The Evaluation and Management of Failed Distal Clavicle Excision

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Abstract: Excision of the distal clavicle (DCE) is a commonly carried out surgical procedure used in the management of acromioclavicular joint pathology. Although successful outcomes after both open and arthroscopic distal clavicle excision occur in a high percentage of patients, treatment failures have been reported, creating a difficult clinical scenario for the treating orthopedic surgeon. The most common mode of failure after DCE is persistent pain and potential etiologies include under-resection, over-resection leading to joint instability, postoperative stiffness, heterotopic ossification, untreated concomitant shoulder pathology, and postoperative infection. Less common causes of failure include distal clavicle fracture, reossification or fusion across the acromioclavicular joint, suprascapular neuropathy, and psychiatric illness. Persistent symptoms and disability after distal clavicle excision require a careful assessment of these potential causes of treatment failure and the formulation of a treatment plan, which may include conservative care, revision surgery, or coracoclavicular ligament reconstruction. Although careful patient selection, preoperative planning, proper surgical technique, and appropriate rehabilitation during the index procedure can minimize the likelihood of poor outcome, this paper reviews the work-up and management of cases of failed distal clavicle excision.

Key Words: acromioclavicular joint, distal clavicle excision, coracoclavicular ligament reconstruction, open surgery, arthroscopic surgery, revision surgery

Patients with pathology of the acromioclavicular (AC) joint, including osteoarthritis and distal clavicle osteolysis commonly present with pain and difficulty with activities that require cross-arm adduction. After a trial of nonoperative management, which typically includes activity modification, nonsteroidal antiinflammatory medications, physical therapy, and intraarticular corticosteroid injections, patients with symptomatic AC joint pathology are often indicated for surgical treatment including distal clavicle excision. Whether carried out open or with an arthroscopic technique, distal clavicle excision has been reported to result in successful outcomes in a high percentage of treated patients.

In a recent systematic review, Rabalais and McCarty[1] reported that among 289 patients treated with open distal clavicle excision, good to excellent results occurred in 76.3% at a mean of 4.9 years of follow-up (range 50% to 100%). As techniques and instrumentation have evolved and surgical experience has increased, arthroscopic distal clavicle excision has become increasingly popular. Proponents of the arthroscopic technique report improved cosmesis, easier postoperative rehabilitation, and a faster return to function, secondary to the preservation of the AC joint ligaments, capsule, and the deltotrapezial fascia. Clinical studies have shown good to excellent outcomes after arthroscopic distal clavicle excision in 85% to 100% of treated patients.[2]

Patients with persistent symptoms and disability after either open or arthroscopic distal clavicle excision represent a difficult clinical scenario for the treating orthopedic surgeon. Potential etiologies of failure after distal clavicle excision include under-resection, over-resection leading to postoperative joint instability, postoperative stiffness, heterotopic ossification, untreated concomitant shoulder pathology, and postoperative infection. Less common causes of failure include distal clavicle fracture, reossification, or fusion across the acromioclavicular joint, suprascapular neuropathy, and psychiatric illness (Table 1).

Patients presenting as failed distal clavicle excisions require a careful work-up in an attempt to identify the etiology behind their persistent symptoms and the formulation of a treatment plan that may include revision surgery or coracoclavicular ligament reconstruction. Although careful patient selection, preoperative planning, proper surgical technique, and appropriate rehabilitation during the index procedure can minimize the likelihood of poor outcome, this paper reviews the work-up and management of cases of failed distal clavicle excision.

ANATOMY AND BIOMECHANICS OF THE ACROMIOCLAVICULAR JOINT

The acromioclavicular (AC) joint articulation anchors the clavicle to the scapula. It is a diarthroidal joint with approximately 4 millimeters of space between the hyaline cartilage surfaces of the acromion and the distal clavicle.

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TABLE 1. Potential Etiologies of Failed DCE

More common causes	Less common causes
Persistent pain	Distal clavicle fracture
Under-resection	Acromioclavicular joint
Over-resection	Reossification/fusion
Stiffness	Suprascapular neuropathy
Heterotopic ossification	Psychiatric illness
Untreated concomitant	
shoulder pathology	
Infection	

A fibrocartilaginous disk within the joint is a meniscal homologue, but serves no known function. The AC joint degenerates with age, and secondary to degeneration or injury, may become a source of anterosuperior shoulder pain.[3]

Horizontal and vertical stability of the acromioclavicular joint is required for proper joint function. Static restraints include the acromioclavicular ligaments, the coracoclavicular ligaments, and the coracoacromial ligament. The acromioclavicular ligaments and joint capsule serve as the primary restraints to anterior and posterior (horizontal) translation. The 2 portions of the coracoclavicular ligament are the posteromedial conoid and the anterolateral trapezoid. The conoid is more active in preventing vertical translation of the distal clavicle, whereas the trapezoid confers axial stability[3–7] (Fig. 1).

Dynamic restraints of the acromioclavicular joint include the deltoid, trapezius, and serratus anterior musculature. The acromioclavicular ligaments are reinforced by the origin of the deltoid and fibers of the insertion of the trapezius muscle. The trapezius and serratus anterior muscles form a force-couple, which dynamically stabilizes the acromion.[5]

Motion at the acromioclavicular joint includes rotation and translation in the anterior-posterior and superior-inferior planes. Approximately 5 to 8 degrees of rotation has been noted to occur at the AC joint with forward elevation and abduction of the upper extremity. In addition, the AC joint serves as the pivot point for scapular (acromial) protraction and retraction.[5,8]

CAUSES OF DISTAL CLAVICLE EXCISION FAILURE AND MANAGEMENT

In 1995, Basamania et al[9] published a classification system for failed distal clavicle excision that included
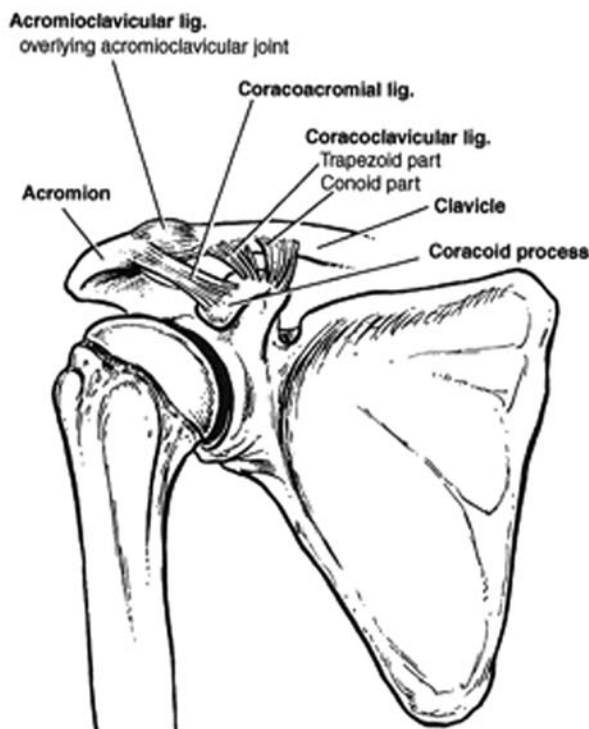

FIGURE 1. Anatomy of the acromioclavicular joint.

diagnostic error, inadequate resection, joint instability, weakness, and miscellaneous factors. Although diagnostic error clearly can lead to failure of an AC joint resection, with patients reporting continued symptoms after even a well carried out procedure, misdiagnosis can be minimized with an appropriate preoperative history, physical examination, and radiographic evaluation. More commonly, complications after distal clavicle excision are owing to improper surgical technique. An appropriate work-up including adjunctive radiographs such as the Zanca view focusing on the AC joint, CT scans, and MRI's may help identify the specific cause of postoperative failure. In addition, selective injections of local anesthesia into the AC joint may support the diagnosis of a failed DCE and help guide subsequent management.

Under-resection

Incomplete resection of the superior or posterior cortex of the distal clavicle is a potential cause of failure that has been more commonly reported after arthroscopic techniques than open procedures, likely secondary to incomplete visualization.[10] Inadequate resection can also occur secondary to retained posterior cortical ridges or an uneven resection of the distal clavicle.[11,12] Arthroscopic visualization during a distal clavicle excision can be improved with the use of hypotensive anesthesia, use of epinephrine in the irrigation bag, and meticulous coagulation of bleeding tissue.[10] Specific techniques to improve visualization of the AC joint include manual intermittent depression of the distal end of the clavicle with use of the arthroscope in the lateral portal,[13] direct anterior visualization with the arthroscope in the anterior portal, and the use of spinal needles to verify complete resection of the superior border. It is critical to view the resection in 2 planes during the procedure to confirm adequate resection of bone.

In a biomechanical study of 13 shoulders by Branch et al,[14] it was shown that a minimum of 5 mm of the distal clavicle must be removed to prevent bone on bone contact postoperatively.

Patients with insufficient resection usually present postoperatively with symptoms similar to those that led to the indication of the index procedure. These symptoms include localized AC joint pain, pain exacerbated by cross arm adduction, and pain worsened with upper extremity motion. The presence of retained bone is confirmed with an appropriate radiographic evaluation, including the use of a Zanca view to focus on the AC joint articulation (Fig. 2). Additional detail regarding the extent and location of the retained bone may be obtained through the use of a CT scan with thin cuts through the AC joint. MRI may also have use in the work-up of persistent symptoms secondary to under-resection, typically showing increased signal (bony edema) in the distal clavicle indicative of persistent contact. In addition, selective anesthetic injections into the AC joint may be used to confirm the diagnosis of failed DCE secondary to incomplete resection.

Incomplete resection can be addressed by a revision distal clavicle excision, carried out either open or arthroscopically, generally using a technique that is similar to that used during the original procedure. An arthroscopic approach may be indicated when the history and physical examination is consistent with the presence of concomitant shoulder pathology.[15] A study by Freedman et al[15] of 17 patients undergoing distal clavicle excision (9 open, 8 arthroscopic) found that 50% of those in the participants in
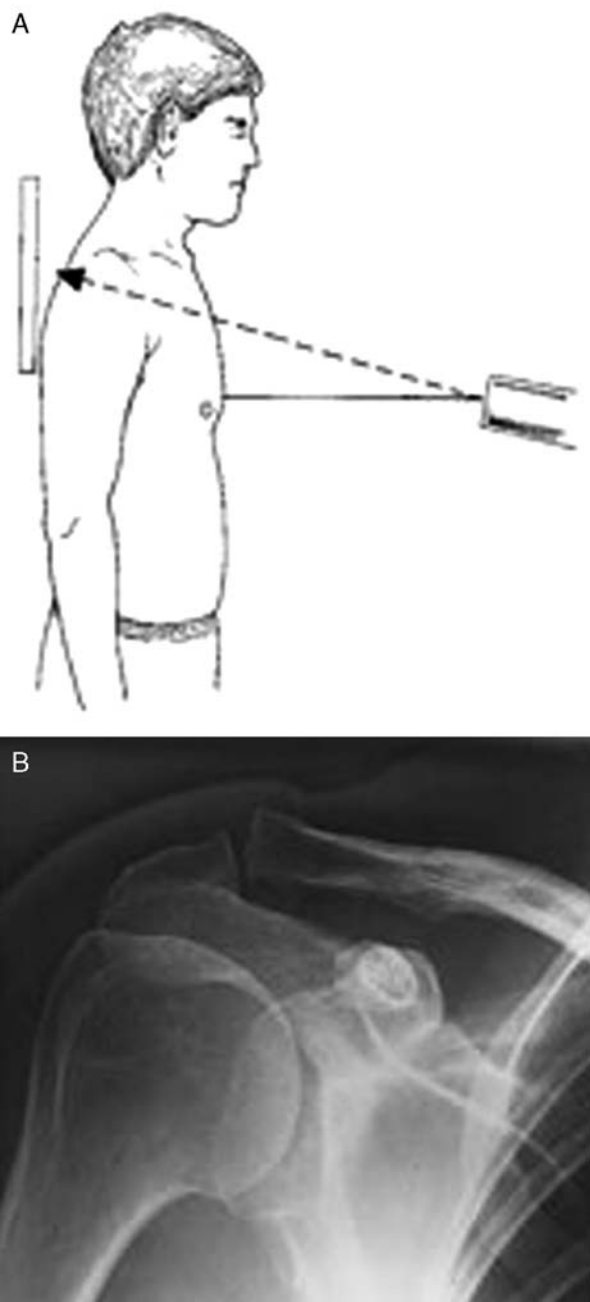
FIGURE 2. A, Technique for taking a zanca view. B, Zanca View of the acromioclavicular joint.

the arthroscopic group had concomitant glenohumeral or subacromial pathology that would have been missed without a diagnostic shoulder arthroscopy.

Some surgeons believe that the ability to avoid violation of the deltotrapezial fascia with an arthroscopic resection can allow for a more rapid return to activity and therefore, is preferred for younger athletic patients. An additional possible consideration for carrying out an arthroscopic revision resection over an open resection is a patient with comorbidities that would increase the risk of postoperative infection such as diabetes or a localized skin disorder.

Open revision procedures are preferable in cases in which an isolated distal clavicle excision is required, in cases of hypertrophic osteoarthritis, and when patients are medically unstable. In hypertrophic osteoarthritis, an open procedure will facilitate superior osteophyte removal and allow for proper reconstruction of the deltoid-trapezius aponeurosis after resection of the expanded distal clavicle. In this fashion, the ability to imbricate the AC joint capsule and deltoid-trapezius aponeurosis may improve stability of the joint in cases in which the surgeon suspects instability as a potential contributing factor to pain. An open procedure is also preferable for medically unstable patients or those with cardiac conditions who may become hypotensive in the standard beach chair position, as the open distal clavicle excision can generally be carried out more quickly than one carried out more quickly than one performed arthroscopically. One study showed that an open distal clavicle excision could be completed in less time than that required to set up the arthroscopic equipment and carry out a diagnostic glenohumeral arthroscopy.[16] Mini-open repair is a third option that may be considered for revision distal clavicle excision. Mini-open distal clavicle excision uses a similar approach as a traditional open procedure with less soft tissue dissection and less disruption of the deltotrapezial fascia, thereby decreasing the possibility of wound dehiscence or postoperative AC joint instability.[17]

Over-resection/Joint Instability

Over-resection of the distal clavicle is a significant problem that can result in joint instability with resultant pain and limitation of upper extremity function. Although the diagnosis of distal clavicle instability in the case of significant over-resection (> 1.5 cm) can be easily made based on physical examination and imaging, identifying more subtle instability in the presence of a more modest resection can be difficult. Disruption of the anterior and posterior AC ligaments and the joint capsule in the case of an over-resection can lead to horizontal instability of the remnant distal clavicle. An anatomic study of 36 shoulders by Boehm et al[18] found that resection of 1 cm of the distal clavicle detaches an average of 8% of the trapezoid ligament and therefore, resection greater than 1 cm may lead to AC joint instability. The results of a 1996 Finnish study,[19] involving 73 patients treated with distal clavicle excision who had an average of 16-mm resected (range 5 mm to 37 mm), suggest that a correlation exists between the amount of distal clavicle resected and postoperative acromioclavicular symptoms. Postoperative pain was more frequently reported ($P < 0.03$) by patients who had greater than 10 mm of distal clavicle resected. A study by Blazar et al[20] correlated pain scores with translation after distal clavicle excision. In this study, 17 participants had an average of 8.7-mm resected from the distal clavicle. Stress radiographs were used to determine translation with the contralateral shoulder serving as a control. Patient postoperative Visual Analog Scale score correlated with the degree of anteroposterior translation but did not correlate with the amount of joint space seen on postoperative radiographs.

Prevention of over-resection during distal clavicle excision involves both preoperative and intraoperative assessments. Preoperative evaluation should include appropriate radiographs to evaluate the extent of degenerative changes affecting the AC joint including the presence of osteophytes, joint space narrowing, sclerotic areas, and

cystic changes. Whether the procedure is carried out open or arthroscopically; meticulous measurements should be carried out to ensure 8 to 10 mm of distal clavicle resection. In addition, care should be taken to repair incised ligaments during the open technique. With an arthroscopic technique, soft tissue damage should be minimized and extreme care should be taken to preserve the superior and posterior ligaments.

Patients with symptomatic instability after distal clavicle excision typically present with complaints of pain with overhead activity. Findings on physical examination are often subtle, but may include the ability to manually translate the distal clavicle more than 1 cm in the anterior-posterior direction and a reproduction of symptoms with forced posterior clavicular translation. In an evaluation of 28 patients with symptomatic instability after distal clavicle excision, Nicholson reported eliciting a painful click at the posterior AC joint with forward elevation at and above 90 degrees[21] (Fig. 3). Work-up of patients with suspected distal clavicle instability should include a complete set of radiographs including a Zanca view. Some researchers recommend including stress radiographs to evaluate the potential extent of distal clavicle translation. This is accomplished by the examiner holding the humerus with 1 hand positioning the shoulder in 30 degrees of external rotation and 40-45 degrees of forward elevation in the plane of the scapula whereas the other hand applies direct anterior followed by posterior pressure to the midshaft of the clavicle.[20] Initial management is typically conservative, including rest, activity modification, physical therapy, and corticosteroid injections.

When symptomatic AC joint instability persists after distal clavicle excision, a variety of surgical options have been described for appropriate management. For isolated horizontal instability, options include attempted primary repair or the use of a Weaver-Dunn reconstruction including transfer of the coracoacromial (CA) ligament.[22] If a component of vertical instability is present owing to compromise of the coracoclavicular (CC) ligaments during the index procedure, modifications to the Weaver-Dunn procedure have been described including the addition of coracoclavicular stabilization with a screw, suture, or graft.[23]

Our preferred method of management for failed distal clavicle excision with instability is the anatomic CC ligament reconstruction with allograft and bioabsorbable interference screw fixation, as described by Mazzocca et al.[24] Semitendinosus, gracilis, or anterior tibialis allograft can be used for this procedure.

FIGURE 3. In patients with symptomatic instability after distal clavicle excision, Nicholson reported eliciting a painful click at the posterior AC joint with forward elevation at and above 90 degrees.

Coracoclavicular ligament reconstruction begins with a curvilinear incision along Langer lines beginning approximately 3.5 cm from the lateral aspect of the distal clavicle extending toward the coracoid process. Dissection is taken down to the level of the coracoid process, with care taken to dissect posteriorly enough to ensure that the base of the coracoid process is exposed. The graft can be secured to the coracoid using a bone tunnel placed at the base of the coracoid process, or by looping the graft around the neck of the coracoid. The tunnel in the coracoid is made with or without the use of a drill guide using a 6 or 7 mm cannulated reamer. Owing to the potential risk of coracoid fracture associated with tunnel placement, our preference is to loop the graft around the neck of the coracoid using a Statinski clamp or anatomic passer (Arthrex, Naples, FL) (Fig. 4: Anatomic Coracoclavicular Reconstruction). Next, 6-mm diameter clavicular bone tunnels are created with the conoid tunnel placed 25-mm medial to the lateral aspect of the remnant distal clavicle and drilled at a 45 degree angle from posterior-superior to anterior-inferior, followed by drilling of the trapezoid tunnel 15-mm anterior and lateral to the conoid tunnel.

Each end of the allograft is secured with a No. 2 nonabsorbable suture in a Krakow type fashion. Both ends of the graft are then placed through the prepared tunnels in the clavicle (Fig. 4). The distal clavicle is then manually over-reduced by 2 mm and held in position using a pointed reduction clamp with 1 limb placed under the coracoid base, and the second over the top of the clavicle to maintain reduction. During this process, the arm is supported and anatomic reduction is confirmed using fluoroscopy. Next, the accessory sutures are tied to maintain a provisional reduction and the graft is tensioned and secured using 5 to 6 mm PEEK interference screws in both tunnels. Given adequate residual length of the graft tails, the graft may be draped laterally and sewn in place to reconstruct or reinforce the acromioclavicular ligaments and joint capsule. The deltotrapezial fascial flaps are closed with nonabsorbable suture in an interrupted fashion and the skin is reapproximated in layers.

Postoperatively, Zanca and axillary films are taken at 0 and 6 weeks. Strict sling immobilization is recommended for 6 weeks postoperatively with the arm supported at all times. Shoulder motion is initiated at 6 weeks with isometric muscle activity only. Strengthening is initiated at 12 weeks and the patient can return to contact sports after 24 weeks. Some of the potential complications of this procedure include infection, fracture of the clavicle or coracoid process, osteolysis of the distal clavicle, and failure of graft healing.

Other Causes of Failure

Some less common causes of failure of distal clavicle excision which may require revision surgery include concomitant shoulder pathology which was untreated during the index procedure, heterotopic ossification, postoperative stiffness, and infection. Conditions that are commonly associated with AC joint pathology include subacromial impingement, SLAP lesions, biceps tendinopathy, and rotator cuff tendinopathy.[25] A detailed history, complete physical examination, and careful assessment of imaging studies may help identify shoulder pathology that was present in addition to the symptomatic AC joint at the time of the initial distal clavicle excision, allowing for appropriate subsequent management. Berg and Ciullo
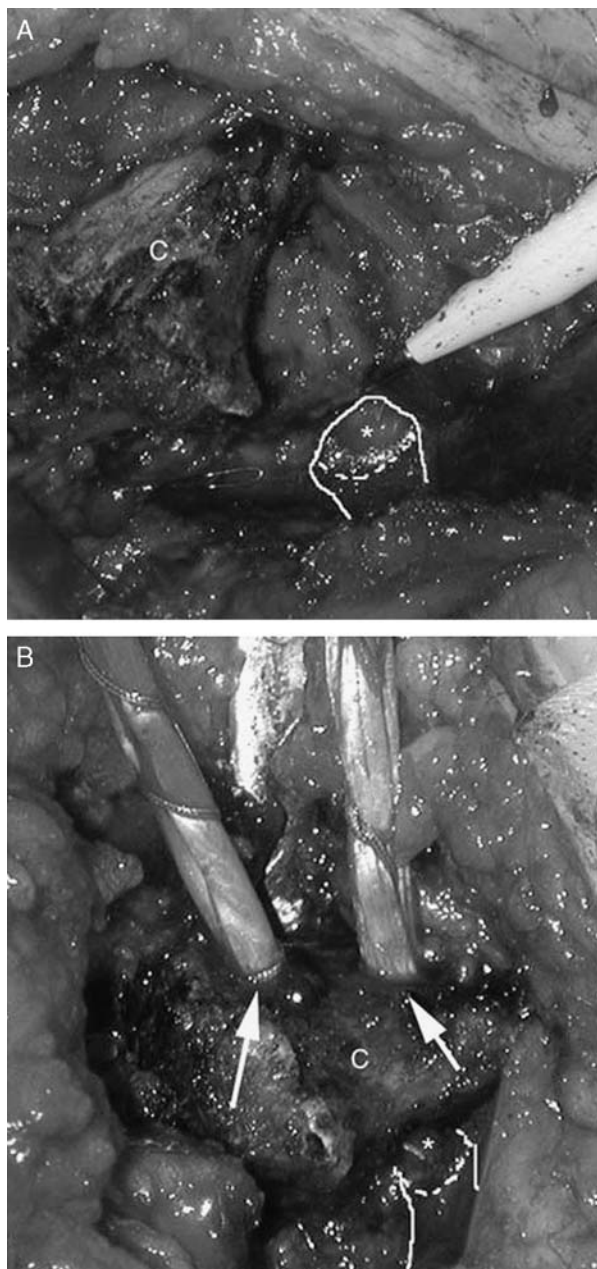
FIGURE 4. Anatomic coracoclavicular ligament reconstruction. Use of a suture passer/clamp inserted from medial to lateral to allow for passage of the graft under the base of the coracoid process (A). Passage of the limbs of the graft through the conoid and trapezoid tunnels (B). (© 2010 American Academy of Orthopaedic Surgeons. Reprinted with permission *Journal of the American Academy of Orthopaedic Surgeons.* 17:214).

reported 15 missed SLAP lesions in 20 patients who presented with persistent symptoms after arthroscopic distal clavicle excision.[26] In their series, 9 of the 15 patients went on to achieve good to excellent results after repeat arthroscopy with stabilization of the SLAP tear.

Formation of heterotopic bone about the AC joint after distal clavicle resection is a relatively rare potential source of treatment failure secondary to pain and outlet impingement associated with the ectopic bone. Postoperative radiographs and/or CT scans can identify the extent and location of the heterotopic ossification, identifying sites of potential abnormal contact with the remnant distal clavicle. Risk factors for the development of heterotopic ossification include comorbid ankylosing spondylitis or hypertrophic pulmonary osteoarthropathy. In a review of 661 acromioplasties and open distal clavicle excisions carried out over a 3 year period, Berg and Ciullo reported 40 cases of symptomatic heterotopic ossification (incidence of 3.2%).[27] Twenty of the 40 patients required reoperation for ectopic bone excision, with 4 having a recurrence of symptomatic heterotopic ossification necessitating repeat excision. Martin et al[13] in a series of 31 patients treated with arthroscopic distal clavicle resection and subacromial decompression reported only 1 case of heterotopic ossification at the site of resection. Current recommendations include postoperative prophylaxis with either oral indomethacin or a single dose of irradiation in patients with identifiable risk factors for heterotopic bone formation and in those who require revision surgery for ectopic bone resection.

Postoperative shoulder stiffness after distal clavicle excision has been reported to occur in up to 29% of treated patients.[13,28] Chronopoulos et al[28] hypothesized that their high rate (29%) of postoperative stiffness may be have been secondary to their relatively short follow-up time (mean of 16 mo) and a difference between their postoperative rehabilitation regimen and that of other researchers. In their series, among the 12 patients who experienced postoperative shoulder stiffness, patients lost a mean of 25 degrees of forward elevation and 10 degrees of external rotation. Two patients had stiffness after the development of postoperative infections and 1 had heterotopic ossification form between the clavicle and acromion. In a long-term study by Eskola et al[19] of open distal clavicle excision with a mean follow-up of 9 years, 16 of the 73 patients (22%) were found to have limitations in glenohumeral motion (greater than 20 degrees loss of external rotation, greater than 30 degrees of abduction, or both). In Martin et al's series of 32 patients treated with arthroscopic distal clavicle excision and subacromial decompression, the researchers reported no loss of postoperative motion.[13] This cohort, which included 4 professional athletes had a mean age of 36 years at the time of surgery and were followed for a mean of 4.8 years.

The management of postoperative stiffness after distal clavicle can be difficult and should be tailored to the individual patient. In the relatively acute setting, an intraarticular corticosteroid injection or medrol dose pack may help diminish associated inflammation and facilitate range of motion rehabilitation. In the rare, chronic cases refractory to conservative management with symptomatic limitation of range of motion, shoulder arthroscopy with lysis of adhesions, and a manipulation under anesthesia may be indicated.

Infection is a relatively uncommon complication that has not been studied extensively in association with distal clavicle excision. In Chronopolous et al series[28] of 42 patients undergoing open distal clavicle excision, a 10% incidence of postoperative infection (4 cases) was reported, including 3 deep, and 1 superficial case. Diagnosis was confirmed with positive cultures in patients who presented with continuous wound drainage. The 3 patients with deep infections were treated with surgical debridement and

6 weeks of intravenous antibiotics. As with any postoperative patient population, a high index of suspicion must always be maintained for the possibility of infection in the presence of persistent pain and wound drainage.

Atypical causes of failure after distal clavicle excision include distal clavicle fracture,[29] reossification or fusion across the acromioclavicular joint,[30] suprascapular neuropathy,[31] and psychiatric illness.[32] Distal clavicle fracture has been reported after distal clavicle excision with subacromial decompression for recalcitrant subacromial impingement.[29] In a case report by Ghodadra et al, their patient reported hearing a loud pop in the absence of trauma less than 24 hours after the original procedure. The patient experienced pain with passive cross body adduction, significant pain with Neer and Hawkins tests, and general guarding with any attempted shoulder motion. Radiographic evaluation showed the presence of a comminuted fracture 3-cm medial to the distal end of the clavicle. Approximately 8 months after the initial surgery after failed attempts at conservative treatment including sling immobilization, activity modification, physical therapy, and subacromial injections, persistent symptoms prompted revision distal clavicle resection, and capsular release with lysis of adhesions. Six months after the revision procedure, the patient reported a significant reduction in pain allowing him to return to work and his regular activities.

Reossification and fusion across the AC joint after an arthroscopic acromioplasty and distal clavicle excision has been documented in a recent case report.[30] The patient was inconsistent with follow-up appointments and returned 15 months after the surgery reporting the same symptoms that she experienced before the original procedure. Physical examination revealed a tender, hard mass over the acromioclavicular joint. Revision open distal clavicle resection was used to treat this complication by removing 1.5 cm of the distal clavicle. The patient was reported to be asymptomatic 9 months after the revision.

Mallon et al have reported 2 cases of suprascapular neuropathy after open distal clavicle excision.[31] In these cases, a 40 year-old male and 43-year-old female presented with pain in the operative shoulder, 6 years and 2.5 years, respectively after undergoing distal clavicle excision. After confirmation of the diagnosis by electrodiagnostic studies, they were treated with neurolysis of the suprascapular nerve starting at the upper trunk of the brachial plexus. To minimize the risk of suprascapular neuropathy, we recommend that no more than 1 cm of the distal clavicle be excised posteriorly and that minimal periosteal elevation be carried out on the posteroinferior border of the distal clavicle during an open procedure.

It has been suggested that psychiatric problems may be correlated with failure of distal clavicle excisions.[32] In a cohort of 50 patients who underwent open distal clavicle excision, Petersson found that almost 50% of the patients presenting with a poor outcome at a mean follow-up of 9 years, suffered from alcohol dependency or other psychiatric illness.[32] In a diagnostic study of 81 participants presenting to a hand and upper extremity clinic, Vranceanu et al[33] showed that comorbid psychiatric illness in general and somatoform disorder in particular is a strong predictor of DASH scores and associated with both nonspecific arm pain and arm disability. Careful patient selection is essential to screen for and potentially prevent psychiatric-related complications.

CONCLUSION

Patients with persistent symptoms and disability after either open or arthroscopic distal clavicle excision, represent a difficult clinical scenario for the treating orthopedic surgeon. Potential etiologies of failure after distal clavicle excision include under-resection, over-resection leading to postoperative joint instability, postoperative stiffness, heterotopic ossification, untreated concomitant shoulder pathology, and postoperative infection. Less common causes of failure include distal clavicle fracture, reossification or fusion across the acromioclavicular joint, suprascapular neuropathy, and psychiatric illness.

Treating orthopedic surgeons need to be aware of these possible causes of failure after distal clavicle excision and be prepared to carry out revision resections or reconstructions when indicated.

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