A Sports Medicine Clinician's Guide to the Diagnosis and Management of Distal Clavicular Osteolysis

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Abstract

Weightlifting associated shoulder injuries have seen a dramatic rise in the last 20 years. Distal clavicular osteolysis, coined weightlifter's shoulder, is one such condition caused by repetitive microtrauma to the distal clavicle with subsequent, painful development of bony erosions and resorption of the distal clavicle. Diagnosis, treatment, and prevention of this condition can be challenging. In this article, we highlight evidence-based clinical recommendations for the diagnosis and management of distal clavicular osteolysis, including specific considerations for atraumatic and posttraumatic etiologies, to help clinicians better care for their patients. Activity modification and rehabilitation are the mainstays of the initial treatment. Adjuvant treatments, such as injections or surgery, may be required in refractory cases or in certain patient populations. Early recognition and treatment of weightlifter's shoulder is essential to prevent progression to acromioclavicular joint pathology or instability and to allow for continued participation in sport-specific activities.

Introduction

The popularity of weightlifting has seen a steady rise over the last 20 years. In 2015, the U.S. Bureau of Labor Statistics estimated that weightlifting was the second most popular form of sport or exercise activity, second only to walking (1). Increased use of barbells and dumbbells by both younger and older adults, as well as a rise in participation by women, has resulted in many health clubs decreasing their purchase of cardiovascular exercise machines to make space for free weights (2–4). At the same time, CrossFit has seen a significant rise in popularity, growing from 13 affiliate gyms in 2005 to more than 15,000 gyms in 2016. With this increased popularity of weightlifting, there also has been a significant increase in weightlifting associated injuries — in particular, shoulder injuries (5). One important type of shoulder injury that is frequently overlooked by sports medicine providers is distal clavicular osteolysis (DCO), otherwise known as "weightlifter's shoulder" (6).

DCO is a unique cause of shoulder pain resulting from repetitive micro-trauma and increased osteoclastic activity at the distal clavicle (3,7). It began receiving more recognition as "weightlifter's shoulder" after Cahill illustrated a strong association between atraumatic acromioclavicular joint (ACJ) pain and weightlifting frequency (7). The etiology is often separated into two distinct categories: posttraumatic or atraumatic. The true incidence of DCO, as well as the relative incidence of atraumatic versus posttraumatic DCO, is somewhat unknown. In atraumatic DCO, one study identified signs of osteolysis in approximately 5% of patients that underwent magnetic resonance imaging (MRI) for unspecified shoulder pain (6). In posttraumatic DCO, one study estimated the incidence to be approximately 6% following ACJ injuries (8).

Early diagnosis can be challenging for clinicians as DCO may have an indolent course and often shares a similar clinical presentation to ACJ osteoarthritis or other shoulder pathology (3,9). Furthermore, DCO is often missed on radiographs, as these may be negative 50% of the time in early stages of disease (8). Prompt diagnosis is essential to determine success of conservative care, especially in high level athletes. If missed, diagnosed late, or incompletely treated, athletes can be at higher risk for progression to ACJ osteoarthritis or widening of the ACJ with subsequent instability (10). Given the rise in popularity of weightlifting and associated shoulder injuries, it is important for clinicians to recognize DCO early and provide appropriate treatment recommendations. The purpose of this article is to provide a brief review of the relevant anatomy and pathophysiology of DCO followed by a clinical approach to the diagnosis, recommended activity modifications, and management (conservative, interventional, and surgical) of DCO.

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Anatomy and Pathophysiology

The ACJ is a diarthrodial joint formed by the articulation between the distal, lateral end of the clavicle and the acromion process, which is an anterior, bony projection of the scapula (11). It is lined by a synovial membrane and encased within an ACJ capsule. Between the distal clavicular head and the acromion process lies an intraarticular fibrocartilaginous disc that aids in the transmission of force and movement. Three main ligament complexes provide stability to the ACJ — the acromioclavicular (AC) ligament, the coracoclavicular ligaments, and the coracoacromial ligaments (11). Superficially, the deltoid and trapezius muscles provide dynamic stability. The ACJ provides stability and motion to the glenohumeral complex — particularly with shoulder abduction and flexion. It additionally facilitates the transmission of forces from the arm to the axial skeleton. Given that the ACJ is not typically a weight-bearing joint, heavy loads during bench pressing or intensive resistance training places the ACJ at particular at risk for injury (6,11,12).

The exact pathogenesis of DCO has been debated, but the most widely accepted theory involves the effects of trauma or microtrauma to the distal clavicle with resultant injury to the subchondral bone (9,10). The pathophysiology is theorized to be similar in atraumatic and post-traumatic DCO, as histologic and radiographic findings are often alike (13). In *atraumatic* DCO, hyperextension of the shoulder during weightlifting or sports places excessive traction on the ACJ. Repetitive movements with high amounts of force can translate into distal clavicular microtrauma (14). This repeated microtrauma injures the subchondral bone and is often associated with a nondisplaced subchondral stress fracture (3,9,15). In *posttraumatic* DCO, an acute injury may similarly result in nondisplaced subchondral fractures (13,15). With these subchondral injuries, there tends to be an initial increase in osteoclastic activity with a later increase in osteoblastic activity, suggesting an attempt at healing by the body (9,14). Repeated attempts at healing result in chronic inflammatory changes with further disruption to the articular cartilage (13).

Clinical Evaluation

History and Physical Examination

Patients will generally present with dull, aching pain localized to the ipsilateral shoulder or ACJ. While the average age of these patients is typically closer to the late 20s through mid-30s, athletes as young as 13 may be affected (6,10). It is more prevalent in overhead athletes (baseball, softball, basketball, volleyball, tennis, and swimming), weightlifters, and males (10,16). In overhead athletes, symptoms may preferentially affect the dominant side and/or throwing side. These athletes should be questioned regarding their throwing volumes (pitch count, warm-up, and bullpen throws) and evaluated for any recent changes in activity. In weightlifters, symptoms can be present bilaterally (17). Patients may report their symptoms are exacerbated by weight training (bench press, push-ups, parallel bar dips, shoulder shrugs, military press, clean and jerk) or overhead sports activities (9,18). Pain also may be significantly worse the night after a weightlifting session. Certain sleep positions, such as side-lying with the arm flexed and adducted at the shoulder, tend to further exacerbate symptoms. Discomfort may be described as diffuse with radiation to the trapezius or deltoid muscles. When compared to the contralateral side, a small degree of swelling may be described (18). Patients tend to report short-term resolution of their symptoms during periods of rest with recurrence of pain following resumption of activity (14).

In atraumatic DCO, there is insidious and gradual onset of pain without a clear inciting event (3,9,18). Early in the disease process, pain may be minimal and symptoms may not be bothersome, often resulting in delayed presentation (19). As a result, DCO is more frequently identified in the subacute or chronic stage after three or more months of symptoms (18,19). In post-traumatic DCO, patients may recall a distinct injury to the shoulder, such as a fall, collision, or motor vehicle accident (often with ACJ dislocation/separation or clavicular fracture) prior to the onset of their symptoms (18). Alternatively, they may report a specific overhead movement or sporting event when they first felt these symptoms. The timeline for post-traumatic DCO may be variable, ranging anywhere from 2-months to a year (20). Post-traumatic and atraumatic DCO are generally evaluated and managed similarly.

On physical examination, clinicians should begin with a thorough inspection of the shoulder, cervical spine, upper back, scapula, and chest. Palpation may reveal tenderness at the distal clavicle or ACJ. Tenderness to palpation over the superficial ACJ has been shown to be highly sensitive (96%) for ACJ pathology, though not necessarily specific for DCO (21). For this reason, careful, comparative palpation of the distal clavicle versus the acromion is suggested to help narrow down the area of pathology. Forward flexion of the arm past 90 degrees may worsen pain, particularly when combined with adduction (18). Neural injury to the lateral pectoral nerve or suprascapular nerve, which provides articular innervation to the ACJ, also may result in pain at the ACJ and should be investigated during the neurologic examination.

Special testing can then be conducted to further support the diagnosis (Table 1). While there is no specific special testing that isolates the distal clavicle, maneuvers that stress ACJ are typically positive. While there are multiple special tests that stress the ACJ, the combination of ACJ palpation and the O'Brien active compression test has been found to be the most sensitive when screening for ACJ pathology and DCO (21). These tests also have been found to be highly specific when used in parallel (96.7%) and thus are the preferred combination (22). The active compression test of O'Brien, while commonly utilized for labral pathologies, also was originally described by O'Brien et al. as a test for ACJ pathology as there is increased ACJ loading that occurs when the arm is at 90 degrees of flexion, 15 degrees of adduction, and maximal internal rotation (21).

Imaging

When there is a strong clinical suspicion for DCO, next diagnostic steps include obtaining plain radiographs and/or performing diagnostic ultrasound (depending on availability). Although the ACJ is seen on standard shoulder AP views, its angulation may be variable with overpenetration. For this reason, obtaining a Zanca view is recommended as it provides clear images of the distal clavicle while minimizing overlap from the scapula (3,23). The Zanca view is an angulated AP view wherein the beam is centered over the ACJ and then tilted 10 to 15 degrees cephalad (24). Bilateral Zanca views also may be beneficial for a side-by-side comparison of the distal

Table 1.
Summary of clinical diagnosis for DCO.

History	Clinical Presentation		Special Considerations
Initial Evaluation	–Young and middle-aged men > women –Weightlifters, throwing athletes partaking in pressing exercises, or significant overhead activities –Pain localized at the shoulder or ACJ that worsens during or after training and improves with time away from sport		–Atraumatic: insidious, gradual onset of symptoms –Posttraumatic: patients are able to identify an event or particular timepoint preceding symptoms
Physical Exam	Maneuver	Findings	Considerations
Initial Evaluation	–Inspection –Palpation –Range of motion –Neurologic assessment	–Trace to minimal soft tissue edema –Tenderness at the ACJ and distal clavicle –Generally preserved but pain may be present with flexion and abduction –No significant weakness	–Careful consideration should be made when palpating the ACJ to compared between acromial- or clavicular-sided tenderness –Evaluate for lateral pectoral nerve or suprascapular nerve injury
Special Testing	1. Cross-body abduction stress test 2. O'Brien Active compression test 3. Resisted AC extension test 4. Paxinos test	1. Forward flexion at shoulder to 90 degrees followed by adduction of the arm to compress the ACJ 2. Shoulder at 90 degrees of flexion, 15 degrees of adduction, and maximal internal rotation with a downward-directed force at the arm 3. Place shoulder and elbow in 90 degrees of flexion followed by resisted extension at the shoulder 4. Manually compress acromion, clavicle, and shoulder together while the patient rests their arm at their side	1. Sensitivity, 77%; specificity, 79% 2. Sensitivity, 16% to 100%; specificity, 90% to 97% 3. Sensitivity, 72%; specificity, 85% 4. Sensitivity, 79%;, specificity, 50%
Initial Imaging	Findings		Considerations
X-Ray (Standard Shoulder, Zanca Views)	–Loss of subchondral bone and lucency/tapering at the distal clavicle, widening of the ACJ greater than 6 mm		–Less sensitive and may be negative earlier in disease course –Zanca views minimize osseous overlap of the clavicle and spine of the scapula
Ultrasound	–Cortical irregularity, widening of ACJ, soft tissue edema, hyperemia		–Sonopalpation may reproduce pain at the distal clavicle
Secondary Imaging	Findings		Considerations
MRI Shoulder without contrast	–Increased distal clavicular bone marrow edema, cortical thinning, subchondral cysts, periarticular edema –T2-weighted images (fat-suppressed or STIR) can illustrate increased distal clavicular signal without bone marrow edema at the acromion		–Sensitive even earlier in the disease course –Helpful in ruling out or identifying other concomitant pathologies
Tertiary Diagnostics	Findings		Considerations
Diagnostic Injection	–Diagnostic injections can be beneficial whenever there are multiple shoulder pathologies present and it is difficult to discern the etiology of a patient's pain		–Ultrasound guidance and sterile technique are recommended –1 to 2 mL of injectate consisting of anesthetic and corticosteroid

clavicle (25). Radiographs may reveal loss of subchondral bone in the distal clavicle, lucency or tapering of the distal clavicle, and widening of the ACJ greater than 6 mm in females or 7 mm in males (24,26) (Fig. 1A and B). These changes should be limited to the distal clavicle without evidence of sclerotic changes in the ACJ joint or resorption/lucency at the acromion (3,23). It is important to note, however, that the degree of osteolysis or resorption may not always correlate with clinical symptoms (10). Furthermore, in chronic cases of DCO or in older patients with pre-existing shoulder pathology, there is often concurrent ACJ osteoarthritis.

There are certain limitations to using X-ray (XR) for diagnosing DCO, particularly when having mild symptoms or early in time course. Radiographs may be less sensitive early on and changes may not be seen for weeks to months after the onset of clinical symptoms (23,26). As early diagnosis can help minimize disease progression, alternative forms of imaging (such as ultrasound or MRI) are frequently recommended when radiographs are negative but clinical suspicion is high (Table 1) (10).

Diagnostic ultrasound has the benefits of being cost effective, dynamic, and providing real-time information — often even before radiographs are obtained (27,28). In addition, ultrasound may be more sensitive than an XR and more helpful in early or mild DCO cases (23). Ultrasound may demonstrate fragmentation or cortical irregularities of the distal clavicle,

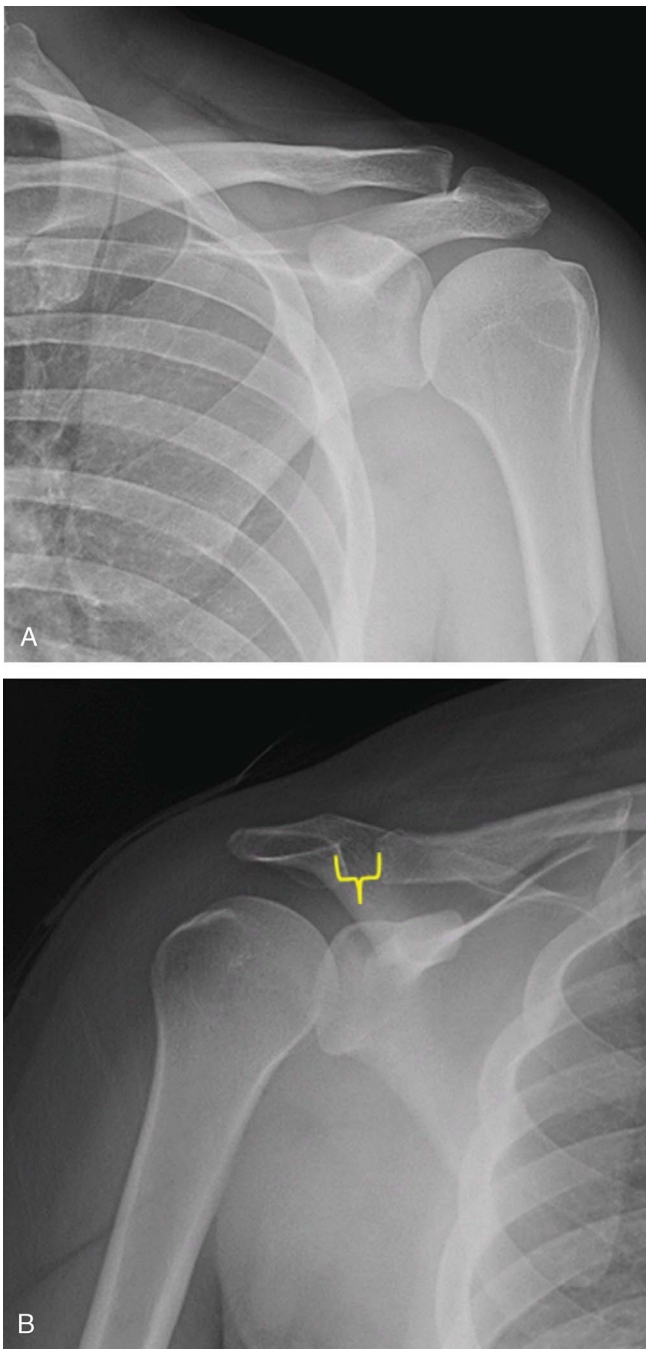

Figure 1: Shoulder radiographs (AP view) illustrating DCO. A, Left shoulder radiograph illustrating mild subchondral irregularities of the distal clavicle. B, Right shoulder radiograph illustrating chronic DCO with ACJ widening (yellow bracket), generally using a cutoff of 7 mm. Normal joint space width is generally 1–7 mm in males and 1–6 mm in females, measured from the medial cortex of the acromion to the lateral cortex of the distal clavicle (24).

widening of the ACJ space, possible effusion, or soft tissue edema (Fig. 2) (23,29). Power Doppler analysis can demonstrate increased activity (hyperemia) and neovascularization, a sign of focal inflammation (23). This is the recommended diagnostic modality for early or mild DCO when XR is negative.

If there is concern for concurrent labral or rotator cuff injury, MRI is recommended additionally. Furthermore, MRI is more sensitive than XR and can be beneficial for visualizing the soft tissue structures surrounding the distal clavicle in early stages of injury (24). This may be needed if a high-resolution ultrasound machine is not available and XRs are negative. Posttraumatic and atraumatic DCO will have similar appearances on MRI, illustrating increased distal clavicular bone marrow edema, cortical thinning, and subchondral cysts (13,24) (Fig. 3). Periarticular soft-tissue edema and hypertrophic bone formation also may be seen. These edematous changes may be more prominent in early DCO, making MRI a useful tool early in the disease course.

Treatment

The treatment algorithm is guided by a variety of factors, including the patient's age, any underlying shoulder pathology, medical co-morbidities, level of activity, and desire to return to competition or sport-specific activities. Initial management is generally conservative in nature. Rest, ice, topical analgesics, oral anti-inflammatory medications, activity modification, and evaluation of weight-pressing technique should all be incorporated (9). Specific rehabilitation exercises should then be implemented early to improve stability and control at the ipsilateral shoulder and ACJ. Early diagnosis and treatment can decrease the total amount of bone loss, minimize the duration of the lytic phase, and reduce clinical symptoms (19). Following conservative treatments, and often in conjunction with these strategies, nonoperative injections may be trialed for pain relief. In specific cases, operative management may be indicated (arthroscopic vs open procedures) (Table 2) (3). These treatments are discussed in more depth in the subsequent sections.

Activity Modification

Activity modification is the first step clinicians should implement for these athletes. For competitive pitchers, decreasing the total number of innings pitched should be recommended, as throwing volume has been correlated with DCO and ACJ pathology (30). Overhead athletes that also incorporate a supplemental weightlifting program are at a higher risk of DCO compared with pure weightlifters or overhead athletes who

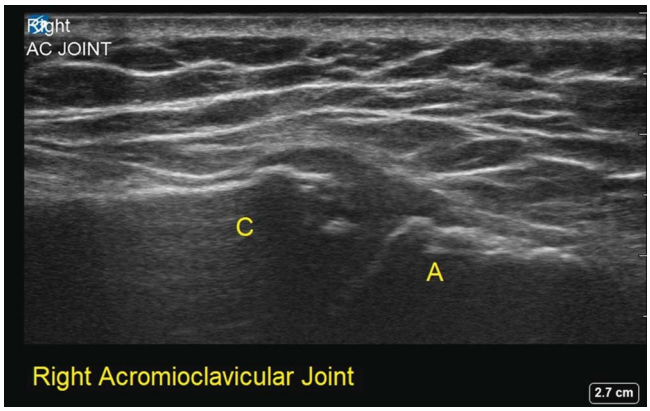

Figure 2: Sonographic correlate to Figure 1. There is cortical irregularity at the distal segment of the right clavicle (C). Acromion (A). Machine: Sonosite X-Porte with 6–15 MHz linear transducer.

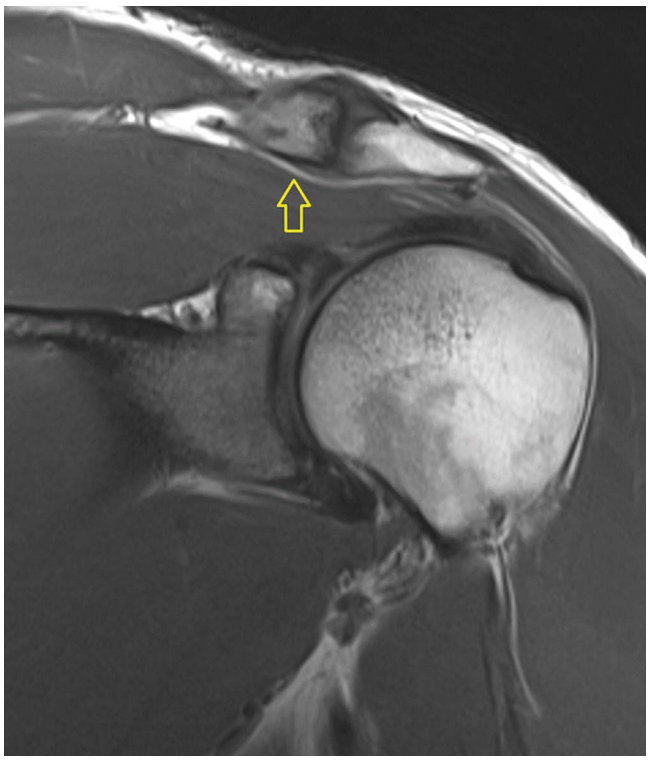

Figure 3: Magnetic resonance (MR) imaging in multiple views illustrating asymmetric edema involving the clavicular head in a 35-year-old man. There also is concurrent ACJ capsule hypertrophy and edema without significant AC osteoarthritis. Arrow pointing towards distal clavicle. A, COR PD TSE LEFT SHOULDER (Coronal Proton-Density Turbo-Spin-Echo MR).

do not incorporate a supplemental weightlifting program. These patients should be counseled on the importance of activity modification and load management to prevent missing significant time away from sport (10). Current protocols for activity modifications in DCO are largely limited to case reports or extrapolated from general ACJ literature (3,4,10,19,25). For patients with mild DCO symptoms that occur only with weightlifting or sport-specific activities, removing these specific movements patterns for 4 to 8 wk with a gradual return to activity may be sufficient. However, in more severe cases when patients have pain even with daily activities or movements unrelated to sport, 4 to 8 wk of restriction from both sport and weightlifting may be necessary (4,25). As the pathophysiology of DCO is thought to include microfractures of subchondral bone, it has been suggested that these patients should be treated similarly to fractures or stress injuries with an initial period of decreased stress/increased rest followed by rehabilitation (4).

If athletes are unable or unwilling to remove or replace certain pressing exercises from their training regimen, technique modifications should be trialed. For the bench press, two specific modifications that athletes can make are in their hand spacing/grip selection and the barbell's descent. Grips are generally categorized as wide (2.0 times biacromial width or maximally 81 cm, as per most bench press competitions), medium (1.5 times biacromial width), or narrow (biacromial distance) (31,32). Athletes and trainers should be made aware that while there is similar muscle activation between medium and wide grips, narrow grips generate increased triceps brachii, decreased biceps brachii, and decreased anterior deltoid activation. This is thought to be secondary to the more adducted position of the shoulder (31,33,34). Wider grips are generally preferred by weightlifters, and there is some evidence illustrating greater 1- and 6-repetition bench press maximums with wide grips when compared to narrow grips (31–33). This increased maximal load may in part be due to the reduced vertical displacement requirement of the barbell when using a wide grip. However, biomechanical studies also have illustrated there is a greater shoulder flexion moment arm with wide and medium grips when compared with narrow grips, allowing for the production of greater torque (34). Although advantageous for competition, wide grips are associated with greater risk of DCO and ACJ injury (32). Based on these studies, medium grip width has the most favorable balance of safety and performance (31–33). Medium grips have greater anterior deltoid activation when compared to the narrow grip, equivalent pectoralis activation when compared with the wide grip, and comparable 1- or 6-repetition maximums when compared with the wide grip (31,32). This grip distance also allows for safer shoulder positioning with both abduction (45 degrees or less) and extension (15 degrees or less) during the pressing movement (12,32,35). One other modification that can be suggested is that during descent, the barbell should be controlled to end approximately 4 to 6 in. above the anterior chest, which will again serve to decrease shoulder extension (12). While this decreased range of motion may be an appropriate recommendation for recreational lifters, it should be noted that there will be incomplete muscle activation with the decreased range of motion. Furthermore, it often cannot be recommended to competitive weightlifters as the barbell must touch the chest when competing (32).

For recreational lifters, replacing bench press, pushups, and dips for alternative exercises (dumbbell press, dumbbell fly, cable cross over) can help decrease forces through the ACJ by improving shoulder positioning and minimizing excessive shoulder abduction (32,35). Electromyographic activity of the anterior deltoid and pectoralis has been found to be similar between barbell bench presses and dumbbell bench presses. However, they have been found to be decreased when performing dumbbell flys (36). In contrast, there appears to be increased activity of the biceps brachii and decreased activity of the triceps brachii with dumbbells, theorized to be associated with the higher stability demands of this exercise (37). Neutral or flat bench pressing exercises are favored to inclined bench press as the incline position can increase humeral external rotation with subsequent increases in force through the ACJ (32).

Rehabilitation and Return to Sport

Physical therapy is an important supplement to activity modification and should be optimized by the prescribing physician. While no specific rehabilitation protocols are outlined for DCO, many principles are similar to the treatment strategies for ACJ pathology (4). These principles include an initial emphasis on improving internal and external shoulder range of motion while strengthening the deltoid and trapezius muscles. Abduction and flexion are then incorporated, as well as strength training (while still avoiding significant pressing loads), with a focus on scapular control. Advanced pressing exercises

Table 2.
Summary of treatment recommendations for DCO.

Conservative Management	Recommendations	Considerations
Activity modification	–Remove or replace provocative exercises from weightlifting program, reduce pitching volume –Medium grip width (1.5 times biacromial distance) with controlled barbell descent ending 4 to 56 inches above anterior chest	–Grip size and barbell descent will result in variable muscle activation
Rehabilitation Protocols	–Improve range of motion, address scapular dyskinesis and scapular control, address muscle imbalances, rotator cuff strengthening	–Generally, recommend 2 to 3 weekly sessions for 6 to 12 wk
Surgical Management	Recommendations	Considerations
Arthroscopic Management	–Direct approach is currently preferred to indirect approach as there is less risk of ACJ capsule injury, lower risk of inadequate resection, and faster return to sport	–Posttraumatic DCO may have worse outcomes than atraumatic, although this is poorly defined. –AC ligamentous injury should be considered if there are continued symptoms after resection
Return to play	Recommendations	Considerations
Conservative	–Return to play is based on patient's pain and functional limitations	–Activity modifications should be tailored to an individual patient and the degree of their symptoms
Surgical	–Athletes can generally return to play within 3 to 6 wk of direct, arthroscopic distal clavicular resection –A sling may be used in the first 24 h, followed by active and passive range of motion –Formal physical therapy is initiated for the next 2 to 3 wk with a gradual return to functional and sport specific activities	–Return to play may be slower in patients with a posttraumatic etiology of DCO or in patients treated with indirect distal clavicular resection

are added next, followed by sport specific activities (38). Closed chain exercises are generally recommended prior to open chain exercises as they tend to decrease forces acting on the arm and increase sensory feedback (39). Additional areas of focus included cervical and thoracic range of motion, soft tissue therapy, and both concentric and eccentric exercises using resistance bands.

Addressing muscle imbalances are another important consideration. Many recreational weight lifters train their larger muscles at greater proportions than their shoulder complex stabilizers, leading to abnormal scapulothoracic motion, abnormally decreased abductor/adductor ratios, and decreased external rotator/internal rotator strength ratios when compared with control groups (40). Strengthening the external rotators of the shoulder, improving scapular control in multiple directional planes, and minimizing thoracic kyphosis or rounded shoulders through stretching exercises should all be included (39).

Return to sport or activity should occur when residual pain is minimized and biomechanical imbalances are addressed. In most cases, activity modifications, decreasing the overall weightlifting volume, and rehabilitation are effective. Programs will vary in duration and frequency, but an ACJ program consisting of two to three weekly sessions for a minimum of 6 wk (may be as long as 12 wk) is generally recommended (25,39). In most cases, the anticipated timeline of conservative treatment before full return to sport is 3 to 6 months (6,10).

Role of ACJ Injections

Ultrasound-guided ACJ injections with local anesthetic/corticosteroid can be utilized as an adjunct treatment in patients with persistent pain. When performing these injections, current recommendations are to inject 0.5 to 1.0 mL of anesthetic with 0.5 to 1.0 mL of corticosteroid (triamcinolone, methylprednisolone) using ultrasound guidance (41). Pain relief after the injection has been shown to have a diagnostic benefit and provides reliable prognostic information for the success of later surgical resection (3,42). However, the results of this injection may be short-lived; a previous study illustrated that while ACJ injections were 93% effective at reducing pain and improving function, their mean duration of efficacy was 20 days (43). Patients should be counseled on this potentially short timeframe of relief prior to proceeding with this treatment. While they are frequently used to help get athletes through the season, they should not be used in lieu of activity modifications or rehabilitation programs given the risk of continued osteolysis and disease progression (20). Other injection options, such as prolotherapy or autologous adipose-derived mesenchymal stem cell therapy, have been described in the treatment of ACJ pathology, but there are currently no studies supporting their use in isolated DCO (44,45).

Surgical Treatments and Return to Activity

Patients tend to do well with conservative management. Prior studies have illustrated that as many as 76% to 93% of patients may have resolution of their symptoms with conservative management and avoid further interventions (6,10). However, when conservative management fails to improve symptoms or activity modification cannot be implemented, surgical intervention may be needed. This is generally after at least 3 to 6-months of physician directed treatments (25,46). In some populations, surgery may be offered sooner.

Weightlifters and bodybuilders may not be willing to interrupt their training for months to implement conservative management. Overall, current surgical treatments for DCO have been found to be safe and efficacious with a return to daily activities within 1 to 2 wk and return to sport activities within 3 to 6 wk (3,9,46,47).

Typically, surgery for DCO consists of distal clavicular resection — this may be an open or an arthroscopic procedure. Open surgery, known as the Mumford procedure, is generally not used due to increased tissue damage, a longer rehabilitation course, poor cosmesis, and the risk for ACJ ligamentous instability (3,9). Arthroscopic surgery avoids many of these issues through less tissue dissection, minimal injury to the joint capsule, decreased recovery time before passive or active range of motion, improved cosmesis, and preserved strength (3,9,46,48,49). As such, arthroscopic surgery is currently recommended and has been shown to have greater success rates than open surgery in decreasing pain and facilitating earlier return to activity (49).

There are two widely used arthroscopic approaches: the indirect (subacromial) approach and the direct (superior) approach. The indirect approach is more advantageous if the surgeon needs to address any other shoulder pathology alongside the DCO (9). Overall, however, the direct approach is believed to be the superior approach and have a lower risk of inadequate resection or ACJ capsular injury when compared with the indirect approach (3,25). In addition, the direct approach can provide a quicker return to sport when compared with the indirect approach. Charron et al. compared outcomes for 34 athletes (weightlifting, football, and other overhead sports) treated with either indirect and direct distal clavicular resection. Average clavicular resection was 8 to 10 mm in both groups and rehabilitation protocols were standardized postoperatively. While both groups illustrated statistically significant functional improvement compared with preoperative scores, the direct group illustrated greater improvement at 2 and 6 wk with a quicker return to sport-specific activities postoperatively (21 d compared with 42 d) (47).

Strength appears to be maintained following arthroscopic surgery, which is often an important consideration for the weightlifting athlete. One study found that weightlifters treated with direct arthroscopic distal clavicular resection (average resection, 4.5 mm) were able maintain bench press, military press, and incline press strength at latest follow up (18.7 months) (46). However, if athletes continue to have significant symptoms despite surgical treatment and rehabilitation, ACJ instability should be considered. Excessive ACJ widening (an increase relative to baseline of 7.6 mm in men, 5.2 mm in women) may compromise the superior AC ligament with resulting horizontal instability. This may occur in cases of severe osteolysis and/or in cases requiring larger distal clavicular resection. In these athletes, open resection with AC ligament reconstruction may be required (20).

Treatment Considerations in Atraumatic and Posttraumatic DCO

With regard to conservative management, atraumatic and posttraumatic DCO are treated similarly (3,9). However, uncovering the etiology of injury during the patient history is still important as this may have prognostic implications with surgical management. Zawadsky et al. compared long-term outcomes (mean, 6.2 years) following direct, arthroscopic resection for DCO (mean resection size of 4 to 7 mm) among atraumatic and posttraumatic shoulders. They found that patients with posttraumatic DCO had slightly worse outcomes (pain, range of motion, functional limitations) when compared with atraumatic DCO cases treated similarly (50). Another review that broadly evaluated distal clavicular resection in posttraumatic ACJs (including both ACJ osteoarthritis and DCO) similarly found a trend toward poorer outcomes in posttraumatic injuries when compared with atraumatic cases (49). One theory behind this difference is suspected to be subtle preoperative ACJ instability resulting from prior trauma that predisposes the postoperative joint to continued microinstability (50). Although there is limited evidence available providing direct comparisons of surgical outcomes in atraumatic versus posttraumatic DCO, this is nonetheless an important consideration for clinicians when guiding patients through potential treatment options. Athletes with posttraumatic DCO and may require a longer rehabilitation course to address shoulder biomechanics given the propensity of these injuries to involve the AC ligament and cause horizontal ACJ instability (20).

Prevention

Given that the pathology of DCO is thought to be secondary to repetitive microtrauma one strategy for prevention is to moderate the overall load placed at the distal clavicle (6). This can include strictly regulating the total amount of bench pressing (sets, repetitions, or overall weight) and improving pressing form to decrease forces across the distal clavicle and ACJ. This is particularly important in throwing athletes that have implemented both sport specific training and resistance training in their program. In these athletes, limiting the intensity of bench pressing to less than 1.5 times the body weight and to no more than once per week may help decrease the risk of DCO, particularly if there is underlying shoulder pathology (6). Proper warm-ups with a focus on shoulder range of motion and anterior chest wall stretching should be incorporated before any pressing movements. Scapular training is of the utmost importance. Biomechanical studies suggest that activities requiring stability of a protracted scapula are more frequently implicated in generating forces across the ACJ and distal clavicle (17). Once DCO is diagnosed, secondary prevention of ACJ osteoarthritis or unstable ACJ widening should be prioritized by clinicians through continued activity modifications and by encouraging home exercise program compliance (10).

Conclusion

Identifying DCO in athletes with shoulder pain is important to help create the best treatment and management program to protect their shoulder long term. It can present insidiously (atraumatic) or after a localized injury to the shoulder (posttraumatic). DCO has been shown to correlate with bench pressing frequency, intensity, and duration, earning it the nickname of "weightlifter's shoulder." Diagnosis of this condition is made by a thorough history and physical examination that can be supplemented by imaging or diagnostic injections. While no formalized rehabilitation protocols exist, the mainstay of treatment consists of activity modification, load reduction, and an evaluation of biomechanics with form corrections. Surgery may be required in certain cases and is generally effective for pain relief. Additional research is needed to

elaborate on the spectrum of nonoperative treatment interventions available for this condition. Furthermore, specific rehabilitation protocols are needed that focus on both the prevention and treatment of DCO.

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