utilizes an arthroscopically placed fixation with a GraftRope construct augmented with an allograft (or autograft) centrally. After glenohumeral joint arthroscopy, the subacromial bursa is debrided and the AC joint visualized. Joint reduction is checked with fluoroscopy. Following clearance of the coracoid base, the tunnel is drilled with use of a drill guide through a small incision over the clavicle. A semitendinosus or tibialis tendon is passed through the implant system before it is inserted with use of a passing suture. An interference screw is placed between the graft limbs for final construct fixation.

A technique to perform the Weaver-Dunn procedure in an all-arthroscopic way is described by Boileau et al. This procedure also starts with debridement of the undersurface of the base of the coracoid process through the rotator interval. Then the scope is moved to anterior, where the CA ligament is released from the acromion (with a chip of bone remained attached to the ligament). Thereafter, a lateral clavicle resection is performed, and the medullary canal of the clavicle is enlarged and deepened with a burr. Then, the CC reduction and

Figure 4 Intra-operative pictures of an autograft tendon reconstruction technique of the coracoclavicular joint without bone tunnels in combination with direct suture fixation of the acromioclavicular joint. A: The lateral clavicle is resected, and a double nonabsorbable suture is used for AC joint repair; B-D: A semitendinosus tendon is passed under the coracoid and over the clavicle for CC joint repair. AC: Acromioclavicular; CC: Coracoclavicular.
fixation is performed with use of a double-button system. Finally, the bone-ligament transfer of the CA ligament is pulled in the created cavity of the lateral clavicle and fixed through a second drill hole on the superior cortex. A mean follow-up of 36 mo is now available for a group of 57 patients\(^5\). Two patients experienced a recurrent dislocation and 6 patients a partial loss of reduction. The Subjective Shoulder Value ranged from 54% to 85%, and 96% of the patients were satisfied with the procedure and the cosmesis\(^5\). There are no randomized controlled trials comparing the outcomes of open vs arthroscopically assisted or all-arthroscopic techniques. Arthroscopic techniques in case series are relatively safe procedures, with equivalent outcomes to open surgery, but demonstrate a distinct complication profile\(^29,46,47,52,58\). Arthroscopic suture button techniques generally demonstrate good radiographic outcomes but significant hardware irritation.

**Postoperative management**

The rehabilitation programs differ between surgical techniques. In general, a sling is provided and progressive range-of-motion exercises up to 90 degrees elevation are begun early after surgery for 6 wk. After this initial period, range-of-motion and strengthening exercises are gradually increased. Non-contact sports can be resumed after 3 mo. Generally, contact athletes are allowed unrestricted sport activities after 6 mo.

**TIMING OF SURGERY**

Accurate reduction in AC dislocation is considered easier when surgery is performed earlier after injury\(^5\),\(^6\),\(^60\). However, there is no clear definition of early and delayed surgery. Rockwood and Young\(^12\), have noted that acute pain generally disappears 2-3 wk after an AC dislocation. Therefore, approximately 3 wk seems a clinically relevant dividing line.

A recent review of Song et al\(^6\) summarized eight studies comparing acute and delayed surgical treatment of AC dislocation. The dividing line between early and delayed surgery was defined as 3, 4 and 6 wk after injury. They concluded that early surgery (< 3 wk) has better reduction and clinical outcomes than delayed surgical treatment (> 3 wk) and no significant difference in the complication rate\(^6\). The studies included in this review used several different methods of reconstruction and this limits the strength of this conclusion.

Delayed surgery is necessary for patients with AC dislocations that failed conservative treatment or with intolerance for early surgical treatment. Adam et al\(^3\) reported higher rates of deformity recurrence and poorer functional outcome in chronic cases. On the other hand, other studies report satisfactory results after surgical treatment of chronic AC dislocations\(^48,52,59,61\).

In conclusion, early surgery for grade III - V dislocations may result in better functional and radiological outcomes, with a reduced risk of loss of reduction compared with delayed surgery\(^7,54,60\). However, a nonoperative trial period of 6 mo seems justified for type III lesions, based on high satisfaction rates and normal functionality in 80% of patients\(^62\). For example, Rolf et al\(^43\) treated patients early at a mean of 10, or delayed at a mean of 7.7 mo (after failure of conservative treatment).

**OUTCOMES**

Many shoulder scoring systems are used to determine functional outcomes in the literature. Unfortunately, none of these is specific for AC dislocations. In a review of eight studies, more than 30 shoulder scoring systems were applied\(^60\). This makes reliable comparison of studies difficult.

A Cochrane review in 2010 reported data from three studies (174 participants) and found no significant difference in movement, strength, or function between surgically and conservatively treated patients\(^54\). Another review in 2013, which specifically looked at Rockwood type III AC dislocations in eight studies (247 participants), showed the objective and subjective shoulder function outcome was better in the operative group (especially in young adults), though the rate of complications and radiographic abnormalities were higher\(^17\). The rehabilitation time was shorter in the conservative group but the cosmetic outcome was worse.

AC dislocation is a typical sports related injury\(^65\). Therefore, resumption of sports and work are important outcome aspects. Recently, a retrospective review of Dunphy et al\(^66\) showed that most patients (77%) were able to return to work following nonsurgical management of type \(\nabla\) injuries after six months but had limited functional outcome scores. Patients who are treated nonoperatively for a Rockwood type III AC dislocation need roughly half the time to return to work and sport, compared with patients treated operatively\(^23,7,67\). Manual workers treated surgically returned to work after an average of 11 wk, compared with 4 wk after nonsurgical treatment\(^67\). Gstettner et al\(^68\), however, reported that operative treatment of Rockwood type II AC dislocation resulted in more patients returning to the same level of activity at work (82% vs 63%). The level of sports did not differ (67% vs 65%). In Rockwood type \(\nabla\), overhead athletes require more time to resume their sports activity\(^69\). In minimally invasive anatomic CC reconstructions of type III AC dislocation, 100% return to sports rates has been reported; however, the influence of type of sport was not considered\(^56,70\).

The main concern when comparing outcome data is the lack of long-term outcome studies. We performed a literature search of comparative studies with a minimum of 4 years of follow-up (Table 1). We found five studies and classified the operative techniques in the four categories described above\(^39,52-59\). There were one randomized controlled trial and four retrospective cohort studies. The studies described early and delayed treatment of type \(\nabla\) dislocation, as well as different operative techniques. Generally, few statistically significant differences were found between the groups.
(Table 1). The main differences included more pain experienced by patients treated with a hookplate vs PDS sutures, a better reduction and less complications after early reconstruction vs late reconstruction, and better Constant scores in allograft vs artificial ligament reconstruction. Literature showed no conclusive evidence for outcome of conservatively or operatively treatment of Rockwood type III - V AC dislocations. Overall, physically active young adults seem to have a slight advantage in outcome when treated operatively. Randomized controlled trials that compare long-term outcomes of nonoperative treatment with different surgical techniques are needed in order to draw firm conclusions.

### COMPLICATIONS

Patients with complications have significantly lower clinical scores, suggesting that the presence of complications appears to be the only predictor of poorer clinical outcomes. Complications after surgical treatment range from 27% to 44%; the main being infection (4% to 8%), hardware complications (4%), and further surgery (13%). In a recent review of four studies, 12 (13%) complications were found in 96 patients after early surgery and 14 (18%) complications are occurred in 79 patients after delayed surgery.

Hookplate fixation has an overall complication rate of 11% and an infection rate of 5%. Long-term retention of the plate may lead to acromial osteolysis or fracture, which implies that a second surgery is required to remove the plate after 3 mo, when the ligaments have healed.

Clavert et al prospectively reported a complication rate of 27% in 116 primary anatomic button fixations. There were 16 cases of hardware failure resulting in symptoms or loss of reduction. Forty-eight patients also had persistent dislocation of > 150%. Singh reported secondary progressive loss of reduction in 7 out of 9 patients after a mean of 3.1 mo. Three patients underwent revision.

Millet et al presented a review of 12 studies that reported complications following anatomic CC ligament reconstruction with biologic grafts and described an overall complication rate of 40%. The most serious complications were graft failure, hardware complications, and distal clavicle and/or coracoid fractures as a result of the bone tunnels. Coracoid/clavicle fractures remain a significant complication that occur predominately in techniques utilizing bone tunnels.

The rate of surgical complications in the literature following arthroscopic reconstruction of the CC ligaments varies from 13% to 27% and can reach 40% if postoperative loss of reduction is taken into account. The five most commonly documented complications of arthroscopic fixation are superficial infection (4%), shoulder pain (27%), CC calcification (32%), fracture (5%), and loss of reduction (27%). Thus, many studies have reported postoperative loss of reduction (17% to 80%) after open anatomic reconstruction.

### Table 1 Characteristics of comparative studies with a minimum 4-yr follow-up

| Ref. | Type of study | LE classification | Operative technique (No. of patients) | Category1 | FU (yr) | Outcome |
|------|---------------|-------------------|--------------------------------------|-----------|---------|---------|
| Boström Windham et al2010 | Retrospective case control | III | Delayed type III-V (47) | Weaver-Dunn and PDS suture (23) | 3 | 6.1 | Constant score: P > 0.05; SPADI: P > 0.05 |
| Kovilazhikathu Sugathan et al2012 | Retrospective cohort | IV | Early type III (7) | Open reduction and internal fixation + tension band wiring (7) | 1 | 6.3 | OSS: P = 0.05; Complications: 71% (early), 9% (delayed) |
| Motta et al2012 | Retrospective case control | III | Delayed type III-V (34) | CC reconstruction with LARS (34) | 3 | 5.4 | Reduction: P < 0.05 (in favor of early reconstruction) |
| Fauci et al2013 | RCT | I | Delayed type III-V (40) | Allograft (semitendinosus) (20) | 4 | 4 | Constant score: P = 0.01 |
| Jensen et al2014 | Retrospective comparative study | III | Early type III-V (56) | Hookplate (30) | 2 | 4 | VAS: P > 0.05 |

1Statistically significant difference (P < 0.05); 2Four categories: (1) fixation of the AC and/or CC with hardware including screws and K-wires; (2) hook plates; (3) fixation of the CC with sutures or suture buttons; and (4) reconstruction of the CC ligaments with autograft or allograft tendon. LE: Level of evidence; FU: Follow-up; SPADI: Shoulder pain and disability index; QuickDASH: Disabilities of the arm, shoulder and hand score; VAS: Visual analogue scale; OSS: Oxford shoulder score; LARS: Ligament augmentation and reconstruction system; RCT: Randomised controlled trial; SST: Simple Shoulder Test; TR: Tight rope.
reconstruction with autogenous tendon graft or arthroscopic assisted fixation with suture buttons. However, a partial loss of reduction does not appear to influence the overall functional results.

Nowadays, the cosmetic outcome is becoming more and more important for patients. However, the surgeon should consider the preference of a better cosmetic outcome against the higher complication rate in surgically treated patients.

RECENT DEVELOPMENTS

There has been an exponential increase in the number of publications on surgical AC joint reconstruction and repair over the past few years. Recent studies have concentrated on minimally invasive or arthroscopic anatomical reconstruction of the CC ligaments. Although many improvements have been made, some questions still remain: How many drill holes are needed in the coracoid and clavicle? Which type of graft should be used? And, should only the CC ligaments be reconstructed or both the CC and AC?

Bone tunnels are commonly used for anatomic reconstruction of the CC ligaments. Because the conoid and trapezoid ligaments attach in different areas of the clavicle and the coracoid, making two holes in both bones looks appealing. However, the use of multiple tunnels is technically demanding and increases fracture risk. Jerosch et al. in a biomechanical study evaluated eight different AC reconstruction techniques. They found the best restoration of anatomy with suture anchor fixation in the base of the coracoid process.

The historical choice of material for stabilization of the CC ligament mainly depends on the clinical setting and timing of surgery, with synthetic material (sutures or tape) in the acute and tendon graft in the chronic injury. Today, most surgeons agree that a biological augmentation is required in chronic cases to enhance the healing potential of the torn structures. Laboratory studies have shown that anatomic reconstruction with double graft tendons have native-like biomechanical properties and clinical data are promising.

Since horizontal instability of the AC joint may result in chronic pain and functional shoulder impairment, there is a raising focus on the relevance of specific techniques to improve horizontal stability. Schneibbel et al. described persistent horizontal instability in 41% of cases after isolated CC double ligament stabilization, and developed an all-arthroscopic, radiographically assisted technique that uses a triangular AC cerclage in conjunction with the CC reconstruction to provide better horizontal stability. Saier et al. showed biomechanically that only combined AC and CC reconstruction can adequately restore physiological horizontal AC joint stability. In addition, a recently published study showed that triple-bundle reconstruction including AC graft augmentation yielded superior clinical and radiological outcome than single-bundle CC reconstruction.

CONCLUSION

The aim of the current review was to provide an up-to-date and evidence-based overview of relevant treatment options for AC joint dislocations.

The recently published literature has significant limitations, namely a paucity of high quality trials and long-term follow-up. Most of the studies include heterogeneous populations with varying severities and chronicity of injury. Also, the existence of many different surgical techniques prevents the drawing of firm evidence-based conclusions.

The available evidence does provide some important clues. Operative treatment of Rockwood III AC joint dislocations results in better cosmetic and radiological results and similar function but longer time off work and increased complication rates compared with conservative treatment. Current literature suggests that the decision for treatment of type III injuries should be made on a case-by-case basis, with an emphasis on initial nonoperative treatment. Early operative treatment for grades III-V dislocations may result in better functional and radiological outcomes, with a reduced risk of infection and loss of reduction compared with delayed surgery.

Various operative techniques have been described. However, most techniques do not anatomically restore the complex articulation of the AC joint. Anatomical CC ligament reconstruction may result in optimal functional and radiological outcomes. The conoid and trapezoid ligaments have unique anatomic alignments and different functions. Each ligament should be considered during operative treatment.

Arthroscopically assisted AC reconstruction has the possible advantages of the minimally invasive nature, better visualization of the coracoid and the possibility to detect associated glenohumeral lesions, but demonstrates a distinct complication profile in the less experienced arthroscopist. There is currently no evidence to support arthroscopic rather than open surgery, as comparative studies are not available.

Further studies are needed especially in terms of randomized controlled trials and long-term outcomes to confirm stability of the AC joint and optimal functional results.

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