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INJURIES IN OVERHEAD ATHLETES (J DINES AND C CAMP, SECTION EDITORS)

Acromioclavicular joint injuries in overhead athletes: a concise review of injury mechanisms, treatment options, and outcomes

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Abstract

Purpose of the review To review the relevant literature surrounding acromioclavicular (AC) joint injuries particularly pertaining to overhead athletes.

Recent findings The AC joint is a unique anatomic and biomechanical portion of the shoulder that can be problematic for athletes, particularly throwers, when injured. Treatment of these injuries remains a topic in evolution. Low-grade injuries (Rockwood types I & II) are typically treated non-operatively while high-grade injuries (types IV, V, and VI) are considered unstable and often require operative intervention. Type III AC separations remain the most controversial and challenging as no clear treatment algorithm has been established. A wide variety of surgical techniques exist. Unfortunately, relatively little literature exists with regard to overhead athletes specifically.

Summary Treatment of AC joint injuries remains challenging, at times, particularly for overhead athletes. Operative indications and techniques are still evolving, and more research is needed specifically surrounding overhead athletes.

Keywords Acromioclavicular joint injuries · Acromioclavicular separation · Overhead athletes

Introduction

Acromioclavicular (AC) joint injuries are common in the athletic and non-athletic community, encompassing a wide range of pathology including sprains, fractures, and physeal injuries. Particularly in overhead athletes, evaluation and management requires special attention to function and return-to-play (RTP) as efficiently and safely as possible. The biomechanics of the overhead throwing motion places tremendous demand on the glenohumeral (GH) and AC joints, making these athletes a unique subset compared with AC injuries in the general population. The following discussion seeks to update the reader on management of these injuries in overhead athletes.

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Anatomy and biomechanics of the AC joint

The AC joint is a true diarthrodial joint between the convex lateral clavicle and the concave medial acromion. The clavicle begins to ossify before any other bone and froms three separate centers—two primary (medial and lateral body) and one secondary (sternal) center. The acromial ossification centers appear by age 14 to 16 and fuse by 18 to 25 years, while the coracoid is ossified from two centers beginning at 12 to 18 months and fusing around the same time as the acromion [1]. The ends of the lateral clavicle and medial acromion are covered in hyaline cartilage, often transitioning to primarily fibrocartilage by the second to third decade of life. Within the AC joint is a fibrocartilaginous, intra-articular disk thought to function similar to a meniscus in the knee. While this succumbs to age-related degeneration in the second and third decade of life, it does pose a risk for injury in the young, active patient.

The clavicle braces the upper limb at a fixed distance from the axial skeleton in an effort to allow optimal movement and power of the upper extremity, possible only through the clavicle's attachment to the scapula at the AC joint. Stability at the AC joint has several contributions. Most stability comes from the scapuloclavicular attachments via the coracoclavicular

(CC) ligaments and AC joint capsule—comprised of anterior, posterior, and superior and inferior components. This capsule primarily provides horizontal (anterior-posterior) stability. Studies have shown that distal clavicle resection of as little as 10 mm may result in 32% increase in posterior translation although it is unknown to what extent horizontal instability becomes clinically relevant [2]. The CC ligaments include the more medial conoid and more lateral trapezoid ligaments, which are approximately 4.5 and 3 cm medial to the AC joint, respectively [3, 4]. While they are primarily responsible for vertical stability of the distal clavicle, cadaveric studies have suggested independent function of the conoid and trapezoid ligaments [5]. Of lesser importance but still requiring consideration is the dynamic stabilization provided by the trapezius and the anterior head of the deltoid. And while we often simplify the function of the AC and CC ligaments as anterior-to-posterior and superior-to-inferior stabilizers, respectively, lateral clavicle stability is significantly more complex, as can be seen from results of past experimental cadaver investigations [6, 7] as well as historical fixation technique failures.

Motion about the AC joint can be described as primarily a gliding motion, with minimal rotational component. As the upper extremity raises, the clavicle elevates 11–15° and retracts 15–29°. Rotation about the clavicle can be up to 40 to 50 degrees posteriorly with elevation of the arm at the shoulder; however, only approximately 8° of rotation occurs at the AC joint [8].

Evaluation

In overhead throwing athletes, special consideration should be given to the athlete's sport, position, frequency of repetitive overhead movements, training regimens, overall workload, frequency of rest, etc. It is often beneficial to consult the opinion of the athlete's trainer, coaches, and physical therapists on the nature of the injury and requirements to return to full function.

Physical examination should focus not only on the AC joint, but also the GH joint and scapulothoracic (ST) motion. Careful neurologic and vascular exams should always be included. Walton and colleagues have demonstrated the greatest sensitivity for detection of AC joint disorders to be direct palpation of the AC joint followed by Paxinos test [9]. The Paxinos test involves simultaneous application of anterosuperior pressure to the posterolateral acromion and posteroinferior pressure to the mid-clavicle; a positive test elicits pain over the AC joint. The commonly used cross-body adduction test, while sensitive, is fairly non-specific [10]. Local anesthetic injected into the AC joint may help identify the cause of shoulder pain in a patient with an inconclusive examination. However, injection under ultrasound or fluoroscopic guidance is preferred as incorrect needle placement can occur up to 60% of the time when performed by palpation alone [11].

Radiographic evaluation usually begins with plain films. Our typical shoulder series involves an upright AP with both shoulders on the same plate, Grashey AP, scapular Y, and axillary lateral views. The AP views help to determine the vertical stability, and the axillary lateral elucidates any posterior instability. A cross-body adduction view is used, at times, if the diagnosis is in question. Magnetic resonance imaging (MRI) is often obtained to assess for the extent of the injury as well as concomitant injuries within the GH joint, which may occur in up to 18% of cases [12].

Spectrum of pathology

Pathology of the AC joint in overhead athletes takes many forms. Some of these include acute injuries, such as sprains or "separations," or chronic degenerative conditions, such as AC arthritis or distal clavicle osteolysis. In young patients, additional consideration should be taken for injury to the intra-articular AC disk. As stated before, AC joint complaints are often accompanied by associated GH or ST pathology. We will concentrate on the management considerations for acute AC joint injuries in overhead athletes for the remainder of this review.

AC separation: classification

Most commonly used classification system for AC injuries is by Rockwood (Table 1). This considers not only the AC joint but the CC ligaments, deltoid and trapezius muscles, and the direction of dislocation of the clavicle with respect to the acromion.

One of the virtues of the Rockwood system is its application to management. It has been generally accepted that type I and II AC injuries can be managed non-operatively with brief immobilization, rest, anti-inflammatories, ice, and physical therapy. Type IV, V, and VI injuries are felt to be unstable and generally have superior outcomes using operative intervention. However, type III injuries remain controversial with no clear consensus on management.

Type I and II AC separations

There is a general consensus for non-operative treatment of type I and type II AC injuries [13–15]. Depending on pain and function, there is typically a short period of immobilization (maximum of 2 weeks) to remove stress on ligamentous structures. During that period, it is important to come out of the sling regularly for elbow, wrist, and hand motion to prevent stiffness. After this, a rehabilitation program may be implemented with emphasis on scapular control and shoulder range-

Table 1 Rockwood classification of acromioclavicular injury

Type	AC ligaments	CC ligaments	Deltotrapezial fascia	CC distance increase
I	Sprained	Intact	Intact	Normal (8.1 mm)
II	Torn	Sprained	Intact	< 25%
III	Torn	Torn	Disrupted	25–100%
IV	Torn	Torn	Disrupted	Increased
V	Torn	Torn	Disrupted	> 100%
VI	Torn	Torn	Disrupted	Decreased

of-motion and strength [16••]. Typically, athletic activities are held for 2 weeks in type I and at least 3–6 weeks in type II. However, this timeframe is often extended, based on symptoms, for overhead athletes if the injury involves the throwing shoulder due to the tremendous stress placed across the AC joint. For persistent pain, local anesthetic and/or corticosteroid injections may be considered for symptom management.

Non-operative treatment of type I and II injuries has been associated with good short-term results in the majority of patients although minimal is reported on overhead athletes specifically [17–19]. Regardless, intermediate and long-term outcome suggest that the morbidity of low-grade AC injuries may be underestimated [18, 20]. Among the United States Naval Academy population, Bergfeld and colleagues found up to 9% of type I and 23% of type II patients reported pain with limitation of activities at follow-up times up to 3.5 years [19]. Mouhsine et al. retrospectively reviewed 33 patients with type I or II AC injuries and reported nearly 50% of patients continued to be symptomatic after mean follow-up of 6.3 years [18]. In contrast, several authors do report good-to-excellent functional outcomes at mid- and long-term follow-up with 80–90% patient satisfaction [21, 22].

Type IV, V, and VI AC separations

There is relatively little by way of randomized studies with regard to high-grade AC injuries; however, McKee et al. did perform a prospective, randomized trial of operative versus non-operative treatment for type III, IV, V injuries in a generalized, non-athlete population [23]. Patients were randomized to surgery utilizing a hook plate versus non-operative treatment. Overall, both groups improved from a significant level of initial disability to a good or excellent result. DASH and Constant scores were significantly better in the non-operative group at 6 weeks and 3 months, but there was no difference at 6 months, 1 year, or 2 years. Radiographic results were superior in the operative group. Notably, this study looked only at hook plate fixation, which is less commonly utilized currently in the USA to address such injuries.

Most commonly, the management of acute high-grade AC injuries is surgical and centers on restoring stability to an inherently unstable AC joint. Despite the frequency of these injuries and this unified goal, surgical strategies remain quite varied. More than 160 operative techniques have been described—an indication that there is no clear consensus as to the optimal approach [24]. Fixation options include metal hardware (K-wires, hook plate), coracoacromial (CA) ligament transfer (Weaver-Dunn procedure), CC interval fixation with both rigid (Bosworth screw technique) and non-rigid (suspension devices with suture, flip buttons, washers) implants, and AC and/or CC ligament reconstruction (with tendon allograft or autograft). More practically, these can be divided into anatomic and non-anatomic AC joint reconstruction with more anatomic reconstructions becoming increasingly popular in recent years.

Type III AC separations

Ideal treatment of type III injuries is a matter of ongoing debate. Virk et al. summarized current concepts albeit not specifically for overhead athletes [16••]. First, incomplete reduction of the AC joint does not equate to poor outcomes. Second, chronic changes at the AC joint, such as osteolysis, distal clavicle hypertrophy, and calcification of the CC ligaments, also do not necessarily portend a poor prognosis or painful shoulder. Third, while the deformity does not completely reduce with time, it may reduce somewhat in severity. Lastly, there is a legitimate proportion of patients who do not do well with non-operative treatment although this is still not well delineated.

In an effort to enhance the clinical approach to type III injuries, the ISAKOS Upper Extremity Committee provided a more specific classification by stratifying these injuries into types IIIA and IIIB [24]. Type IIIA is defined by a stable AC joint without overriding of the clavicle on cross-body adduction x-rays and without significant scapular dysfunction. Type IIIB is considered unstable with therapy-resistant scapular dysfunction and an overriding clavicle on cross-body adduction view. Their recommendation is for initial non-operative management of all type III injuries with repeat clinical and radiographic evaluation at 3–6 weeks to determine type IIIA vs IIIB with definitive non-operative vs operative management, respectively.

Virk and colleagues reviewed 14 studies comparing operative with non-operative treatment of type III injuries with a cumulative total of 706 patients and mean duration of follow-up of 67.1 and 57.8 months, respectively [16••]. A favorable clinical outcome (defined as good or better) was reported in 88% of operative and 86% of non-operative patients. They did not find sufficient evidence to warrant recommending routine operative intervention in overhead athletes. Both return to work and RTP were quicker for the non-operatively managed patients by nearly half the time. Generalizability is cautioned, though, given the lack of high-quality studies, heterogeneity of operative techniques and limited use of validated outcome measures.

Two large reviews have demonstrated fairly equivocal outcomes for non-operative and operative management of type III injuries. A 2018 meta-analysis by Tang et al. analyzed 10 trials and found no significant differences between surgical and conservative treatment in terms of pain, weakness, tenderness, post-traumatic arthritis, restriction of strength, unsatisfactory function, and patient-reported outcome scores (Constant, UCLA, Imatani, SST, DASH, Larsen) [25••]. Conservative treatment was superior with regard to CC ligament calcification and lateral clavicle osteolysis; however, operative treatment was superior at maintaining anatomic reduction. Limiting this analysis was lack of stratification of athletes versus non-athletic populations and lack of differentiation between operative techniques. Longo et al. performed a systematic review focusing on rate of recurrence and outcome scores [26]. Fourteen studies were included for a total of 646 shoulders, which demonstrated no significant differences between conservative and surgical management in terms of postoperative osteoarthritis, persistence of pain, and mean constant scores. Postoperative loss of reduction was noted in 14% of cases; however, when evaluating only hook plate and arthroscopic suspension techniques, the rate dropped to 1.5%.

A recent national survey in the UK queried shoulder specialists for their preferred method of management of type III injuries [27]. Of the 137 responders, all initially treated conservatively. When performed, surgical intervention took place at an average of 3.8 months after injury with most surgeons using the LockDown technique, followed by Ligament Augmentation and Reconstruction Systems (LARS), hook plate, and arthroscopic cortical button fixation for acute injuries. For delayed cases, LARS, modified Weaver-Dunn, and AC resection were most commonly used after LockDown.

Timing of Surgery

There remains insufficient evidence to support either early or delayed operative treatment of high-grade AC joint injuries.

Virk et al. found that favorable outcomes were superior in the early-operative group at 91%, compared to 73% in the delayed operative group [16••]. Given the relatively small number of patients (135 early and 90 delayed) as well as the heterogenous surgical techniques, this may be difficult to generalize broadly. Particularly for overhead athletes, we recommend situational evaluation of timing should surgery be considered, and this may take into account their time in or out of the season, contract considerations among other factors.

Operative outcomes

Tauber et al. prospectively evaluated 24 patients managed with either Weaver-Dunn procedure or anatomic reconstruction of the CC ligaments and demonstrated superior outcome scores (ASES, Constant) with anatomic reconstruction and improved resistance to vertical stress loading [28]. Fraschini and colleagues compared anatomic reconstruction using a Dacron vascular prosthesis (group 1), reconstruction with the Ligament Advanced Reinforcement System (*Surgical Implants & Devices*, Arc-sur-Tille, France) (group 2), and conservative management (group 3) [29]. Operative groups demonstrated superior outcomes to non-operative. Of the operative patients, group 2 demonstrated better outcomes with 93% good or excellent results and only 3% complication rate; group 1 had 53% positive results with a 43% complication rate. Eschler et al. compared an anatomic procedure using an absorbable polydioxanone (PDS) suture sling to hook plate fixation, demonstrating no significant difference in Constant score [30]. The authors did report a more accurate, albeit not significant, restoration of CC distance in hook plate versus PDS group.

More recently, there have been several retrospective studies comparing functional outcomes of TightRope cortical button fixation (*Arthrex,* Naples, FL) versus hook plate fixation in acute type IV, V, and VI injuries. Andreani et al. found satisfactory results for both techniques with constant scores averaging 90 for TightRope fixation and 75 for hook plate [31]. Jensen and colleagues also had primarily good-to-excellent results with both fixation techniques although no significant differences between the two [32]. Natera-Cisneros and colleagues looked specifically at the effect of each technique on quality of life [33]. TightRope patients demonstrated significantly higher SF36, VAS, DASH, and constant scores as well as global satisfaction scale. There was also a significant improvement of sleep and sports activity in the TightRope group. There was no difference with regard to motion, strength, or daily living limitations. The authors attribute the comparatively worse quality of life with a hook plate to chronic irritation of the subacromial space.

Return to play

Saier evaluated RTP in a primarily recreational cohort of 42 athletes with acute, type V separations following arthroscopic fixation using a cortical fixation button with a mean follow up

31 months [34•]. All patients were able to RTP with a 62% return to prior level of performance although there was a significant decline (26%) in the frequency of activity. Notably, there was no significant difference in ability to return to either overhead or contact sports. Subjectively, 69% of patients felt capable of participating in overhead activities. Some athletes did choose to change sporting activities; however, the AC joint injury was listed as a determining factor in only half the cases.

Porschke and colleagues retrospectively reviewed 68 patients with type V injuries to determine RTP following the same single cortical fixation button technique at a median of 24 months [35•]. They found a 95% RTP rate without a difference in rate of return for overhead Allain level III and IV and non-overhead athletes. The median time to return was noted to be significantly longer—9.5 versus 4.5 months, respectively. Additionally, overhead athletes were significantly more likely to reduce intensity, decrease frequency, and ultimately change sports.

Ultimately, further data looking at athletes, throwers in particular, is needed. However, the available literature demonstrates a high RTP rate although return to prior level of performance is less certain. Particularly for the overhead population, frank counseling is needed preoperatively if surgery is anticipated. These athletes demonstrated longer RTP timeline and difficulty for some patients in performing overhead activities or returning to pre-injury levels.

Complications

Given the wide variety of operative techniques, the postoperative complication profile varies significantly. However, complications or need for a second surgery are not uncommon, which should give surgeons pause when considering an operation, particularly in an overhead athlete.

Hook plates have declined in use in the USA in recent years, in large part due to the almost universal need for removal. Kienast, et al. retrospectively reviewed 225 patients treated with hook plates [36]. At a mean follow up of 36 months, 100% of patients had discomfort relating to the plate. These symptoms were alleviated following removal of hardware; however, 3% of patients re-dislocated the AC joint after plate removal. The overall complication rate was 10.6%. Despite the waning interest in hook plates, the patient outcomes were encouraging: 89% good-to-excellent results and average constant score of 92.

Modern techniques have advantages of being more anatomic but still have relatively high complication rates. A retrospective series of 59 anatomic procedures demonstrated an overall complication rate of 27%—specifically, 23% with cortical fixation buttons and 28% with soft tissue grafts [37]. These complications included failure of the graft or hardware, fracture to the coracoid or clavicle, pain, and several others. Two-year survivorship was 83%. Another review of reconstruction utilizing soft tissue grafts only, either with a coracoid tunnel or loop around the coracoid base, noted a 52% complication rate [38]. Eighty percent of the coracoid tunnel patients had complications with the majority being loss of reduction or coracoid fracture. Of the loop group, 35% had complications, mainly loss of reduction or clavicle fracture. Accordingly, the authors caution that newer techniques have a steep learning curve, sometimes with major issues. Additionally, a study evaluating only cortical button fixation, found a 44% complication rate overall with hardware failure, bone erosion, and AC joint arthritis [39]. One third of patients had failure of fixation (> 50% increase in CC distance) within 3 months of surgery.

Conclusion

AC joint injuries continue to be common and can be problematic. Type I and II injuries are typically non-operative while type IV, V, and VI injuries are felt to be unstable and generally require surgery. But for the general population, the athletic community as a whole, and specifically overhead athletes, the treatment algorithm surrounding type III injuries remains in flux. The lack of data involving overhead athletes makes definitive recommendations impossible; however, we recommend an individualized approach involving a shared decision-making model between the player and their surrounding medical team. However, we favor a more conservative approach in throwers where the dominant arm is affected. For type III injuries, surgery is considered only upon failure of high-quality conservative management, including extensive rehabilitation.

Although not isolated to AC injuries, outcomes for the throwing shoulder as it relates to pathology such as rotator cuff, SLAP tears, and biceps tendonitis provides a background and should give surgeons pause when considering operative management. Modern techniques continue to evolve and have demonstrated good outcome scores and high RTP but questionable return to prior performance and have a reasonably high complication rate. As this area continues to evolve, we hope the treatment algorithm and surgical techniques improve as well—both for overhead athletes and patients overall.

Compliance with ethical standards

Conflict of interest Christopher F. Deans and Joseph M. Gentile each declare no potential conflicts of interest.

Matthew A. Tao is a member of the editorial board for *Current Reviews in Musculoskeletal Medicine*.

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