54 Osteolysis of the Distal End of the Clavicle

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Abstract

Osteolysis of the distal end of the clavicle is an overuse-related injury observed commonly in weightlifters and heavy manual workers. The most common symptom is pain localized at the distal clavicle end which increases with overhead activities and shoulder adduction. The main imaging findings on MRI are the presence of localized bone marrow edema with or without a subchondral fracture and areas of distal clavicle osteolysis. Osteolysis and variable bone absorption are also the principal findings in plain radiographs. The problem is commonly self-limiting, and conservative treatment with activity modification and intraarticular injections is usually successful. In patients with persistent symptomatology, limited arthroscopic distal clavicle excision predictably alleviates the symptoms.

Keywords

Acromioclavicular joint · Distal clavicle · Osteolysis · Overuse · Shoulder

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54.1 Introduction

The acromioclavicular joint (ACJ) is a diarthrodial joint with an interposed fibrocartilaginous meniscal disk that connects the upper limb with the axial skeleton. The functional role of the clavicle is to keep the upper limb away from the thorax and, through the ACJ, serve as a fulcrum aiding the positioning of the upper limb and the hand in space. Despite the limited mobility of the ACJ, the small opposing articular surfaces are subjected to high shear stresses, especially with overhead activities and increased loading [1]. Due to its crucial position, the ACJ is prone to trauma and degeneration.

Distal clavicular osteolysis (DCO) is a well-described affliction of the distal or lateral end of the clavicle and is an aftermath of acute or repetitive upper extremity trauma. Athletes or people involved with heavy manual labor who perform vigorous overhead activities with significant loads, such as weightlifting and powerlifting, are prone to the development of DCO [2–12].

54.2 Epidemiology

There are many case series in the literature but no well-designed epidemiological studies. As such, DCO is underdiagnosed and underreported. Findings of DCO were disclosed in 5% of patients undergoing shoulder magnetic resonance

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imaging (MRI) between the ages of 20 and 40, with females comprising 9% [11]. In a retrospective, 30-year study, including 1130 shoulder X-rays of competitive athletes without a history of shoulder trauma or systemic disease, the radiologic incidence of DCO was 1.96% (23/1170 cases) [12].

DCO is asymptomatic in many cases [13] and the symptoms may improve with the cessation of all overhead activities. On the other hand, in patients who present late with ACJ osteoarthritis, the causative effect of DCO is not recognized. Nowadays, DCO is diagnosed more frequently due to the increased awareness among sports physicians and the increased popularity of weight training as an integral part of general fitness and sports conditioning programs.

DCO may affect adolescents and adults, males and females, athletes and non-athletes, although it is more commonly encountered in young, adult male athletes involved in strenuous overhead activities and workers involved in heavy labor [2, 3, 6, 14]. DCO is especially common in weightlifters, bodybuilders, powerlifters, wrestlers, rugby players, and hockey players [13, 15] and has also been reported in judo and handball athletes [10, 12] predominantly in the dominant arm [16].

Combination of both an overhead sport and weight training increases the possibility of developing DCO [11, 17–19].

54.3 Pathophysiology

There are two types of DCO: posttraumatic and atraumatic, the latter resulting from chronic overuse. Both types are similar with regard to symptomatology, clinical examination, and MRI findings. DCO occurs at the site of the lateral clavicle epiphysis, which does not ossify until the early adult life [20].

The precise mechanism of DCO pathogenesis is not fully elucidated. In the initial reports, DCO was often associated with direct shoulder trauma but in later reports a non-traumatic, overuse mechanism was described [2, 3, 10]. Other possible causative factors, although of lesser importance, include infection [21] and synovial invasion of the distal clavicle [22], although the role of the synovium in the pathogenesis of DCO is disputed by Jeandel et al. [23]. Bone ischemic necrosis and autonomic nervous system dysfunction have also been proposed as possible mechanisms [24].

In posttraumatic DCO, a distinct, even minor, traumatic event is followed by ACJ symptoms weeks to years after the incident [25].

Cahill [2] reported the pathogenesis and clinical course of DCO in 46 male athletes without a history of trauma. He reported the presence of intense osteoblastic activity in the subchondral bone and the presence of microfractures in almost 50% of his cases. He further proposed that repetitive microtrauma caused subchondral stress fractures and induced bone remodeling leading eventually to DCO.

The chronic cumulative microtrauma causes articular cartilage fissures with articular fluid egressing into the cancellous bone of the distal clavicle, consequently forming cysts in the subchondral bone [2, 10]. The subchondral bone eventually collapses giving rise to subchondral insufficiency fractures below the articular cartilage, leading to increased osteoclastic activity with bone resorption being the final result. Subchondral fractures at the distal clavicle are encountered in 74% of adolescents [17] and in 86% of adult patients with DCO [26] with the acromion typically spared.

The effect of a neurologically mediated mechanism is probable in the development of DCO. In a study of patients with spinal cord injury without upper extremity problems, 10/76 developed radiographically DCO within 1 month from their admission [27].

DCO involves a lytic and a reparative phase [7]. The lytic phase starts weeks to several years from the traumatic event, continues for a further 12 to 18 months, and results in the absorption of 0.5–3 cm of the distal clavicle [7]. Absorption of the acromial articular surface may occur at the later stages of the lytic phase and is an indication of imminent ACJ destruction with eventual development of osteoarthritis. The ACJ becomes symptomatic during the lytic phase with pain, loss of upper limb function, and reduced strength. A reparative phase follows for 4 to 6 months with repair of the cortical erosions despite permanent ACJ widening and tapering of the clavicular end [7, 28].

Histologic examination of distal clavicle specimens with DCO reveals fissuring and violation of the articular cartilage, presence of subchondral cysts, and metaplastic bone formation with increased osteoclastic activity—an indication of an active remodeling process [29]. Synovial overgrowth and increased vascular proliferation were reported in several studies [7, 22–25, 30–32].

DCO is a self-limiting disorder that resolves within 1 to 2 years with significant activity modification, but progresses with continuous overhead activity. Between 0.5–3 cm of bone loss from the distal clavicle but not from the acromion is expected [7]. The lytic process may continue despite joint protection for 12 to 18 months, although the disease is not always symptomatic. During the repair phase, osteolysis ceases and the distal clavicle becomes smooth with permanent ACJ widening. In the long term, patients with an extensively destructed ACJ will develop osteoarthritis, although not always symptomatic [17].

54.4 Clinical Diagnosis

54.4.1 History

The diagnosis of DCO is based on the history of the patient and the location of the pain. It is commonly unilateral, although both ACJ may show evidence of the disease.

DCO is asymptomatic until an injury threshold is reached. In atraumatic DCO, ACJ pain presents surreptitiously and gradually without a history of trauma. In traumatic DCO, there is a history of shoulder or ACJ injury, minor or more severe, which may have occurred between a few weeks or several years before the symptom's onset.

The main symptom is anterosuperior shoulder pain located at the ACJ with limited radiation to the trapezius or anterior deltoid area (Fig. 54.1).

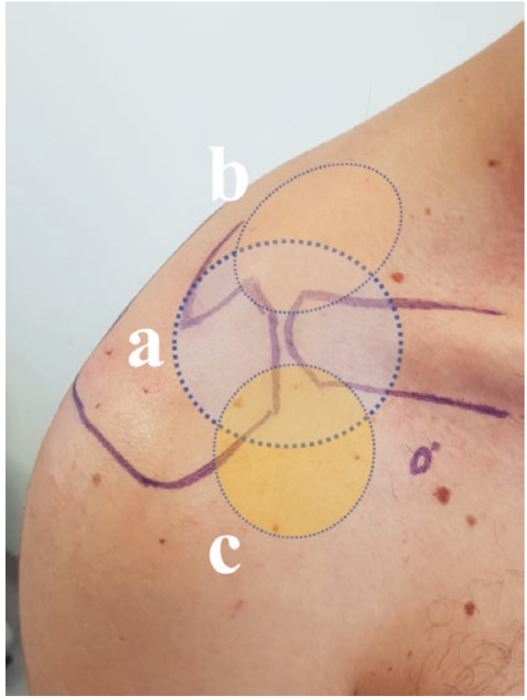


Fig. 54.1 The primary pain location in DCO is the ACJ (**a**) but it may radiate proximally (**b**) or distally (**c**)

The pain is exacerbated by repetitive loading, strenuous overhead activities, and weightlifting and can occasionally completely hinder the patient from athletic activities. Initially, pain is reported during exercise but with progression of the disease it gradually gets worse, persists after the end of the exercise, and may be present at night, thereby preventing sleep on the affected side. With progression of the disease, everyday activities may also become painful. A general sense of shoulder disability and weakness is frequently reported. DCO symptomatology overlaps with other pathologic conditions, primarily ACJ arthritis and ACJ strain and dislocation.

54.4.2 Differential Diagnosis

Typically, DCO is encountered in a young athlete or heavy laborer with a history of significant chronic shoulder overloading or trauma who presents with localized ACJ pain. Osteolysis of the distal clavicle in elderly or child patients with serious accompanying diseases is not benign and should rouse suspicion. Osteolysis in the clavicle accidentally found in older patients should alert the surgeon to the possibility of malignancy, especially metastatic tumors [33, 34]. A detailed physical examination of the patient is necessary and selection of the appropriate imaging modalities is crucial.

Other sources of shoulder pain shoulder be ruled out, especially ACJ osteoarthritis, rotator cuff tears, glenohumeral joint pathology, subscapularis calcific tendinitis, biceps tendon lesions, scapular dyskinesia, and cervical spine pathology. DCO may develop secondary to traumatic ACJ dislocation [35], arthroscopic acromioplasty [36], ACJ stabilization using a synthetic graft [37], and following the modified Weaver–Dunn procedure [38]. DCO and ACJ osteoarthritis are difficult to distinguish solely by clinical findings. The presence of ACJ instability should be ruled out using a combination of clinical examination, stress testing, and advanced imaging.

The possibility of referred pain from cervical radiculopathy, cardiac, pulmonary, or gastrointestinal disease should also be considered.

DCO may be a manifestation of the rare Gorham vanishing bone disease or primary idiopathic osteolysis, which is characterized by the proliferation of a bone vascular channels resulting in resorption and replacement of the bone with angiomatosis or hemangiomatosis [39, 40]. DCO has also been reported to occur as part of McDuffie's syndrome or hypocomplemententemic urticarial vasculitis syndrome [41]. Other causes of DCO are radiation therapy [42], metabolic bone diseases, especially hyperparathyroidism, rheumatoid Arthritis [42], fibrous dysplasia, primary and metastatic tumors, infection [21], synovial diseases, simple and aneurysmal bone cysts, multiple myeloma, gout, scleroderma, septic or tuberculous arthritis, eosinophilic granuloma, and cleidocranial dysplasia. In bilateral DCO, the most common causes are athletic DCO, hyperparathyroidism, and rheumatoid arthritis. In unilateral DCO, the most common causes are athletic DCO, ACJ osteoarthritis or dislocation, rheumatoid arthritis, synovial diseases, infection and tumors, both primary and metastatic.

54.4.3 Clinical Examination

Inspection of the affected shoulder may reveal ACJ swelling and asymmetry and the presence of scapular dyskinesia. Patients with DCO can precisely locate the origin site of their symptoms and, on palpation, present point tenderness over the ACJ. The pain is exacerbated by athletic or work activity, notably overhead lifting. Occasionally, mechanical symptoms such as catching, locking, popping, and grinding are present. The pain is reproduced with passive, cross-body adduction, resisted abduction and/or adduction and horizontal shoulder hyperextension, where the elbow is placed behind the shoulder level.

Passive and active ROM is not usually compromised in DCO. Terminal active shoulder ROM, especially full shoulder forward flexion and extension, may be avoided due to pain. Passive shoulder ROM is normal unless other accompanying pathology such as posterior capsule tightness is present, and pain is felt on the posterior side of the shoulder.

Shoulder strength is normal, although in the presence of a long-term ACJ disease, unilateral reduction of muscle strength may be encountered secondary to disuse. The stability of the AC joint also needs to be assessed using manual examination and radiographic evaluation.

The most sensitive clinical test is pain on palpation of the ACJ, which denotes a positive test with 96% sensitivity, 10% specificity, and positive and negative likelihood ratios of +1.07 and −0.40, respectively [43].

Various stress tests have been described for the evaluation of ACJ pathology. Tests with high sensitivity show low specificity and vice versa [43]. The following four clinical tests (Fig. 54.2) for the clinical evaluation of ACJ pain can be considered positive if localized ACJ pain is reproduced during their execution:

Cross-Body Adduction Stress or Scarf Test. The affected side upper limb is flexed 90° in the shoulder with the elbow extended or flexed 90°. The upper limb is fully adducted across the body reaching the contralateral shoulder. This maneuver causes localized ACJ pain, especially when

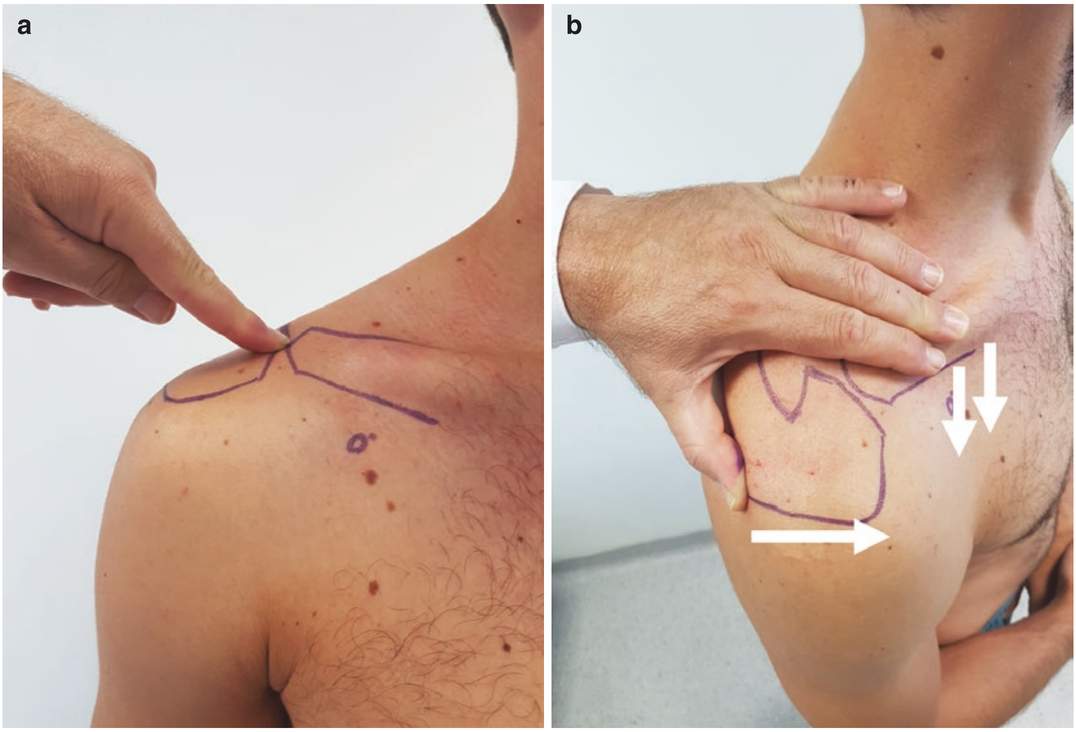


Fig. 54.2 (**a**, **b**) Clinical examination in DCO. (**a**) palpation of the ACJ and (**b**) the Paxinos test

resistance is applied. This test has 77% sensitivity, 79% specificity, and positive and negative likelihood ratios of +3.67 and −0.29, respectively [44].

Acromioclavicular Resisted Extension Test. The upper limb is positioned into 90° of shoulder and elbow flexion and the patient is asked to horizontally abduct the arm against resistance. This test has 72% sensitivity, 85% specificity, and positive and negative likelihood ratios of +4.8 and −0.33 respectively [44].

O'Brien's Active Compression Test. The shoulder is flexed 90° and adducted 10°, the elbow is extended, and the forearm is sequentially fully pronated and fully supinated. The patient is asked to resist a downward applied force on the arm. The test is positive for ACJ pathology when pain is reproduced with maximal supination. The test shows high specificity and variable sensitivity [44]. In a series of 262 patients by O'Brien et al. [45], sensitivity and specificity were 93% and 96%, respectively, and the positive and negative likelihood ratios of +23.1 and −0.08, respectively.

Paxinos Test. The examiner's hand is placed over the affected shoulder. The thumb is placed under the posterolateral aspect of the acromion, and the index and middle fingers are placed on the midpart of the clavicle. The thumb applies pressure in an anterosuperior direction and the index and middle fingers in an inferior direction. The test shows 79% sensitivity, 50% specificity, and positive and negative likelihood ratios of +1.58 and −0.42, respectively [43]. Combination of this test with bone scanning is the most reliable imaging modality for the diagnosis of ACJ pathology [43].

The diagnostic accuracy is significantly increased with a detailed history, appropriate imaging modalities, and the combination of several clinical examination tests [44]. When combined, the Paxinos and O'Brien's tests have a specificity of 95.8% [46]. If the cross-body adduction, Paxinos test, and ACJ palpation are negative, painful ACJ dysfunction can be ruled out.

Pain relief minutes after selective intraarticular ACJ injection of lidocaine under ultrasound guidance confirms ACJ pathology as the cause of symptoms and improves the diagnostic accuracy, although complete pain relief is not always the case. An additional subacromial injection may rule out the rotator cuff as the source of the symptoms.

54.5 Imaging

54.5.1 Conventional Radiology

Conventional radiographs are sufficient for the identification of DCO but the bony changes may take weeks or months before they are evident [29]. The first step in the diagnostic evaluation of the ACJ is to obtain a plain anteroposterior shoulder radiograph with a 10°–15° cephalic tilt centered on the ACJ (Zanca view) with a 50% penetration of the normal shoulder radiograph to avoid overlapping of the scapular spine. The radiographic appearance of all types of DCO is similar [47]. In the early stages of DCO, plain radiographs may appear normal, revealing only soft tissue swelling. In the later stages, radiographic findings include osteopenia, cortical thinning, irregularity and erosions of the distal clavicle, subchondral erosions or cysts, ACJ joint space widening, tapering of the distal clavicle, and osteolysis (i.e., dissolution of the distal part of the clavicle) [15, 29, 35] (Fig. 54.3).

Fig. 54.3 (**a–d**) Clinical examination in DCO. (**a**) cross-body adduction stress or scarf test, (**b**) acromioclavicular resisted extension test, and O'Brien's active compression test in pronation (**c**) and supination (**d**)

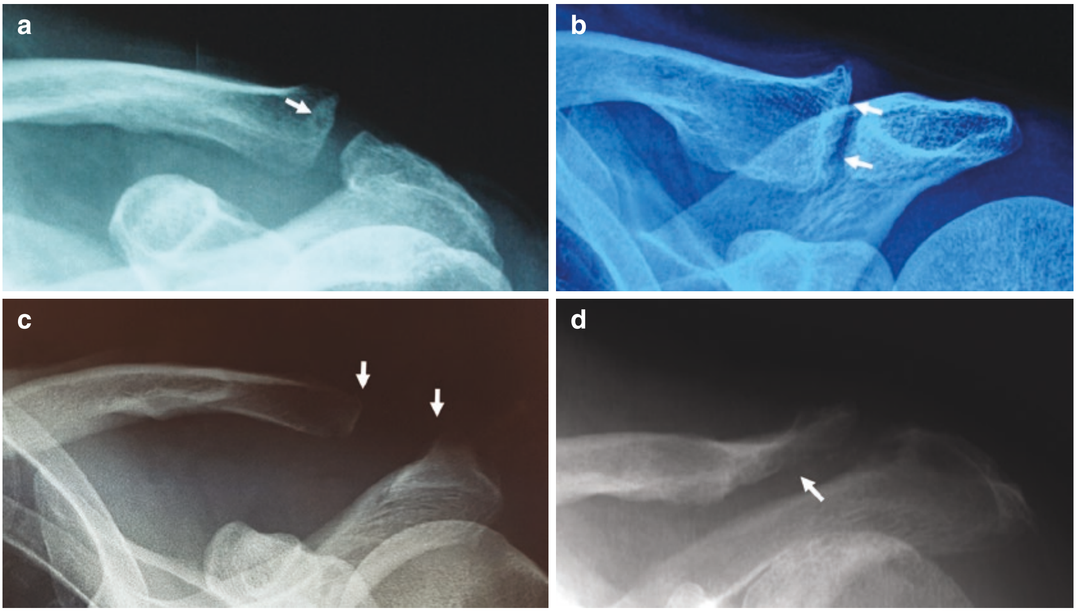


Fig. 54.4 (**a**–**d**) Radiographic findings in DCO. (**a**) Subchondral cysts (arrow), (**b**) fragmentation and erosions limited to the clavicular articular surface (arrow), (**c**) widening of the acromioclavicular joint space (arrows), and (**d**) erosions and tapering of the distal clavicle in long-standing DCO (arrow)

The resorption of the distal clavicle can be 0.5–3 cm in length without lytic lesions on the acromion or the humeral head [7, 12]. The ACJ width is increased in DCO and decreased in osteoarthritis of the joint. Spurring, sclerosis, and narrowing of the ACJ are the radiographic hallmarks of ACJ arthritis [48] (Fig. 54.4).

54.5.2 Bone Scan

A Technetium-99m labeled bone scan is an effective tool to identify early DCO. Increased isotope uptake is seen earlier than radiographic changes. Bone scans show increased focal uptake of the radiotracer at the distal clavicle in the third phase due to the increased osteoblastic activity [2, 14, 28–30, 47, 49].

Nevertheless, bone scan has fallen out of favor, primarily due to the non-specific nature of the findings with high sensitivity and low specificity, but also because it is time-consuming and exposes the patient to substantial radiation. Nowadays, bone scanning is indicated in very young or elderly patients whose symptoms, physical examination, and radiographs are not consistent with DCO, or in those patients with significant comorbidities.

54.5.3 Ultrasound

The ACJ is best assessed using high-frequency linear-array probes positioned longitudinally along the clavicle. Ultrasound examination in patients with DCO is not specific and can reveal the presence of a distended joint capsule, soft tissue swelling, intraarticular fluid, synovitis, irregular cortical erosions, and widening of the ACJ. It is, however, very useful in revealing rotator cuff or biceps tendon disorders. Static and dynamic ACJ testing is also possible.

54.5.4 Computed Tomography

Cortical abnormalities, including the thinned or fragmented clavicle cortex, loose bodies, and subchondral cysts, are more clearly shown in CT scans (Fig. 54.5). The exact location and size of the subchondral cysts and the extent of bone destruction are more adequately depicted with CT scanning [48].

54.5.5 Magnetic Resonance Imaging

There are 6 major findings on MRI in patients with DCO [26, 28, 29, 35, 50–52]: partial or complete distal clavicular bone marrow edema, cortical irregularity and erosions, subchondral cystic changes, presence of a subchondral fracture, periostitis in severe cases, and widening of the ACJ.

There are no differences in the MR imaging features of posttraumatic and atraumatic DCO [50]. Due to its sensitivity, MRI can detect DCO at an early stage revealing the presence of bone marrow edema (BME) in the distal clavicle (Fig. 54.6), and occasionally, but less pronounced, in the articular part of the acromion [29, 50]. Grading of BME is also possible. In Grade I, BME involves only part of the distal clavicle; in Grade II, the whole length and width of the clavicle are occupied; and in Grade III, there is additional periostitis [17]. Periostitis at the distal clavicle is present in advanced cases [28, 29, 50]. The severity of BME in DCO may be associated with pain [17], although this is not always the case. An increased T2 signal in DCO cases may occasionally be seen in the acromion as well (Fig. 54.7), but never in the acromion alone [50, 52]. Compared to ACJ osteoarthritis, BME in DCO is usually only located in the distal clavicle (Table 54.1). There are no osteophytes and there is joint space widening rather than narrowing [52]. The increased distal clavicle bone marrow signal on MRI may normalize following conservative therapy in adults [29] and adolescents [17].

A typical MRI finding in DCO is an undisplaced subchondral fracture in the distal clavicle (Fig. 54.8) presenting as a hypointense subchondral line on all sequences surrounded by bone edema on the T2-weighted sequences [11]. Other non-specific findings are ACJ fluid, capsular and synovial hypertrophy, joint effusion, bone fragmentation, and intra-articular loose bone fragments [26, 52].

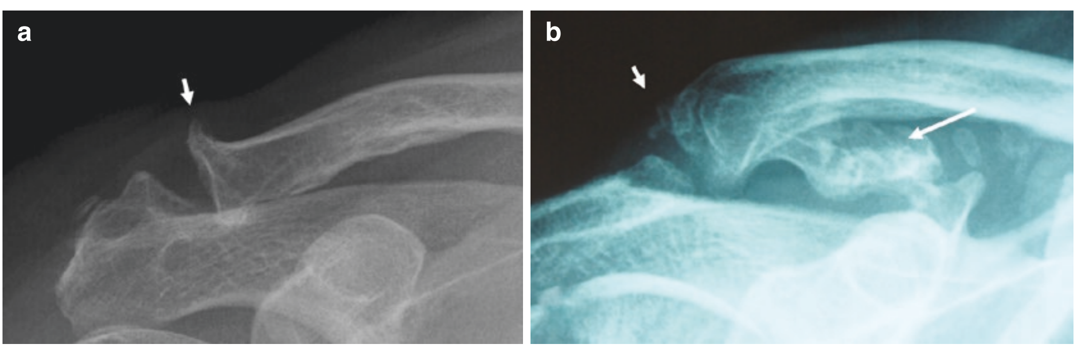


Fig. 54.5 (**a**, **b**) Radiological presentation of chronic DCO. (**a**) Acromioclavicular osteoarthritis with osteophytes and cysts despite the widened acromioclavicular joint space and (**b**) DCO following ACJ dislocation with fragmentation of the distal clavicular articular surface (short arrow) and calcification of the coracoclavicular ligaments (long arrow)

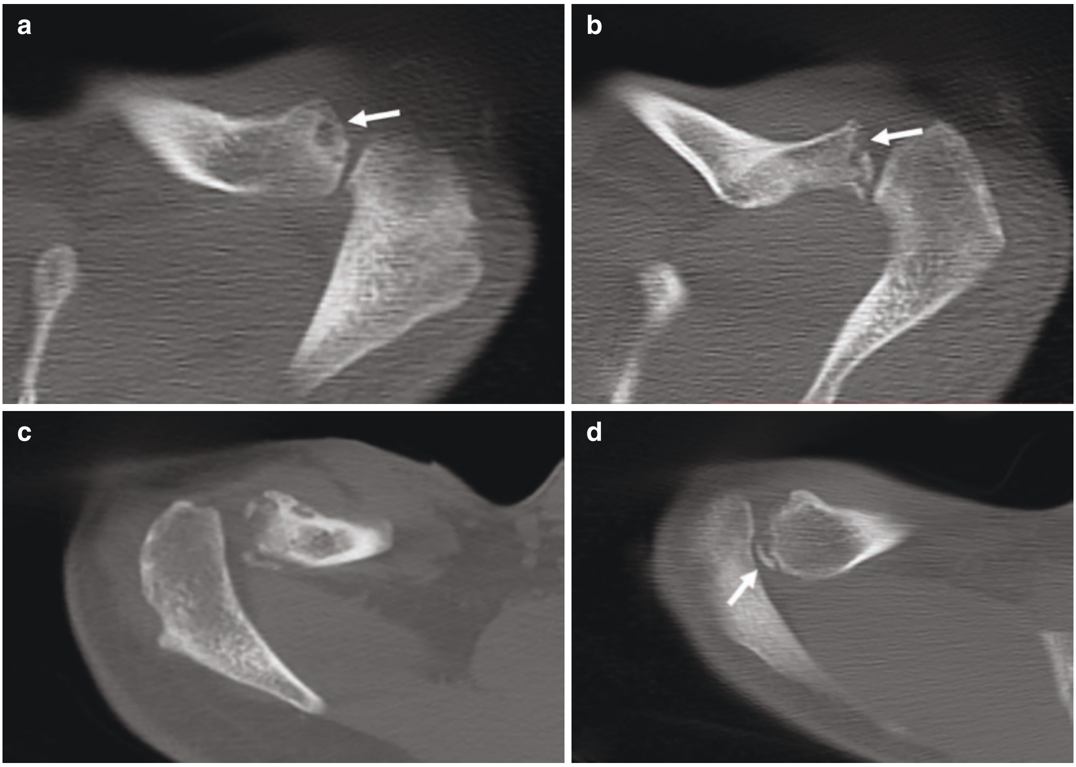


Fig. 54.6 (**a**–**d**) Computed tomography findings in DCO. The location and extent of subchondral cysts (**a** arrow), erosions (**b** arrow), extensive osteolysis (**c**), and the presence of an intraarticular bone fragment (**d**) are shown

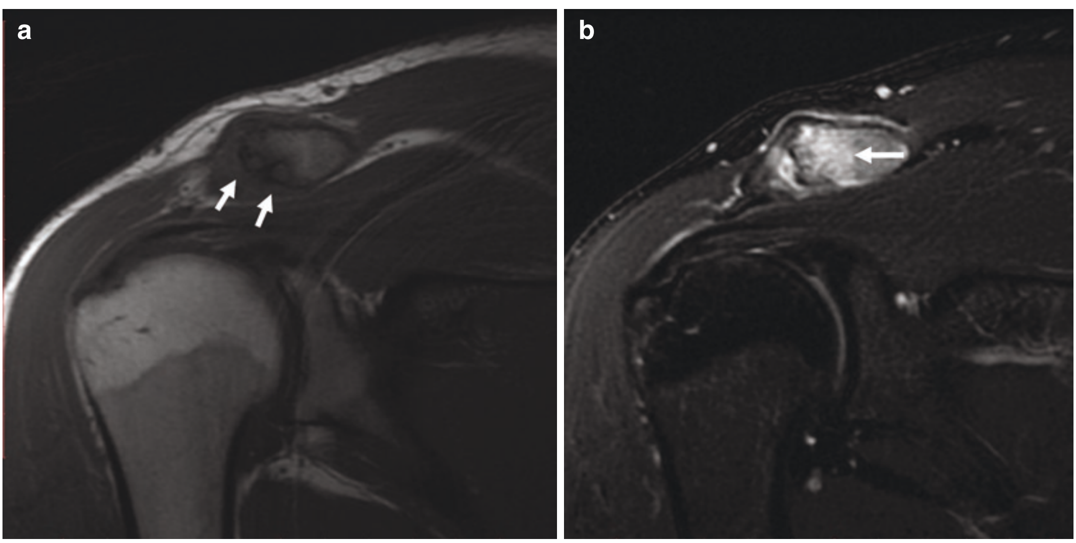


Fig. 54.7 Coronal T1 (**a**) and T2 images with fat saturation (**b**) show the presence of subchondral cysts (**a** arrows) and bone marrow edema (**b** arrow). Edema shows high-intensity signal only in the T2 sequence. In the T1 sequence, the integrity of the bone cortex and the extent of bone involvement are better appreciated

Table 54.1 Comparison of MRI findings in acromioclavicular joint osteoarthritis and DCO (+, present, −, absent)

MRI finding	ACJ osteoarthritis	DCO
Subchondral cysts	+	+
Cortical bone irregularity and erosions	+	+
Distal clavicle absorption	−	+
Bone fragmentation	−	+
Intraarticular loose bodies	+	+
Osteophytes	+	−
Capsular distention/hypertrophy	+	+
Superior capsule disruption	−	+ (39%) [26]
Joint effusion	+	+
Joint space narrowing	+	−
Joint space widening	−	+
Periosteal reaction	−	+
Increased bone marrow T2 signal		
Distal clavicle only	−	+
Acromion only	+	−
Both sides of the ACJ	+	+ minimal (58. 6)

DCO classification; *ACJ* acromioclavicular joint; *BME* bone marrow edema

A classification of DCO based on clinical and imaging findings is presented in Table 54.2. Following and initial phase (Stage 1) with mild symptoms of a bone marrow edema on MRI, a lytic stage follows with erosions (Stage 2) or absorption of the distal clavicle (Stage 3). In extensive bone destruction, the ACJ becomes osteoarthritic (Stage 4A), while when extensive bone absorption occurs the ACJ joint space is occupied with fibrotic tissue (Stage 4B).

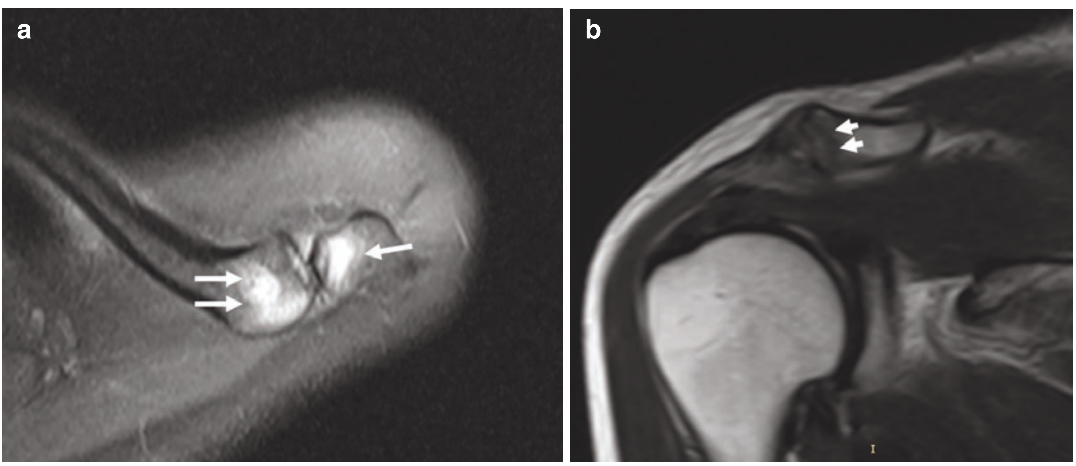


Fig. 54.8 (**a**) Axial PD FS MR image showing the presence of bone marrow edema in both the acromion (arrow) and the distal clavicle (double arrows). This finding is common in ACJ osteoarthritis but can be also seen in DCO. (**b**) Coronal T2 TSE MR image shows the presence of a subchondral insufficiency fracture in the distal clavicle (arrows)

Table 54.2 Comparison of MRI findings in acromioclavicular joint osteoarthritis and distal clavicle osteolysis (DCO)

	Stage 1	Stage 2	Stage 3	Stage 4A	Stage 4B
Histological findings	Non-specific changes	Lytic	Lytic	Degenerative-reparative phase	Absorptive-reparative phase
Duration	Variable, Months to years	6–18 months	Years	Years	Years
X-ray	Normal	• Lucencies • Erosions • Cysts • Osteopenia of the distal clavicle	• Extensive erosions • Clavicular absorption • ACJ widening • Subchondral sclerosis	• Excessive bone destruction • ACJ osteoarthritis • Osteophytosis • Involvement of acromion	• Clavicular end tapering • Dystrophic calcification
MRI	Partial BME on T2 MRI sequence	• BME partial-medium extent • Intraarticular fluid • Capsular hypertrophy	• BME complete clavicle • Subchondral fracture-hypointense line • Cartilage fissuring • Acromion BME less distinct • Periosteal reaction • Capsular tear • Periarticular edema	• Cartilage loss • Bone destruction • Osteophytosis • Obliteration of joint space • Acromion BME • Intraarticular fluid • Capsular hypertrophy • Periarticular edema	• Distal clavicle BME • Acromion BME • Bone loss • ACJ fibrosis
CT	Negative	• Erosions • Cysts • Fragmentation • Loose bodies	• Bone loss • Destruction of bone architecture • ACJ widening	• ACJ osteoarthritis with bone-to-bone contact • Excessive bone destruction • Osteophytosis	• Distal clavicle bone loss • Increased acromioclavicular joint space
Bone scan	Negative	Positive	Positive, occasionally negative depending on the osteoblastic activity	Positive	Negative occasionally positive depending on the osteoblastic activity
Clinical symptoms	Mild or no pain	Activity pain	Activity and/or rest pain	Variable pain or moderate severity symptoms Commonly inconsistent with imaging severity	Variable pain or moderate severity symptoms Commonly inconsistent with imaging severity

54.6 Treatment

54.6.1 Nonoperative Treatment

DCO is a self-limited disease that responds readily to conservative treatment in the majority of cases [2, 17, 52]. If DCO is not recognized and treated early, it may become a disabling and career-ending problem.

Nonoperative management is the mainstay of treatment for DCO. Conservative treatment includes a variety of techniques with primary aim to lessen the pain by reducing clavicle loading, thereby allowing the bone lesion to heal and become asymptomatic. It comprises rest, ice, physiotherapy using various physical modalities, mobilization techniques, nutritional supplementation, activity restriction, modification of training techniques and cross-training, local ACJ injections, and kinesio-taping.

The use of non-steroidal anti-inflammatory drugs (NSAIDs) and pain killers for a short period are indicated to reduce pain and joint inflammation, although NSAIDs may prevent bone healing. Immobilization in a sling is not necessary.

Intraarticular ACJ injections with local anesthetic, cortisone, and hyaluronic acid have both diagnostic and therapeutic value. The beneficial effect of ACJ injections may be temporary or short term rather than permanent [53]. Repeated corticosteroid injections may actually negatively affect the natural progression of DCO and should be avoided. No more than 2 injections are recommended over a period of 6 months.

Rest and avoidance of symptomatic or exaggerating activities is the first line of treatment and the most important step in the conservative treatment of DCO. Patient compliance is essential for the success of the treatment. Modification of the lifting technique, avoidance of all aggravating exercises, minimizing of ACJ overloading, altering the exercise program, and reduction of overhead lifts are all necessary to reduce the patient's symptoms. Detection and treatment of scapular dyskinesia and restoration of the normal ROM and strength to the affected shoulder are of utmost importance. In mild cases, activity modification for 3 to 6 weeks will render the ACJ painless. In more serious cases with established radiologic or MRI changes, protection for a longer period of time, 6 weeks to 6 months, may be necessary, although compliance in professional, high-level athletes is often limited.

Complete elimination of strenuous overhead activities is not possible for most athletes and heavy laborers. In this high-risk patient group, modification of the training intensity and technique and avoidance of excessive training or weightlifting are the only preventative measures. Modification of the exercise technique and avoidance of all aggravating weightlifting exercises is necessary. It has been noted that bench pressing more than 1.5 times body weight (bench weight/bodyweight ratio > 1.5) more than once per week and for more than 5 years increases the risk of DCO by 46.5% [11].

54.6.2 Operative Treatment

When the conservative treatment fails, operative intervention is justified. Failure of the conservative treatment is regarded the presence of persistent point ACJ tenderness, the persistence of exercise pain, the need to return to competitive sports, and the deterioration of the MRI or radiological findings.

Indications for surgery include:

- Limited or no response with persistent ACJ pain and functional impairment despite an extensive (>6 months) conservative treatment
- Unwillingness or inability to modify the activity level or hard labor with persistent symptoms
- High-level athletes who wish to return to competitive sports early

Contraindications for operative treatment include patients with uncertain diagnosis, minimal symptomatology, secondary osteolysis due to tumors or systematic diseases, and unrealistic expectations about the surgery.

54.6.3 Decision-Making Algorithm

The treatment of DCO is challenging because it tends to occur in young, athletic individuals with high expectations. Treatment options must be individualized, taking into account factors such as the patient's age and sex, activity level, shoulder dominance, occupation, severity, chronicity and intensity of symptoms, functional restriction, the patient's needs and expectations, and, finally, but most importantly, the patient's willingness to comply.

The mainstay of treatment for DCO is conservative but in patients with persistent symptoms surgical treatment is advocated. Nevertheless, if left untreated, the symptoms will persist, eventually leading to absorption of the distal end of the clavicle and ACJ osteoarthritis [25].

A decision-making algorithm is presented in Fig. 54.9.

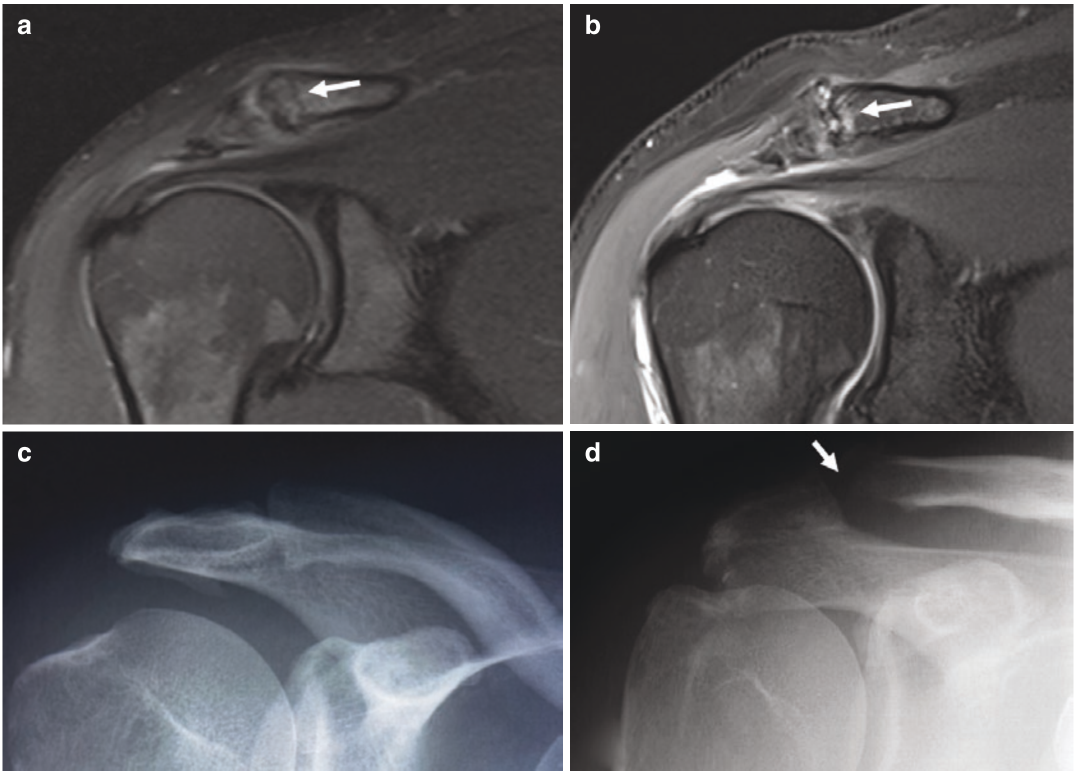


Fig. 54.9 (**a**) PD FS coronal MR image reveals the presence of a subchondral fracture in the distal clavicle with extensive bone marrow edema and bone erosions. (**b**) MRI 2 years later shows the presence of ACJ osteoarthritis. Radiographs before (**c**) and after distal clavicle excision (**d**)

54.6.4 Clinical Case/Example

A 24-year-old weightlifter presented with anterosuperior shoulder pain of gradual onset localized to the ACJ. The symptoms started 2 months prior to the examination and there was no past history of similar injury.

On examination, there was enlargement of the ACJ, point tenderness, and pain with provocative cross-body arm adduction. There was no ROM restriction, and the rotator cuff muscle power was normal. Ultrasound examination revealed distension of the joint space, synovial thickening, and erosions of the clavicular articular surface. An ultrasound-guided injection was performed and a course of NSAIDs with avoidance of upper body resistance training for 6 weeks was recommended. The MRI findings included BME of the distal clavicle, cysts, and mild erosions and a subchondral fracture was evident within the distal clavicle with resorption of the bone distal to the line (Fig. 54.10). The initial treatment improved his symptoms, which recurred after 4 months. A second ultrasound-guided injection was performed with limited success. The patient decided to undergo conservative treatment and he presented 2 years later with osteoarthritis of the ACJ and reduction of the supraspinatus muscle strength. Subacromial distal clavicle excision and repair of a partial articular surface rotator cuff tear were performed, and the athlete returned to his athletic activities after 6 months.

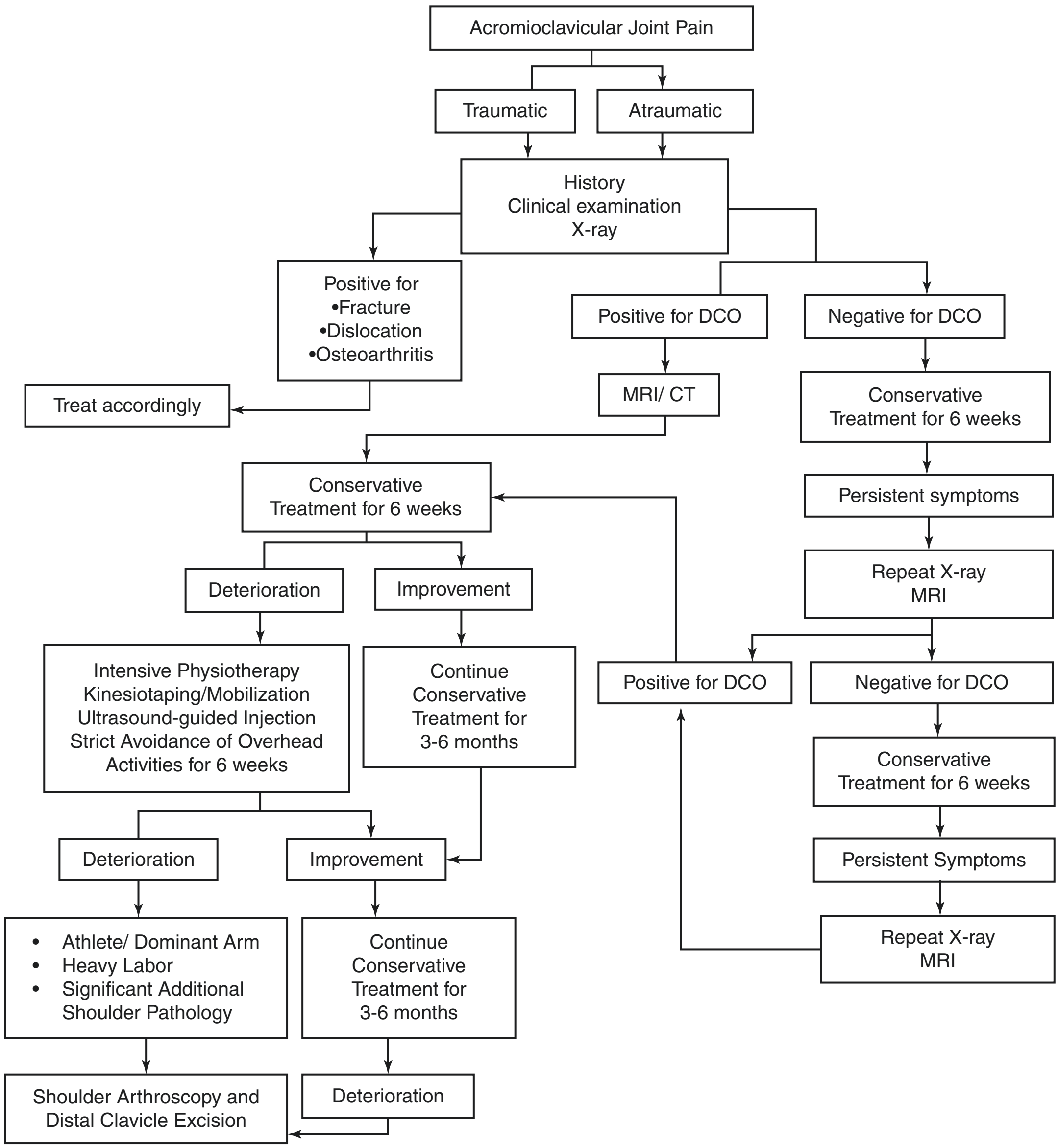


Fig. 54.10 The treatment decision-making algorithm in DCO

54.7 Surgical Technique

The procedure of choice for the treatment of persistent symptomatic DCO is excision of the distal clavicle (DCE), especially when there are extensive osteolysis and ACJ osteoarthritic changes. The rationale of this procedure is to remove the area of bone destruction and prevent abutment of the clavicle with the acromion when arthritic changes are present. DCE can be performed using an open or arthroscopic technique (Table 54.3). Excellent results have been reported with an open approach, resecting 1–2 cm of bone [2] and with arthroscopic resection of only 4 mm [54–58]. Usually 0.5–1 cm of DCE is necessary, keeping in mind that part of the distal clavicle is already eroded or vanished. It is useful to measure the ACJ space on shoulder radiographs or

Table 54.3 Advantages and disadvantages of arthroscopic treatment of DCO with complete or partial DCE compared to open techniques

Advantages
1. Less operative trauma
2. Better bleeding control
3. Improved cosmesis
4. Can be performed as an outpatient procedure
5. Less postoperative scarring
6. Less postoperative pain and dysfunction
7. Ability to evaluate the glenohumeral joint and the subacromial space for concomitant pathological lesions
8. Can be accompanied with other procedures such as synovectomy, SLAP repair, acromioplasty, suprascapular nerve release, etc.
9. Lesser complication rate, such as infection or wound healing problems
10. Faster recovery and return to sports
11. Better patient compliance
12. Reliable results
Disadvantages
1. Increased cost of the procedure
2. Advanced technical skills and instrumentation are required
3. Incomplete ACJ excision more probable
4. Less amount of bone removal is feasible

CT scans bilaterally and aim for a 5–10 mm ACJ space. Resection of less than 5 mm of the distal clavicle does not increase horizontal clavicle translation, whereas resection of more than 10 mm increases anterior and posterior translation [59].

Arthroscopic DCE for DCO can be performed using the superior (direct) or the subacromial (indirect) approach. Both surgical approaches provide a successful clinical outcome by the mid-term follow-up, although an earlier return to sports has been shown with the superior approach, probably due to lesser surgical trauma or the exclusion of patients with comorbidities [57].

With the superior approach, the arthroscopic instruments are inserted directly into the ACJ through an anterior–superior and a posterior–superior portal [56, 57]. With the subacromial approach, the posterolateral and anterolateral portals are used as viewing portals and the distal clavicle is excised with a bone burr inserted from an anterior ACJ portal, which is the main working portal.

Glenohumeral arthroscopy helps in the diagnosis and treatment of occult labral pathology, which may as high as 50% [58].

54.7.1 Patient Positioning

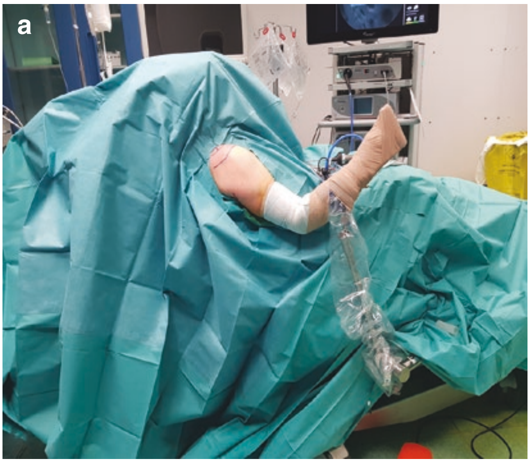
The patient is placed in the beach position with the upper limb stabilized using a limb-positioning system. General hypotensive anesthesia, preemptive pain control using an intrascalene nerve block, and continuous cerebral oximetry by near-infrared spectroscopy are routinely employed. Preoperative prophylactic antibiotics are administered intravenously during the induction of anesthesia. An arthroscopy pump is used with the pressure set to 50 mmHg and the joint is inflated with normal saline with 1:1000 epinephrine (1 ml for a 3000 ml bag of fluid).

54.7.2 Portals

Following prepping and draping, the bony landmarks are palpated and marked, including the scapular spine, acromion, clavicle, acromioclavicular joint, and coracoid process. Palpation of the ACJ and drawing the anteroposterior direction of the joint are especially useful for orientation. All portals are marked on the skin and two 18-G, 5-cm-long needles are inserted, one in the anterior and one in the posterior edge of the ACJ in order to help with the orientation.

The portals used are (Fig. 54.11) the following:

- Standard posterior portal glenohumeral portal, 2 cm inferior and 2 cm medial to the posterolateral corner of the acromion
- Posterolateral subacromial portal, 2 cm lateral to the posterolateral corner of the acromion
- Lateral anterosuperior subacromial portal, 2 cm lateral and in line with the anterior edge of the acromion
- Anterior ACJ portal, 1 cm distal and in line with the ACJ
- Neviaser portal or superolateral ACJ portal (occasionally).



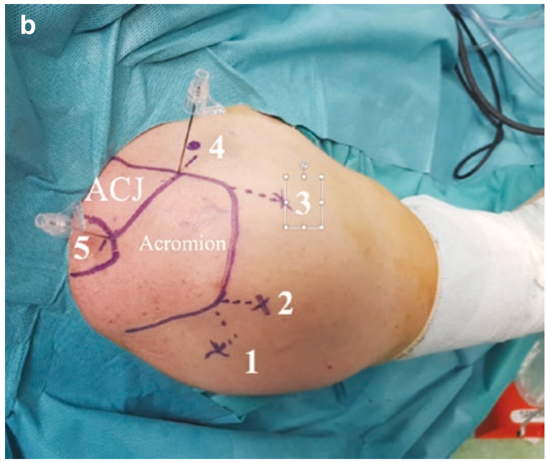


Fig. 54.11 (**a**, **b**) The patient is placed in the beach-chair position with the upper extremity in a limb-positioning system (**a**). The viewing and working portals used (**b**) are the standard posterior glenohumeral portal (1), the standard subacromial portal (2), the anterolateral portal (3), the anterior ACJ portal (4), and occasionally the Neviaser or a superolateral ACJ portal (5)

54.7.3 Step-by-Step Procedure

Through the standard posterior viewing portal, the glenohumeral joint is inspected with the 30° arthroscope for additional pathology, especially SLAP tears and partial articular surface rotator cuff tears and all secondary pathology is addressed.

Subacromial arthroscopy follows with the arthroscope in the posterolateral subacromial portal. In order to visualize the undersurface of the ACJ, partial subacromial bursectomy is performed with an arthroscopic radiofrequency electrode placed in the lateral anterosuperior portal.

The two previously placed 18-G needles are recognized, demarcating the anterior and posterior boundaries of the ACJ. Recognition of the distal clavicle-acromion boundary is facilitated when the assistant pushes down on the clavicle. The caudal ACJ capsule is excised and the distal clavicle is exposed, preferably for 5 mm but always less than 1 cm, taking into account the length of the tip of the radiofrequency electrode is 3 mm and its width 1.5 mm. Occasionally, it is necessary to remove soft tissues from the undersurface of the acromion, including the attachment of the acromioclavicular ligament. Preservation of the superior and posterior acromioclavicular joint capsular ligaments is especially important to avoid painful horizontal ACJ instability.

A third needle is now inserted from the anterior portal in the direction of the ACJ joint line. The direction of the arthroscopic instruments inserted through the anterior portal should be parallel to the AC joint line. In lateral or medial portal placement, the incorrect angle of burr insertion will make arthroscopic resection more difficult. Occasionally, in patients with supple soft tissues, excessive fluid escape into the soft tissues may alter the position of the skin drawings. No cannula is used for three reasons: (1) to minimize the length of skin incisions and the corresponding deltoid and soft tissue injury, (2) reduce egression of saline into the soft tissues, and (3) increase the maneuverability of the arthroscopic instruments.

The arthroscope is placed in the anterolateral portal and the radiofrequency electrode is inserted from the anterior portal completing the preparation of the distal clavicle (Fig. 54.12). The distal end of the clavicle is progressively removed with an arthroscopic barrel burr working from anterior to posterior and from lateral to medial and the resection is completed by working from inferior to superior. Burring should be continuous and uninterrupted to avoid uneven and incomplete resection.

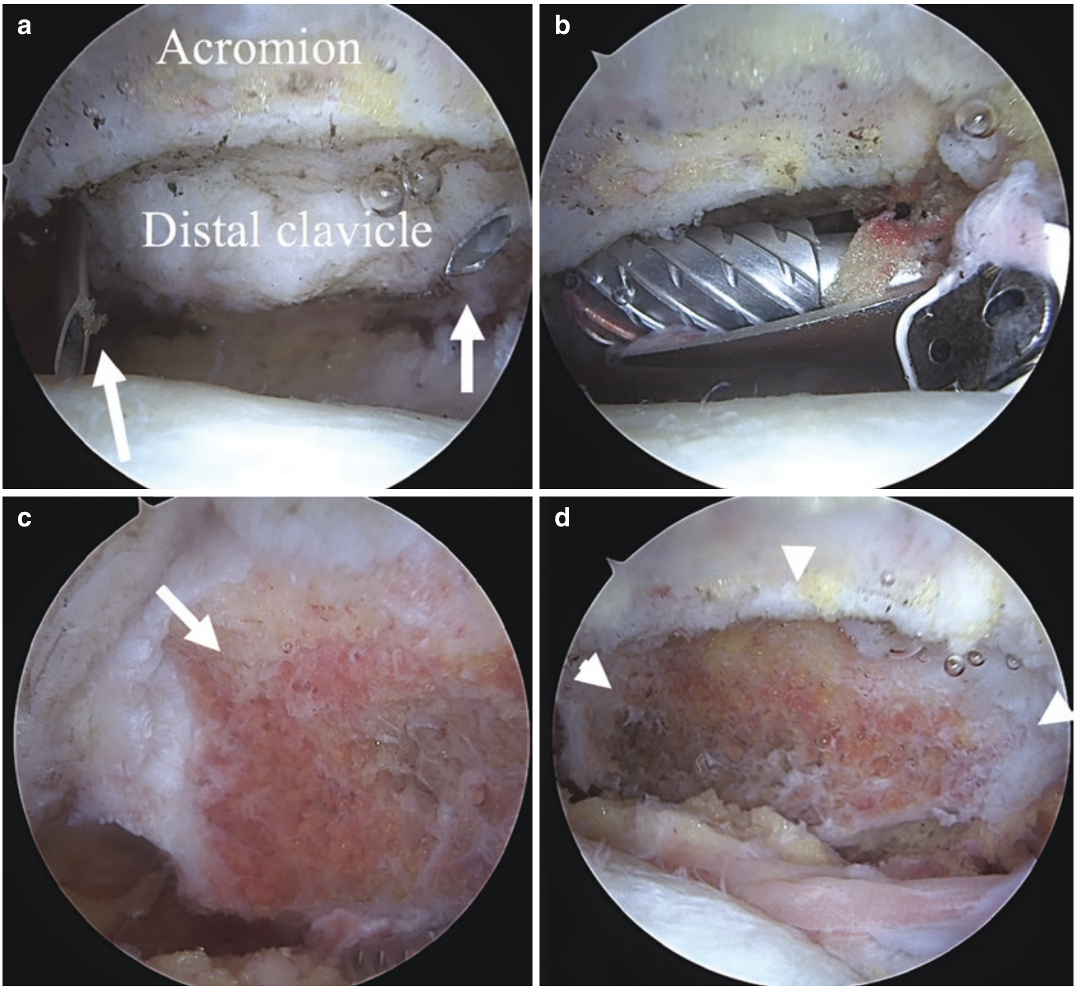


Fig. 54.12 (**a**–**d**) Intraoperative view of the acromioclavicular joint from the standard posterolateral subacromial viewing portal (**a**). The ACJ is demarcated with two needles, one in the anterior and one in the posterior border of the distal clavicle (arrows). (**b**) a bone burr is inserted through the anterior portal and the radiofrequency probe through the anterolateral portal with the arthroscope is in the anterior portal (**c**). Typically, bone that needs to be excised remains in the superior and posterior borders of the distal clavicle. (**d**) The distal clavicle viewed from the anterolateral portal. Preservation of the posterior, superior, and anterior ACJ capsular ligaments (arrowheads) is crucial

Beveling of the posterior edge of the distal clavicle is recommended. The width of the resection can be measured on the skin after placing percutaneously two 18-gauge needles in a mediolateral direction, one in contact with the acromion articular surface and one in contact with the resected distal clavicular surface.

In case of an absorbed distal clavicle, resection of less than 5 mm is performed, preserving the always intact articular surface of the acromion. When the bone lesions are less severe and only bone marrow edema is prevalent on MRI, a limited decompression technique can be used by removing only 5 mm of the bursal surface of the distal clavicle, preserving the length of the clavicle. This procedure has been called "coplaning" and has been used with good results in subacromial decompression [60]. With this procedure, the ACJ is denervated due to the excision of the inferior capsule and the cancellous bone of the distal clavicle is decompressed from the marrow edema. Occasionally, using the limited decompression technique, only the anterolateral portal is necessary, thereby avoiding the need for an anterior portal, especially when the clavicle is longer in its superior-inferior dimension than the acromion. In the case of continuous bleeding from the cancellous bone, it is recommended to perform cauterization using the radiofrequency electrode.

When the excision is complete, the arthroscope is placed in the anterior portal in line with the resected clavicle in order to verify the completeness of the excision.

Resection of the superior and posterior capsule should be avoided in order to prevent painful iatrogenic ACJ instability. Meticulous removal of the resected bone debris is carried out to avoid heterotopic calcification. Absence of clavicle impingement is verified under arthroscopic vision by performing the passive cross-body adduction test.

54.7.4 Tips & Tricks

Complications following DCE are not very common, although the incidence may be as high as 64% [57, 61, 62]. The majority of postoperative complications can be prevented with accurate preoperative planning, meticulous hemostasis, and careful recognition of the anatomical structures, most notably the anterior and posterior borders of the clavicle. Some tips and tricks to achieve a safe and successful procedure are reported in Box 54.1.

Box 54.1 Tips and Tricks of Arthroscopic Distal Clavicle Excision

- Measurement of the resection width and length is performed preoperatively on radiographs, MRI, and CT scans, thereby avoiding over-resection.
- Marking of the anteroposterior direction of the ACJ on the skin and placement of two guiding needles in the anterior and posterior ACJ borders prior to the procedure can assist with intraoperative orientation
- Only the skin is incised to avoid additional muscle damage, bleeding, and possible portal pain
- Avoiding use of cannulas reduces the length of skin incisions and affords greater mobility to the arthroscopic instruments
- Meticulous exposure of the anterior and posterior borders at the distal end of the clavicle is necessary using electrocautery, exposing only 5 mm of the distal clavicle
- Bone resection is performed from anterior to posterior, distal to proximal, and inferior to superior
- Manual downward pressure to the clavicle during DCE facilitates the procedure
- Placing the arthroscope in the anterior working portal after DCE verifies the completeness of the excision
- The dimensions of the barrel burr help to verify the preoperatively measured resection length and width
- Use of the 70° arthroscope and switching the viewing and working portals increases arthroscopic visibility
- Inadequate hemostasis may lead to hematoma formation. Cauterizing the cancellous bone of the distal clavicle and use of tranexamic acid are occasionally necessary

54.8 Postoperative Care

If DCE is performed in conjunction with other procedures, such as rotator cuff or SLAP repair, the physiotherapy protocol of the latter procedure is followed. In the immediate postoperative period and for the first 24 to 48 hours, the operated arm is placed in a sling for comfort, but the patient is encouraged to perform mild ROM exercises. Cryotherapy is initiated in the recovery room and continues for the first week, as tolerated. NSAIDs are administered for 10 days to reduce the possibility of heterotopic calcification. The patient is encouraged to use the arm as tolerated but we do not recommend pendulum ROM exercises. Scapular strengthening exercises start immediately and pain-inducing exercises are avoided. Physical therapy begins on the second day with the use of analgesic and anti-inflammatory modalities, progressing to passive and active-assisted exercises during the first week. Mild active exercises can begin in the second week, adding resistance training in the third postoperative week. Sports-specific exercises may start the fourth postoperative week and the anticipated return to the previous activity level is 6 to 8 weeks after the operation. Avoidance of cross-body adduction is recommended for 8 weeks.

54.9 Literature Review

A more detailed presentation of the published studies regarding the treatment of patients with DCO is presented in Table 54.4. Most studies are retrospective Level IV case series without randomization, with limited patient population, and lack of standardized outcome measures. Only 2 randomized trials report the outcome of DCE in a population of athletes with mixed ACJ pathology [57, 58]. One of the studies [58] is underpowered because post hoc power analysis showed that 14 patients per group, instead of 8 or 9, were necessary to achieve statistical significance [64].

The majority of published studies on open and arthroscopic DCE focus on the treatment of ACJ osteoarthritis rather than DCO. Further to that, patient populations are often mixed and the results are unified. In Cahill's series of weightlifters with atraumatic DCO after open DCE, 19 of 21 patients had an excellent result but only 14 were able to return to their previous level of weight training [2]. Five operated patients had symptom resolution, but they could not resume their previous level of activity.

Several studies have investigated surgical outcomes for DCO in adolescents and adults. Scavenius et al. [13] reported the results of open DCE in 4 athletes with atraumatic DCO and 4 other patients with traumatic DCO following ACJ dislocation or clavicle fracture. They only presented data on the athletic population and the results were described as excellent in all cases with full return to athletic activities, although two patients had persistent tenderness on the ACJ. It should be noted that no valid outcome measure scale was used in this study.

Flatow et al. [56] compared open with direct arthroscopic DCE for DCO in a series of 12 patients. The average amount of DCR was 18 and 17 mm, respectively, but the level of pain and the final functional result was similar in both groups, although pain relief was faster and hospital stays were shorter in the arthroscopy group.

In adolescents (mean age 15.4), the majority of patients with DCO (43/46, 93%) were successfully treated with conservative means and 7% (3/46) underwent arthroscopic resection with complete resolution of symptoms and return to full athletic activity after 12 weeks [17].

In a series of 63 adult male patients with atraumatic DCO who failed conservative treatment and underwent DCE, symptoms were improved in all cases with 0% revision surgery rate after a minimum follow-up of 11 months and a mean follow-up of 14.2 months [11]. In a series of 10 male weightlifters with DCO who were treated with limited arthroscopic DCE (average resection width, 4.5 mm), after an average follow-up of 18.7 months, all patients return to their previous sports after an average of 3.2 days and to the preoperative weight training program after an average of 9.1 days [55].

Arthroscopic DCE using the bursal and the direct approach provide equally good postoperative results [65]. Arthroscopic DCE through a direct or indirect approach both show successful outcomes in patients with either DCO or ACJ osteoarthritis, but the patients who were subjected to direct superior arthroscopic DCR improved clinically faster [57]. In an outcome study of arthroscopic versus open DCE including 37 patients (41 shoulders) with isolated DCO, it was concluded that the results were comparable between the groups but the morbidity in the arthroscopic DCE group was notably lower [16].

Table 54.4 Results of published studies reporting the outcome of open or arthroscopic distal clavicle excision (DCE) in patients with distal clavicle osteolysis (DCO). ACJ, acromioclavicular joint

Study	Year	Study details	Level of evidence	Sample size	Intervention	Outcome measures	Mean follow-up	Results
Cahill	1982	Cases series	IV	21 patients, 25 shoulders Men Atraumatic DCO	Open DCE	N/A Pain Grades I–IV Return to sport Yes-No	7 years [2–11] 19 patients	Return to sport 5/19(26.3%) Pain Grade I 13(68.4%), Grade II 4(21.1%) Grade III 2(10.5%), Grade IV 0
Petersson	1983	Cases series	IV	16 (11 men, 5 women) Non-traumatic ACJ pain	Open DCE 1–2 cm	N/A	Age at operation 49 ± 13 years Age at follow-up 56 ± 13 years	Early results: pleased 13, not pleased 3 Results at follow-up: Good 10, fair 4, poor 2
Scavenius et al.	1987	Cases series	IV	8 patients 4 cases traumatic DCO 4 cases atraumatic DCO	Open DCE	N/A	N/A	50% follow-up rate Excellent results in atraumatic DCO 50% mild pain
Flatow et al.	1992	Case series	IV	12 patients with DCO in 2 groups ($n = 6$)	Group I open Group II arthroscopic DCE	N/A	Group I 30 months [24–37] Group II 18 months [12–20]	All patients had full return to all activities, including athletics, full motion and strength, and no pain.
Slawski and Cahill	1994	Cases series	IV	14 pts., 17 DCR Men Atraumatic DCO	Open DCE	UCLA Shoulder Rating Scale	Average 25 months	Excellent [8] or good [9].
Petchell et al.	1995	Cases series	IV	18 patients, 8 with DCO	Open DCE	UCLA, ASES, Constant, Neer	3 years (9 months-8 years)	72% excellent or good results
Auge et al.	1998	Cases series	IV	10 patients men	Arthroscopic DCE	N/A	Average 18.7 months [12 to 25]	100% excellent Preoperative activity regained at average, 9.1 days [7–12].

Zawadsky et al.	2000	Case series	IV	41 shoulders, 37 patients with DCO	Arthroscopic DCE	N/A	Average 6.2 years	Good/excellent 93% Failure in 7% in traumatic DCO
Levine et al.	2006	Therapeutic case series	IV	60 patients/66 shoulders isolated ACJ pain without ACJ dislocation	Group I, $n = 24$, arthroscopic DCE, bursal approach Group II, $n = 42$, direct approach	ASES	6 years (2 to 11.5 years)	Average ASES score 90 (53–100) in group I and 94 (55–100) in group II (no significant difference) 10% in group II required ACJ stabilization or revision surgery
Charron et al.	2007	Randomized controlled trial	II	36 pts (Group I 18 pts., 12 with DCO and Group II, 16 patients, 11 with DCO)	Arthroscopic DCE Direct and indirect approach	ASES score, Athletic Shoulder Scoring System (ATH) score	27 months [21–31, 35]	33 /34 patients had a clinically successful outcome by both the ASES and ATH scores
Freedman et al.	2007	Prospective randomized study	II	17 patients ACJ osteoarthritis, $n = 9$ and DCO, $n = 8$ Group I, $n = 9$ and II $n = 8$	Open or indirect arthroscopic DCE	VAS, MASES, SF-36, subjective satisfaction score	6-months 100% 1-year 88%	At 1-year follow-up no significant differences in pain scores OA versus DCO VAS score improvement Group I, 75%, Group II, 100% Return to activity Group I, 50%, Group II, 100%
Nevalainen et al.	2016	Cases series	IV	63 patients	DCE	N/A	14.2 months (minimum 11 months)	100% improvement 0% revision surgery
Torrence et al.	2017	Case series	IV	16 patients with DCO 1 bilateral	Subacromial DCE	ConstantScore, QuickDASH VAS satisfaction score	21.38 ± 10.69 months [3–39, 63]	87% returned to their former level of sports VAS increased from 3.7 ± 1.7 to 8.8 ± 2.5 Constant Scores improved from 52.3 ± 12.1 to 87.3 ± 17.8 QuickDASH score improved from 30.5 ± 6.4 to 6.8 ± 1.2

The majority of the patients (93%) had a good or excellent result with preservation of shoulder function and in the three failure cases, significant shoulder trauma was reported [16].

No significant difference has been shown in the clinical outcome between open and arthroscopic DCE [62], although it has been suggested that the open resection technique results in non-significantly improved clinical outcomes but without difference in long-term pain relief [64]. The length of bone resection is significantly less with the arthroscopic techniques, ranging from 5.4 to 10 mm compared to 10 to 13 mm in the open resection techniques [64].

Failure of arthroscopic distal clavicle resection for DCO is heralded by inadequate pain relief and may be due to incorrect diagnosis, failure to treat all pain sources, inadequate distal clavicle resection, iatrogenic AC joint instability, and persistent scapular dyskinesia. Most of the causes of failure are preventable with careful clinical examination, adherence to good surgical technique, and a supervised, individualized physiotherapy program.

54.10 Summary

Distal clavicle osteolysis is a potentially career-ending injury or disease predominating in young athletic individuals or heavy laborers. Early recognition and conservative treatment of the injury using physiotherapy, injection, and activity modification is successful in the majority of patients. If conservative treatment fails, partial or complete excision of the distal clavicle provides good clinical results, eliminating the pain and the disability, and, in most cases, allows for a return to the previous activity level.

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