Review Article

Fractures of the Coracoid Process: Evaluation, Management, and Outcomes

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Abstract

Fractures of the coracoid process are relatively rare, and current management guidelines remain unclear. Most coracoid fractures occur in conjunction with other shoulder injuries, including dislocations and fractures. Identifying coracoid fractures can be difficult because most fractures are nondisplaced and can be missed on radiographs or may be masked by other injuries. Management is largely guided by fracture location and displacement. Conservative treatment is preferred for fractures that are minimally displaced, whereas indications for surgical fixation include fractures that are displaced (>1 cm), have progressed to a painful nonunion, or are associated with the disruption of the superior shoulder suspensory complex. Although conservative treatment has been historically favored, satisfactory outcomes have been reported for both surgical and nonsurgical treatment. We provide a comprehensive review of diagnosis and management strategies for coracoid fractures.

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Coracoid fractures are relatively rare injuries that typically occur because of high-energy trauma, such as a motor vehicle accident. However, blunt trauma related to sporting activities have also been described as a mechanism of injury along with repetitive stress-related injuries. Most coracoid fractures do not occur in isolation because of the high-energy mechanism of injury and is typically associated with additional injuries to the affected shoulder, particularly to the other structures of the superior shoulder suspensory complex (SSSC). Careful clinical evaluation including imaging of the affected shoulder is essential because the presence of concomitant injuries may affect treatment decision-making. Owing to the relative rarity of these injuries, the literature surrounding the management of coracoid fractures is limited. The available evidence to guide treatment decisions is primarily based on level IV and V evidence. The surgical indications for coracoid fractures are evolving as a better understanding of associated injuries and surgical instrumentation or techniques improve.

The purpose of this study is to
(1) review the incidence, relevant anatomy, and mechanism of injury related to coracoid fractures,
(2) describe relevant workup for diagnosis of coracoid fractures with a focus on injury classification and the types of associated injuries found in conjunction with coracoid fractures,
(3) discuss relative surgical indications for coracoid fractures including a succinct review of the outcomes after surgical management, and
(4) discuss the areas of future work for coracoid fractures.

Regional Anatomy of the Coracoid

Most coracoid fractures are associated with additional injuries to the affected shoulder, particularly to the SSSC. Therefore, surgeons should understand the complex anatomy of the coracoid process and have knowledge of the attachment sites of the conjoint tendon, coracoclavicular (CC) (trapezoid and conoid) ligaments, coracoacromial (anterior and posterior bundles) ligament (CAL), coracohumeral ligament, and pectoralis minor. The minimum distance between the tip of the coracoid and the most anterior CC ligament (trapezoid) is 25.1 mm, and sex differences are present with a mean of 28.1 mm and 22.0 mm in men and women, respectively.[1]

Epidemiology and Mechanism of Coracoid Fractures

McGinnis and Denton[2] described the prevalence of coracoid fractures between 3% to 13% of all scapula fractures after a review of the literature in 1989. More recent data from two systematic reviews of scapula fractures in 2006 and 2008 reported the prevalence of apophyseal (acromion, coracoid, and scapular spine) fractures at 6% and 8.2%, respectively.[3,4] Isolated coracoid fractures are rare, with 43 case reports in the English literature and few retrospective case series.

Coracoid fractures are generally due to high-energy direct impact injuries or eccentric pull through soft-tissue attachments (ie, conjoint tendon or CC ligaments) resulting in failure of the bone. Isolated fractures, as described in case reports, are often because of acute trauma, wherein a sudden and violent contraction of the coracobrachialis and the short head of the biceps brachii muscles during resisted elbow flexion places stress at the attachment of the conjoint tendon at the coracoid process, resulting in avulsion of the coracoid tip.[5-10] Fatigue fractures of the coracoid process have also been described in trap shooters,[11,12] cricket players,[6,13,14] and tennis players,[7] where it is likely that repetitive direct microtrauma ultimately leads to bony failure of the coracoid. In addition, isolated fractures can occur secondary to iatrogenic surgical etiologies such as transcoracoid drilling for suture button fixation of unstable acromioclavicular (AC) joint separations and after reverse shoulder arthroplasty.[15-17]

Most coracoid fractures occur in conjunction with other ipsilateral shoulder injuries. This pattern is typically because of high-energy trauma, most often a direct blow from a motor vehicle accident or fall.[18-21] Associated injuries include glenohumeral joint injuries, AC joint injuries, rotator cuff tears, and fractures of the acromion, scapula, distal clavicle, and humerus.[18,19] The most common associated injury is AC joint separation.[9,18-20] In the largest series of coracoid fractures involving nonsport-related trauma, Ogawa et al[18] found that 58% (39/67) of patients with coracoid fractures had associated AC joint injuries. Similarly, in a review of sport-related coracoid fractures, Knapik et al[20] reported concurrent AC joint injury in 60% of patients.

The mechanism resulting in this combination of injury proposed by Wilson et al involves a direct force to the AC joint, causing caudad displacement of the acromion and scapula, whereas the CC ligaments pull the coracoid cephalad.[10] This may result in a coracoid fracture in skeletally immature patients in whom the CC ligaments are relatively stronger than the unfused epiphyseal plate of the coracoid.[9,22] However, this may not explain all coracoid fractures in adults, where the relative strength of the coracoid and clavicle in relation to the CC ligaments suggest that AC joint injuries should more commonly involve a tear of the CC ligaments rather than a coracoid fracture.[23] To explain the combined coracoid fracture and AC separation in adults, Li et al[24] proposed a two-step mechanism in which the sudden contraction of the conjoint tendon and pectoralis minor muscle produces a fracture of the coracoid and the component residual force along the CC ligaments determines whether the CC ligament is disrupted.

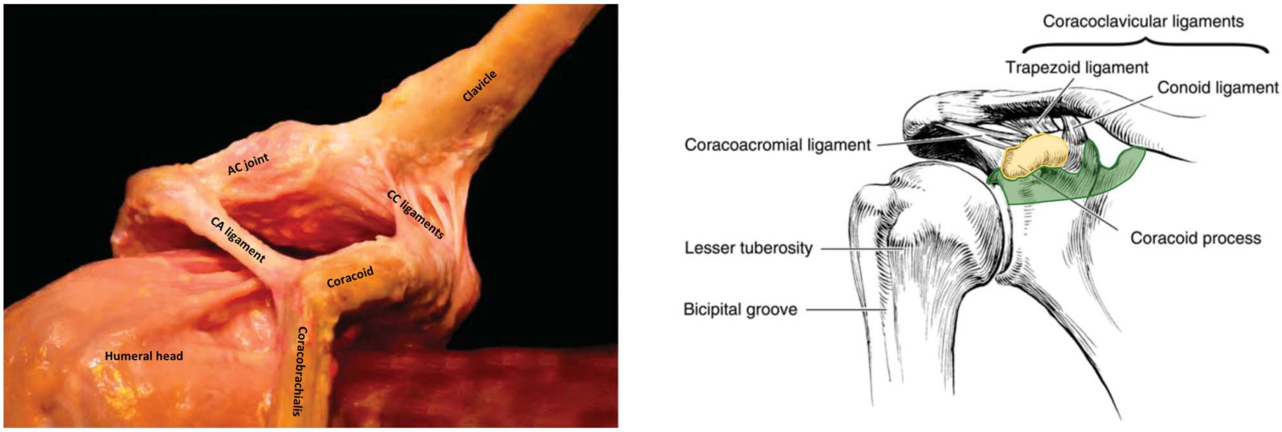
Physical Examination Findings

Identifying coracoid fractures via physical presentation can be difficult as physical examination findings may be nonspecific and are often masked by other concomitant shoulder injuries. Isolated fractures typically present with pain and tenderness to palpation over the coracoid. Patients may also exhibit limited, painful active shoulder abduction, flexion, and/or external rotation, but the neurovascular examination is usually normal.[6,13,25] Examination findings in nonisolated cases vary depending on the associated injuries. The most common combination of coracoid fracture with AC joint injury may present with additional findings of pain and tenderness to palpation over the AC joint, visible deformity, and painful cross-body adduction.[21,24,26-28] Owing to the presence and severity of associated injuries, coracoid fractures may be overlooked—therefore, the physical examination should be performed with a focus on the reported mechanism of injury.

Imaging

True anterior-posterior, scapular-Y, and axillary lateral views will help visualize the fracture. An MRI or CT scan with three-dimensional reconstruction assists in understanding the

Figure 1



Photographs showing relevant anatomy for classification of coracoid fractures and the Ogawa coracoid fracture classification. In type I fractures (green), the fracture line is proximal or behind the CC ligaments. In type 2 fractures (yellow), the fracture is distal or in front of the CC ligament. AC = acromioclavicular, CA = coracoacromial, CC = coracoclavicular. (Adapted with permission from Simovitch R, Sanders B, Ozbaydar M, Lavery K, Warner JJ. Acromioclavicular joint injuries: diagnosis and management. *J Am Acad Orthop Surg*. 2009;17(4):207-219 [Figure 1 from manuscript]. Frank RM, Cotter EJ, Leroux TS, Romeo AA. Acromioclavicular Joint Injuries: Evidence-based Treatment. *J Am Acad Orthop Surg* 2019. doi: 10.5435/JAAOS-D-17-00105 [Figure 2A from manuscript].) Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

fracture morphology and displacement. In addition, it should be noted that the coracoid has two secondary ossifications centers, one over the angle of the coracoid and another at the tip, and these can close as late as 25 years of age.[29] This is important in the setting of trauma in the pediatric and young adult patient when attempting to distinguish a coracoid fracture from normal unfused apophysis.

Classification

Both Ogawa et al and Eyres et al[18,19] have proposed a classification system for coracoid fractures based on the anatomic location of the fracture line. Ogawa et al[18] divided the fracture into two types based on the anatomic location of the fracture in relation to the attachment of the CC ligaments (Figure 1). Type I fractures are located behind the attachment, whereas type II fractures are in front of the CC ligaments. Eyres et al[19] proposed a more detailed classification system based on a review of 12 coracoid fractures. In the classification by Eyres (Figure 2), coracoid fractures are divided into five types and subgrouped into A or B according to the presence or absence of associated injuries to the clavicle or its ligamentous connection that affects scapula stability. Type I coracoid fracture involves the tip or epiphyseal area, type II is midprocess, type III is a basal fracture, type IV is with the superior body of the scapula involved, and type V is extension into the glenoid fossa.

Management

Conservative Management

Definitive treatment guidelines for coracoid fractures are lacking and typically rely on recommendations based on level IV and V evidence. Coracoid fracture treatment is typically described based on the location of fracture plane relative to the coracoid, fracture displacement, and the presence of associated injuries to other structures of the SSSC.[18,19] Isolated coracoid fractures that are either nondisplaced or minimally displaced can be treated successfully with nonsurgical management.[20,26,30-32] Even with displacement, isolated coracoid tip fractures (ie, Eyres type 1/Ogawa type II injuries) and fracture between the CC and coracoacromial (CA) ligaments (Eyres type 2 to 3) can be successfully treated with nonsurgical management.[18,19] Improved surgical instrumentation, including the expanded use of suture anchors, has resulted in some authors advocating for fixation of displaced coracoid tip fractures.[33] Conservative treatment of coracoid fractures typically originates with sling immobilization to decrease pain and minimize further displacement of the coracoid fracture.[30-32] Passive motion and active assisted range of motion with physiotherapy are initiated 6 weeks after the injury.[31,32] A recent systematic review

Figure 2

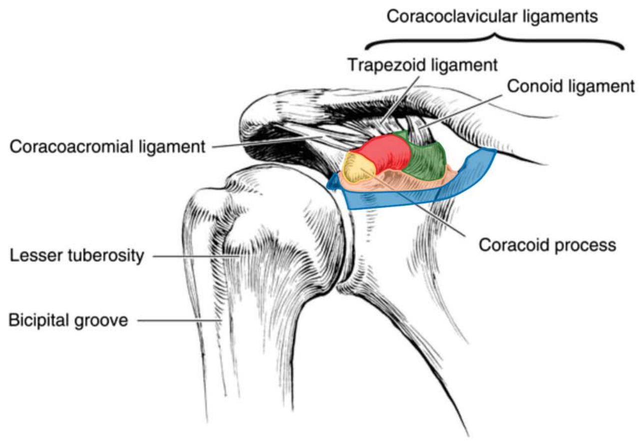


Illustration showing the Eyres coracoid fracture classification: type I, tip or epiphyseal fractures (yellow); type 2, midprocess (red); type 3, basal (green); type 4, superior body of the scapula (orange); AND type 5 (blue), extension into the glenoid fossa. The suffix A or B can be used to denote the presence or absence of damage to the clavicle or its ligamentous connection to the scapula. (Adapted with permission from Simovitch R, Sanders B, Ozbaydar M, Lavery K, Warner JJ. Acromioclavicular joint injuries: diagnosis and management. *J Am Acad Orthop Surg* 2009;17(4):207-219 [Figure 1 from manuscript].) Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

of sport-related coracoid fractures identified return to sporting activities, typically occurring 2 to 3 months after the initial coracoid injury with documentation of fracture stability.[20,32]

Surgical Management

Surgical management of coracoid fractures are typically reserved for unstable, displaced coracoid fractures or coracoid fractures that are associated with other SSSC injuries. Generally accepted surgical indications for coracoid fractures are listed in Table 1. As described previously, the most common concomitant injury to the SSSC with coracoid fractures are AC joint injuries.[18,20] The combination of a coracoid injury in addition to another injury to the SSSC is important to recognize because it represents two disruptions (double disruption) of the SSSC complex, which creates an unstable anatomic situation that may result in persistent disability and poor shoulder function.[34-36] Although the combination of coracoid and AC joint injuries have been treated nonsurgically with success,[20,31,32] some authors advocate for surgical treatment of coracoid fractures associated with AC joint injuries.[19,37,38] One treatment strategy to address double-disruption SSSC injuries that include both AC and coracoid injuries is to first stabilize the AC joint pathology and then reassess the position of the coracoid fracture. If the coracoid fracture is relatively reduced and well-positioned after surgical stabilization of the AC joint, then the coracoid can be treated nonsurgically.[38]

In addition to scenarios where the coracoid fracture occurs in conjunction with additional injuries to the SSSC, isolated displaced coracoid fractures that extend into the scapula or glenoid with displacement (>1 cm) (Eyres type IV and V injuries, respectively) warrant surgical consideration. Although fractures that occur toward the tip of the coracoid may be more related to a traction mechanism of injury to the coracoid through the attached ligaments and tendons, proximal coracoid fractures that extend into the scapular body and glenoid often represent a more unstable and severe shear-type mechanisms because of impaction from the humeral head or clavicle. Eyres et al[19,37] have therefore advocated for coracoid stabilization in the latter scenario. Although using a different classification system, Ogawa et al[18,38] similarly raised the concern that coracoid fractures which occur at the base and posterior to the CC ligaments (Ogawa type I injuries) often represent a notable disruption of the scapuloclavicular connection and therefore should be stabilized; however, this is a relative surgical indication. In addition to fracture patterns and associated injuries, some authors have advocated for the consideration of surgical intervention for displaced coracoid fractures in individuals who may engage in heavy overhead work (ie, manual laborers) to minimize morbidity risk related to fracture nonunion.[27,37]

Ogawa Type 1—Surgical Techniques

Our preferred surgical technique for surgical fixation of Ogawa type 1 (proximal to the CC ligaments) displaced coracoid fractures involves fixation with a cortical screw and washer perpendicular to the fracture line. Preoperative 3D CT scan is paramount to assist in defining the fracture plane orientation and planning the trajectory of screw fixation (Figure 3, A). The patient is positioned supine on a radiolucent table. The table is inclined approximately 15° to allow improved visualization during exposure. A small bump is placed under the ipsilateral scapula to make the scapula and coracoid

Table 1

Indications for Surgical Management of Coracoid Fractures

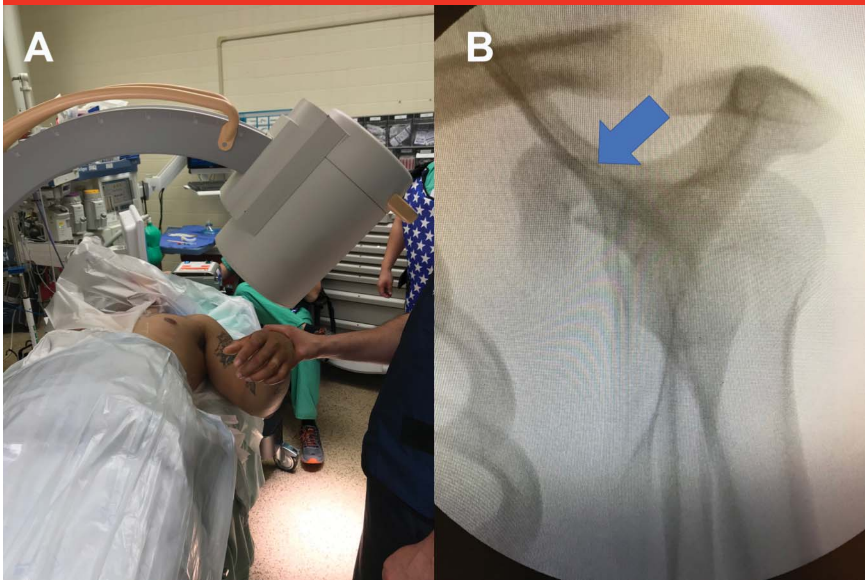
1. Coracoid fractures complicated by other injuries to the superior shoulder suspensory complex (ie, acromioclavicular joint dislocation) or a double disruption scenario.
2. Displaced Eyres type IV and V fractures.
3. Ogawa type I fractures with scapuloclavicular dissociation.
4. Symptomatic coracoid fracture nonunion (pain and tenderness over coracoid with no radiographic signs of healing after 6 mo of conservative management).

Figure 3

A, Photograph showing preoperative 3D CT scan demonstrating the displacement and rotation of a coracoid base fracture (arrow). **B**, Photograph showing large C-arm fluoroscopy is brought in to the operating room from the opposite side of the table to obtain orthogonal imaging for fracture reduction and fixation.

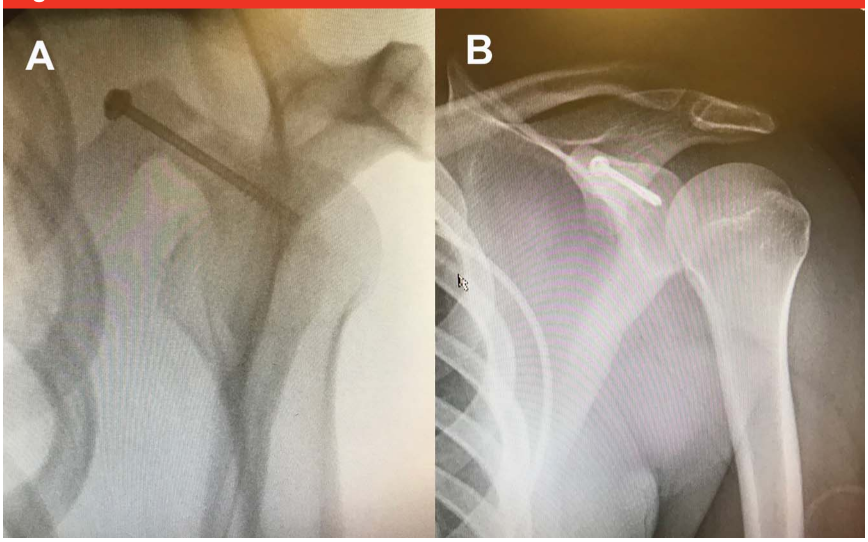
more prominent. The entire chest, shoulder, and ipsilateral extremity are prepped and draped in a sterile fashion. A padded mayo stand is helpful for supporting the surgical arm. Large C-arm fluoroscopy is brought in from the opposite side of the table to obtain orthogonal imaging (Figure 3, B). By positioning the patient on a radiolucent table, it allows the surgeon to obtain a good quality scapular-Y fluoroscopic view which is key to obtaining an indirect fracture reduction (Figure 4, A). A standard deltopectoral approach is performed. A large spiked Hohmann retractor is placed at the base of the coracoid with care taken not to place it into the fracture site, and a blunt retractor is placed under the deltoid around the humerus with care taken to protect the axillary nerve. A Lahey (triple prong) clamp is used to grasp the coracoid for ease of manipulation. With coracoid fractures posterior to the CC ligaments (Ogawa type 1 fractures), it is difficult to visualize the fracture reduction directly because of the CA and coracohumeral ligaments laterally, the intact pectoralis minor medially, and the CC ligaments attached to the fractured fragment. It is helpful to release some of the pectoralis minor and CA ligament insertion to visualize the orientation of the fractured coracoid process for provisional pin fixation (Figure 4, B). The Lahey clamp is then used to manipulate the coracoid fracture, which involves extension of the fracture fragment because of the deforming force of the conjoined tendon while evaluating the reduction on the anterior-posterior and scapular-Y fluoroscopic view. Once reduced, the fracture is provisionally fixated with 1 to 2 Kirschner wires. Definitive fixation is achieved with 1 to 2 bicortical solid screws with washers (Figure 5, A). Postoperative

Figure 4



A, Photograph showing the scapular-Y fluoroscopic image obtained with the large C-arm. **B**, Displacement and rotation of the coracoid fracture fragment is visualized (arrow).

Figure 5



A, Photograph of the scapular-Y view obtained with C-arm intraoperatively after reduction and fixation shows anatomic reduction of the coracoid fracture with a screw and washer bicortical fixation. **B**, Postoperative anterior-posterior radiograph demonstrating anatomic fixation of the coracoid fracture.

radiograph shows anatomic reduction of the coracoid fracture with screw and washer fixation (Figure 5, B).

Typically, Ogawa type 2 (distal to the CC ligaments) coracoid fractures are successfully managed nonsurgically. However, in the rare cases that warrant surgical reduction and fixation because of displacement and potential subscapularis impingement, the technique described by Kennedy et al[33] with suture anchor fixation is an effective technique. A standard deltopectoral approach is performed. Once the fracture site is exposed, a biocomposite suture anchor (6.5-mm) is placed in line with the intramedullary canal of the coracoid. Next, the nonabsorbable sutures are passed through the fractured coracoid process and tied down to secure the fracture. The authors then describe placing two additional smaller (3.0-mm) biocomposite suture anchors. The limbs from these sutures are passed through the proximal conjoint tendon to augment the fixation.

Outcomes

Owing to the rarity of isolated coracoid fractures, few large series exist, documenting clinical outcomes after conservative and surgical treatment (Table 2). Ogawa et al[18] retrospectively reviewed 67 patients with isolated coracoid fractures. Forty-five patients were available for a follow-up at a mean of 37 months (12 to 117 months). Type 1 fractures (31 patients), type 2 fractures (3 patients), and 1 patient of unknown classification were treated with a cortical screw and washer. Eight patients with type 2 fractures were treated conservatively with a sling. Overall, 87% of patients had a good outcome, with only 13% having a fair outcome. No notable difference was observed in the outcomes between patients with type 1 and 2 fractures and between those undergoing conservative and surgical treatment. All type 2 fractures treated conservatively with a sling had good outcomes. In a large retrospective case series, Hill et al[37] analyzed the outcomes of 22 patients with isolated coracoid process fractures treated with surgical fixation (20 type 1 fractures and 2 type 2 fractures). A total of 17 patients underwent open reduction and fixation with 1 to 3 lag screws, whereas 5 patients underwent surgical fixation

Table 2

Outcomes of Coracoid Fracture Management

Study	No. of Patients	Fracture Type (Ogawa Classification)	Treatment	Outcomes	Mean Follow-up (mo)
Martin-Herrero et al[5]	7	7—type 1 fractures (all fractures had either ipsilateral AC joint separation or superior glenoid fracture)	Conservative: 7 patients (sling, 2-4 wk)	Very good result in 5 patients. Good result in 2 patients. No patient reported clinical outcome scores.	28 (12-60)
Eyres et al[19]	12	12—coracoid fractures (did not specify according to the Ogawa classification)	Surgical treatment (1 large fragment cancellous screw): 2 patients	Conservative: 8 of 9 treated conservatively regained full shoulder range of motion. One patient had less than 90° shoulder elevation;	Unk
			Conservative (sling): 10 patients	Surgical treatment (2 patients)—regained shoulder motion at 6 and 9 wk.	
Ogawa et al[18]	67	53-type 1 fractures, 11-Type 2 fractures,	Surgical treatment (screw & washer): 31 type 1, 3 type 2 fractures, 1 unk classification.	45 patients available for follow-up. 87% excellent results, 13% fair results.	37 (12-117)
		3—unknown classification	Conservative treatment (sling): 8 type 2 fractures	No notable difference between type 1 & 2 fractures or between conservative and surgical management.	
				8 patients—type 2 fractures had excellent outcome with sling treatment.	
Ogawa et al[36]	15	10—type 1 fractures	Conservative: 4 type 1 fractures (presenting $<$ 5 wk from injury) 4 type 2 fractures	In the subacute/chronic type I fracture with persistent pain and functional impairment, surgical treatment of the coracoid fracture results in gratifying outcome (5 of 6 patients)	23 (12-41)
		5—type 2 fractures	Surgical treatment: 6 type 1 fractures (presenting $>$ 5 wk from injury with painful nonunion)	Type II coracoid fractures—conservative treatment is indicated (4 of 5 good outcomes). When presenting with chronic subcoracoid impingement, surgical treatment was effective in 1 case.	
			1 type 2 fracture (due to painful impingement, 44 wk post injury)		

(*continued*)

AC = acromioclavicular, SSSC = superior shoulder suspensory complex, unk = unknown

Table 2 (*continued*)

Outcomes of Coracoid Fracture Management

Study	No. of Patients	Fracture Type (Ogawa Classification)	Treatment	Outcomes	Mean Follow-up (mo)
Ogawa et al[38]	36	36—type 1 fractures (34 of 36 patients with double disruptions of SSSC)	Surgical treatment (4.5-mm AO malleolar screw and washer): 36 patients	Surgical treatment—all cases achieved bony union. The Constant score ratio to the intact side at the follow-up survey was 93% ± 7.4% (range, 75%-100%) on average, with the exception of one	15 (12-36)
				Patient presenting with partial paralysis of the brachial plexus as a sequela of the initial trauma.	
Hill et al[37]	22	20—type 1 fractures, 2 type 2 fractures w/ concomitant anterior glenoid rim lesions.	Surgical treatment, l-3 lag screws only: 17 patients	The median DASH score = 12.3 (range: 0 -74; mean = 10.1); 16 (84%) returned to previous work or employment;	23.5 (12-72)
		(All patients had ipsilateral SSSC injury and/or additional fracture of the scapula)	Surgical treatment, 0-2 lag screws + plate (1.5 or 2 mm recon, t-plate, 1/4 tubular, 1/3 tubular): 5 patients	No infections or nonunions. 2 patients required hardware removal	

AC = acromioclavicular, SSSC = superior shoulder suspensory complex, unk = unknown

with a combination of screws and a small plate. At a mean follow-up of 23.5 months, the median Disabilities of the Arm, Shoulder and Hand (DASH) score was 12.3 (range: 0 to 74; mean = 10.1) and 16 (84%) returned to previous work or employment. In addition, there were no infections or nonunions; however, two patients required implant removal. Furthermore, Ogawa et al[38] analyzed the outcomes of 36 type 1 fractures treated with open reduction internal fixation with a 4.5-mm malleolar screw and washer. Thirty four of 36 patients had double disruptions of the SSSC. All cases achieved bony union. The Constant score ratio to the intact side at the follow-up was 93% ± 7.4% (range, 75 to 100%) on average. Based on these small case series, surgical treatment of Ogawa type 1 coracoid fractures with a screw ± washer or buttress plate generally results in good outcomes at the short-term follow-up. In contrast to the case series by Ogawa et al and Hill et al in which type 1 fractures were treated surgically with a screw and washer, Martin-Herrero et al[5] reported on seven type 1 fractures treated conservatively with a sling for 2 to 4 weeks. At the mean follow-up of 28 months (range 12 to 60 months), the authors reported "very good" results in five patients and "good" results in two patients. A limitation of the study was the lack of validated patient-reported outcome measures.

There is limited evidence to guide treatment for Ogawa type 2 coracoid fractures; however, most studies support good outcomes with conservative management in a sling. Ogawa et al[36] followed five patients with type 2 coracoid fractures for a mean follow-up 23 (12 to 41) months. Four of five patients had good outcomes at the final follow-up despite developing a nonunion. One patient had painful subcoracoid impingement because of the displaced coracoid tip and obtained symptom relief with surgical treatment. In addition, in another case series by Ogawa et al,[18] eight patients with type 2 fractures were treated conservatively in a sling and all patients had an excellent outcome at a mean follow-up of 37 months. In summary, conservative treatment is indicated for type 2 coracoid fractures with good results. Rarely, a displaced type 2 fracture will lead to subcoracoid impingement and surgical treatment is effective in relieving symptoms.

Summary

Coracoid process fractures are relatively rare and typically occur because of high-energy trauma. Thus, most coracoid fractures occur in conjunction with other shoulder injuries, including dislocations and fractures. Identifying coracoid fractures can be difficult because most fractures are nondisplaced and can be missed on radiographs or may be masked by other injuries; therefore, MRI or CT with 3-D reconstruction is important to define fracture displacement and morphology. Given the rarity of this injury, available evidence to guide treatment is primarily based on level IV and V evidence. Management is largely dictated by fracture location and displacement. Conservative treatment is preferred for fractures that are minimally displaced and may even be successfully used in displaced fractures closer to the tip of the coracoid (Eyres I, II, & III). Surgical fixation is indicated for coracoid fractures associated with an unstable SSSC, displaced extension into either the scapula body or glenoid fossa, or progression into a painful nonunion. Although conservative treatment has been historically favored, satisfactory outcomes have been reported for both surgical and nonsurgical treatment. The decision between conservative management versus surgical intervention should be a shared decision between the patient and the surgeon based on the fracture pattern, associated shoulder injuries, patient's activity or sporting level, and their expectations.

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