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Fractures of the coracoid process: a systematic review

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A R T I C L E I N F O

Keywords:
Scapular fracture
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Anterior shoulder instability
Acromioclavicular dislocation
Clavicular fracture
Avulsion fracture

Level of evidence: Level V; Review

Background: Although fracture of the coracoid process (CF) used to be considered rare, it is now more commonly encountered due to increased awareness and advances in imaging methods. This review aimed to analyze reported cases of CF to determine its mechanism and appropriate treatment.
Methods: PubMed and Scopus were searched using the terms "scapula fracture" and "coracoid fracture." The inclusion criteria were English full-text articles concerning CF that described patient characteristics with appropriate images. The exclusion criteria included cases without appropriate images and those with physeal injury or nonunion. Citation tracking was conducted to find additional articles and notable full-text articles in other languages. Fractures were mainly classified using Ogawa's classification.
Results: Ninety-seven studies were identified, including 197 patients (131 men, 33 women; average age 37.0±16.9 years). CF was classified as type I in 77%, type II in 19%, and avulsion fracture at the angle in 5%. Concurrent shoulder girdle injuries included acromioclavicular injury in 33%, clavicular fracture in 17%, acromion or lateral scapular spine fracture in 15%, and anterior shoulder instability in 11%. Among patients with type I CF, 69% had multiple disruptions of the superior shoulder suspensory complex. Conservative treatment was applied in 71% of isolated type I CF, while surgical treatment was applied in 76% of type I CF with multiple disruptions. Although the evaluation methods varied, 60% of patients were followed up for more than 6 months, and the outcomes were generally satisfactory for both conservative and surgical treatments.
Conclusion: CF occurred commonly in the age group with higher social activity. The most common fracture type was type I. The possible mechanism of CF is violent traction of the attached muscles, except for avulsion fracture at the angle. Type I CF with multiple disruptions of the superior shoulder suspensory complex requires surgical treatment, whereas conservative care is recommended for isolated type I and type II CFs.

The coracoid process (CF) arises from the upper border of the scapular neck; the inferior portion runs superoanteriorly (inferior pillar) and then bends sharply to project forward and laterally (superior pillar). The junction of the 2 pillars is called the "angle" or "elbow." The superior surface is roughened for both ligamentous and muscular attachments.[42] The pectoralis minor inserts on the superomedial aspect of the proximal horizontal part of the coracoid, while the coracobrachialis and the short head of the biceps (forming the conjoint tendon) insert on its tip. The ligaments anchoring the CF are the coracohumeral ligament, superior transverse ligament bridging the suprascapular notch, the conoid and trapezoid portions of the coracoclavicular ligaments (CCL) attaching at the angle and firmly connecting the scapula to the clavicle, and the coracoacromial ligament forming the anterior part of the coracoacromial arch (Fig. 1).[42] The CF is thus the keystone that maintains the connection between the clavicle and the scapula and the configuration of the coracoacromial arch.[60] It also forms a curved cantilever fixed to the scapula at its base, and the scapula is displaced by the actions of the muscles attached to its body and tip.[42]

Because the coracoid is assumed to play an important role in the function of the shoulder complex from an anatomical viewpoint, fracture of the CF would result in numerous effects on the function of neighboring joints and musculoskeletal structures. The purpose of this review was to systematically evaluate the available literature to clarify the current concept of CF, propose the possible mechanism, and determine appropriate treatment methods.

Institutional review board approval was not required for this review.
Investigation performed at Department of Orthopedic Surgery, Eiju General Hospital, Taito-ku, Tokyo, Japan.

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Materials and methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols guidelines.[50] A literature search was performed from January 2018 to December 2019, and the publication years of the included articles ranged from 1900 to 2018. PubMed and Scopus databases were searched using the terms "scapular fracture" and "coracoid fracture" to identify relevant studies. Two reviewers (K.O. and N.M.) independently conducted the literature search and review. The inclusion criteria were English full-text articles concerning CF that described the patients' characteristics and presented appropriate images to confirm the details of CF, and case series that used widely accepted classification methods. The exclusion criteria included lack of appropriate images to enable the evaluation of the injury details, physeal injury, and nonunion that had not united more than 3 months after the injury. Citation tracking was conducted to find additional related English articles and notable full-text articles written in other languages, which were added to the qualitative synthesis (10 studies). The article selection process is shown in Figure 2. For studies with cohort overlaps, the final articles were selected. Each patient was reviewed regarding age, sex, cause of injury, fracture type, concurrent injuries, type of treatment, and outcome. The main classification used to categorize fractures was Ogawa's functional classification, while Eyres' anatomical classification was used as a supplement when necessary.[18,62] When it was difficult to distinguish between Eyres type III and IV using the provided images, the fracture was classified as Eyres type III or IV (Fig. 3).

The ratios of sex, fracture type, treatment method, and concurrent injuries were evaluated using the chi-squared test. Unpaired t-test was used to assess the age of the patients classified by fracture type, sex, cause of injury, treatment method, and outcome. The level of significance was set at $P<.05$.

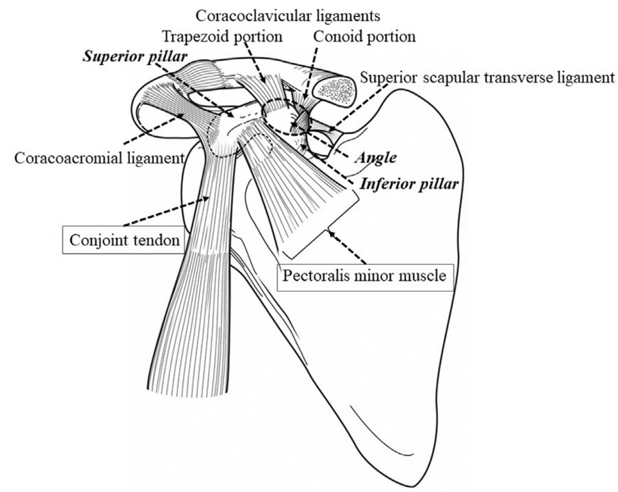

Figure 1 Muscles and ligaments attached to the coracoid process. The names of the parts of the coracoid process are written in italics. The names of the muscles and tendon are written within squares. The coracohumeral ligament is situated behind the coracoacromial ligament and so is hidden in this figure.

Results

Overall, the analysis included 97 studies with 197 patients (131 men, 33 women) with an average age of 37.0±16.9 years (range 12–85 years, n=164). Of the 155 cases in which the injured side was listed, the injuries were on the right side in 76 patients, on the left side in 77, and on both sides in 2 patients. The men were younger than the women (P=.04). The cause of injury was listed in 162 cases, and included various traffic accidents (n=67 patients), fall/fall from a height (n=55), sports activities (n=24), impact with falling heavy objects (n=7), and other accidents (n=9). The average age by cause of injury was 32.8±13.5 years for traffic accidents (n=63), 44.1±17.8 years for fall/fall from a height (n=52), and 25.1±12.8 years for sports activities (n=22). Patients with CF caused by sports activities were significantly younger than patients injured due to all other causes (P=.0006), and younger than patients injured due to traffic accidents and falls/falls from a height (P=.0226, P<.0001).

The CF was Ogawa type I in 151 patients, type II in 37, and avulsion fracture at the CCL attachment (at the angle) in 9 (n=197). According to Eyres' classification, the type of CF was found to be type V in 33 patients, type IV in 8, type III or IV in 97, type II in 17, type I in 17, and avulsion fracture at the angle in 9 (n=181). There was no significant difference in the male:female ratio by Ogawa fracture type (P=.36, n=164). Patients with type I CF (33.4±15.6 years, n=122) were significantly younger than those with type II CF (49.1±16.5 years, n=34) (P<.0001).

The most common concurrent shoulder girdle injury was acromioclavicular (AC) injury, comprising AC dislocation in 62 patients and AC subluxation in 3. The CF types in patients with concurrent AC injuries were type I in 57 patients, type II (Eyres type I) in 2, and avulsion fracture at the angle in 6 (n=197). The next most common concurrent injury was clavicular fracture observed in 33 patients, of which the location was distal in 13 patients, mid-shaft in 7, unspecified in 11, both mid-shaft and distal in l, and avulsion of the inferior cortex in 1. The CF types in patients with concurrent clavicular fractures were type I in 28 patients and avulsion fracture at the angle in 5 (n=197). Fracture of the acromion/lateral scapular spine was observed in 29 patients, with 24 cases of acromion fracture and 5 of lateral scapular spine fracture. The CF types in patients with fracture of the acromion/lateral scapular spine were type I in 28 patients and type II (Eyres type II) in 1. Scapular neck fractures were associated with CF in 21 patients, all of whom had type I CF. CCL rupture was observed in 7 patients, all of whom had type I CF. Anterior shoulder dislocation and subluxation were observed in 22 patients. The CF types of patients with anterior shoulder dislocation and subluxation were type I in 4 cases and type II in 18 (Eyres type I in 9 cases, Eyres type II in 6, Eyres type III or IV in 3, and unknown in 4); furthermore, 10 out of 22 patients (45%) had fractures of the glenoid rim. Other injuries around the shoulder were rib fractures in 5 patients (3 of whom had hemothorax), brachial plexus injury in 4, peripheral nerve injuries in 8 (including 3 patients with suprascapular nerve injury), proximal humeral fracture in 14 (including 9 with greater tuberosity fracture associated with anterior shoulder dislocation), and rotator cuff tear in 4 (2 with supraspinatus tendon tears and 2 with subscapularis tendon tears). Head injury was observed in 12 patients, of which 10 were injured in a traffic accident and 2 were injured by a fall/fall from a height. Patients with type I CF had a higher rate of concurrent injury than patients with other fracture types (P=.036, n=197).

Regarding injuries of the superior shoulder suspensory complex (SSSC) (including the above mentioned concurrent injuries of the shoulder girdle), there were no double disruptions in patients with type II CF.[25] However, multiple disruptions were seen in 104 out of 151 patients (69%) with type I CF and 8 out of 9 patients (89%) with avulsion fracture at the angle. Among patients with type I CF, there were 74 with double disruptions, 23 with triple disruptions, and 7 with quadruple disruptions. Among patients with avulsion fracture at the angle, there were 5 with double disruptions and 3 with triple disruptions (Table I).

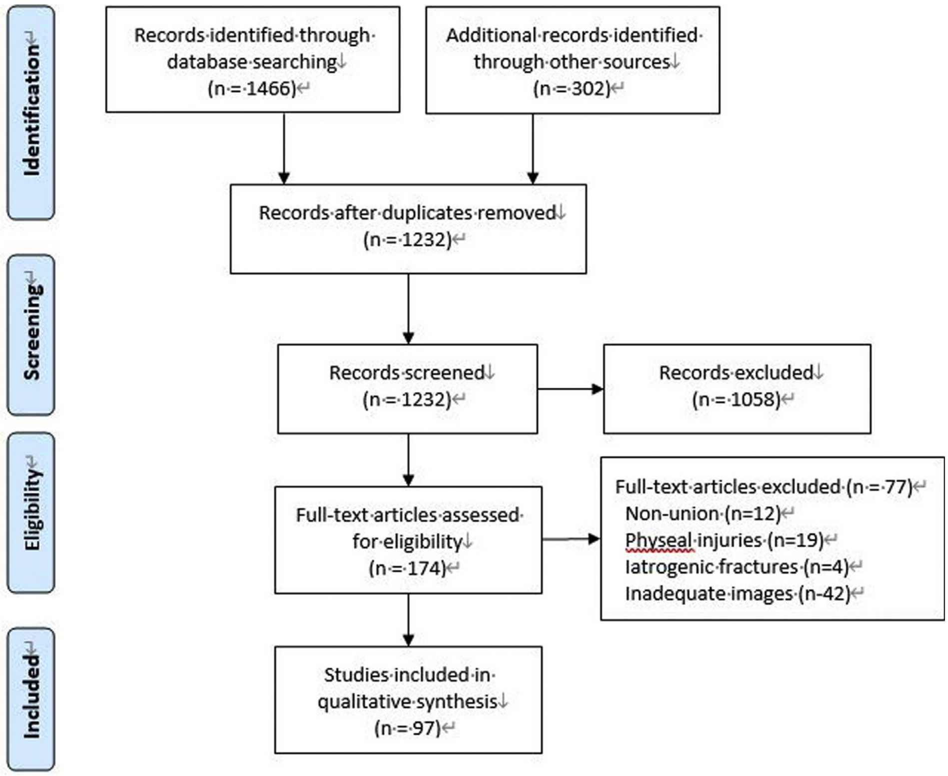

Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart of the study.

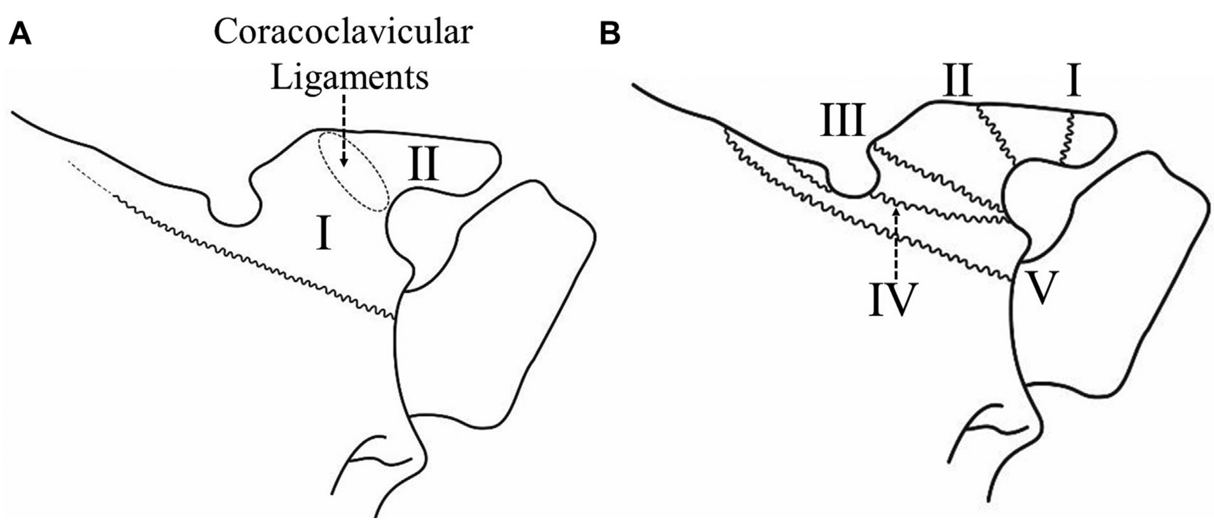

Figure 3 Classification systems used in the analysis. (**A**) Ogawa's functional classification. From clinical and functional viewpoints, CFs are divided into 2 types: type I fractures are located behind the coracoclavicular ligaments, while type II fractures are located in front of the coracoclavicular ligaments. Type I fracture may destroy the firm scapuloclavicular connection. (**B**) Eyres' anatomical classification classifies CFs into 5 types: type I, tip or epiphyseal fracture; type II, mid-process fracture; type III, basal fracture; type IV, involvement of the superior body of the scapula involved; type V, extension into the glenoid fossa (modified from Ogawa et al[62] and Eyres et al[18]). *CFs*, coracoid fractures.

Among patients with type I CF, 34 out of 47 isolated CFs (71%) were conservatively treated, and 79 with multiple disruptions out of 104 (76%) were surgically treated. The treatment of type II CF was conservative in 15 patients and surgical in 19 (n=192) (Table II). However, for 9 of the patients surgically treated for type II CF, the main objective of the operation was to treat concurrent injuries such as greater tuberosity fracture, glenoid rim fracture, and subscapularis tendon tear; the treatment for CF seemed to be secondary or accompanying in these cases. The treatment for avulsion fracture at the angle was conservative in 6 patients and surgical in 3; as the total number of this fracture type was small and the number of cases per injury pattern was small, no consistent treatment tendency was detected. Overall, conservative treatment was significantly more commonly applied to women than men (P=.0004, n=159), but the treatment method did not differ in accordance with patient age (P=.554). The treatment method also

Table I
Types of coracoid fx and concurrent injuries

Types of coracoid fracture and concurrent injuries

Type of coracoid fx	SSSC constituents: Coracoid fx	AC injury	Clavicular fx	Scapular neck fx	Acromion/scapular spine fx	CCL tear	Anterior shoulder dislocation	Number of patients
Type I	○							43
	○	○						41
	○	○		○				1
	○	○			○			3
	○	○	○		○			3
	○	○				○		6
	○	○		○	○			3
	○		○					15
	○		○		○			3
	○		○		○	○		1
	○		○	○				6
	○			○				7
	○			○	○			4
	○				○			11
	○						○	4
	151	57	28	21	28	7	4	151
Type II								16
		○						2
					○			1
							○	18
		2			1		18	37
Avulsion fracture at the angle	○							1
	○	○						3
	○	○	○					3
	○		○					2
	9	6	5					9
Total	160	65	33	21	29	7	22	197

Double disruption Triple disruption Quadruple disruption

SSSC; superior shoulder suspensory complex, fx; fracture
AC; acromioclavicular, CCL; coracoclavicular ligaments

Table II
Types of coracoid fx and treatment methods

fx type	SSSC	Treatment method	Number of patients
Type I	Isolated	Conservative	34
		Surgical	12
		Unknown	1
	Multiple disruption	Conservative	24
		Surgical	79
		Unknown	1
Type II		Conservative	15
		Surgical	19
		Unknown	3
Avulsion fx at the angle		Conservative	6
		Surgical	3
			197

fx, fracture; *SSSC*, superior shoulder suspensory complex.

did not differ in accordance with fracture type (P=.288, n=192), but surgical treatment was significantly more common in patients with concurrent injury than in those with isolated CF (P<.0001).

The content of the surgery was precisely described in 71 of 91 patients (78%) with surgically treated type I CF. The surgical procedure was reduction and internal fixation in 50 out of 71 patients (70%); the fixation devices were various screws with or without a washer in 38 patients,[3,9,12,17,26,28,31,40,45,53,54,60,66,74,75,81] plate and screw in 6, Kirschner wires in 3,[7,35,78] and others in 3. In 17 of 71 patients (24%) with type I CF who underwent surgery, no operative procedures were performed for the CF, although reduction and fixation were performed for concurrent SSSC injuries. In 4 patients with AC dislocation, Dewar's method was performed using the fractured coracoid fragment;[36,61] the objective of the surgery was to treat the AC dislocation, rather than to treat the CF. The precise surgical procedures were described for 18 patients with type II CF. Type II CF was treated with screw fixation in 11 patients,[3,22,65,69] tension band wiring in 2,[65] and no procedure in 3.[61,76] Other surgical procedures performed in patients with type II CF included glenohumeral arthroplasty for glenoid rim fracture using a fractured coracoid fragment in 1 patient,[16] and excision of the fractured coracoid fragment following reattachment of the conjoint tendon to the remaining coracoid in 2.[21,79]

The outcomes of 119 patients (38 who were conservatively treated and 81 who were surgically treated) who were followed up for more than 6 months were reported. In the present analysis, the group of 56 patients who were surgically treated for type I CF with multiple disruptions included 13 patients who were surgically treated for concurrent SSSC injury but did not undergo any surgical procedure for the CF itself. Of these 119 patients followed up for more than 6 months, only 49 patients were evaluated by widely used evaluation methods such as the Constant score and the Disabilities of the Arm, Shoulder and Hand score. Using percentage compared with the healthy side or percentage against the normalized Constant score,[37] we classified these outcomes into 4 categories: excellent (90%-100%), good (80%-89%), fair (70%-79%), and poor (<70%). The outcome was classified into 4 categories in accordance with the raw Constant score: excellent (90-100), good (80-89), fair (70-79), and poor (<70). The Disabilities of the Arm, Shoulder and Hand score was used to define the outcome as excellent (≤10), good (≤20), fair (≤30), or poor (≤40). As a result, of the 119 patients, the outcomes were judged as excellent in 91 (76%), good in 16 (13%), fair in 5 (4%), and poor in 7 cases (6%) (Table III). The outcome did not significantly differ between the 2 treatment methods (P=.11).

Discussion

Scapular fractures account for 0.4%-1% of all fractures and for 3%-5% of fractures of the shoulder girdle,[58,67] and CF accounts for 0%-8% of scapular fractures reported in studies using plain radiography.[1,4,20,34,49,52] However, this prevalence is likely to be underestimated, as CF is easily overlooked unless appropriate plain radiography specifically designed to visualize the entire CF (such as the angle-up views) is performed.[19,32,61] In the last 3 decades, the number of articles reporting many cases of CF has been increasing due to increased awareness of coracoid fracture and advances in imaging techniques and methods such as computed tomography and magnetic resonance imaging.[2,3,8,11,18,20,29,31,35,53,55,56,62,63] Therefore, CF should no longer be considered rare.

In the present review, men accounted for 80% (131 out of 164) of the patients with CF, which is similar to the male prevalence of 82% (55 out of 67) and 78% (52 out of 67) reported in previous studies of acute CF (P=.8115).[56,62] Furthermore, men accounted for 78% of the total number of patients in studies reporting scapular fractures.[1,4,34,49] Therefore, both scapular fracture and CF occur predominantly in men. In the present review, the average age at the time of CF was 37.0±16.9 years, and 127 patients out of 164 (77%) were 13-49 years old. This corresponds with the previously reported average ages at the time of CF of 37.1 and 42.9 years,[56,62] and the average age at the time of entire scapular fracture of 25.9-42.5

Table III
Types of coracoid fx, treatment methods, and outcome

fx type	SSSC	Treatment method	Outcome				Number of patients
			Excellent	Good	Fair	Poor	
Type I	Isolated	Conservative	18	1			19
		Surgical	5	1	2		8
	Multiple disruption	Conservative	8	1			9
		Surgical	40	9	3	4	56
Type II		Conservative	7	2			9
		Surgical	11	1		3	15
Avulsion fx at the angle		Conservative		1			1
		Surgical	2				2
			91	16	5	7	119

fx, fracture; *SSSC*, superior shoulder suspensory complex.

years.[1,4,34,49] Therefore, like scapular fractures, CFs are common in the age group with higher social activity.

Of the 162 patients, the cause of injury was a traffic accident in 67 patients (41%), fall/fall from a height in 55 (34%), and sports activities in 24 (15%); similarly, a previous study reported traffic accidents as the most common cause of CF.[62] Of the sports that caused CF, contact sports such as football accounted for 11 out of 24 cases (46%). Among the cases of CF due to sports, there were 3 stress fractures due to sports activities such as trapshooting,[13] cricket,[15] and golf.[44]

Of the reported cases of CF, 77% were Ogawa type I, 19% were type II, and 5% were avulsion fracture at the angle. The prevalence of type I was similar to previous reports of 79% and 85% (P>.15).[56,62] One patient had an atypical fracture in which the superior pillar fractured horizontally, and the CCL were attached to the cranial fragment (Fig. 4);[71] we classified this atypical fracture as an avulsion fracture at the angle. Avulsion fractures at the angle,[41,51,64,68,73] including the above mentioned horizontal fracture, are functionally classified as type I CF because they destroy the firm scapuloclavicular connection.[51,62,71]

Although CF may occur independently, most CFs are reportedly associated with neighboring musculoskeletal injuries such as AC dislocation, shoulder dislocation, and fractures of the acromion, scapular spine, clavicle, and scapular neck.[27] The most frequent concurrent shoulder girdle injury in the present review was AC injury, which occurred in 65 out of 197 cases (33%). This association rate is similar to the rate calculated based on the total number of patients included in studies reporting many cases of CF (45%; 105 out of 235 patients) (P<.0001).[3,11,18,20,31,53,55,56,62] As AC injury reportedly occurs in 5%-6% of patients with CF,[72,73] physicians treating AC injuries should consider CF as a possible complication.

Clavicular fracture was present in 33 of 197 CF cases (17%) included in the present review. The total rate of clavicular fracture reported in previous studies of CF was 23.3% (48 out of 206 patients),[3,18,20,31,55,56,62] which is similar to the rate in the present study (P<.0001). Although clavicular fractures may occur anywhere,[56,62] most were distal fractures. Fracture of the acromion/lateral scapular spine was also frequently associated with CF, occurring in 29 of 197 cases (14.7%) included in the present review. The total rate of acromion/lateral scapular spine fractures reported in large case series of CF was 19.5% (42 out of 215 patients),[3,11,18,31,55,56,62] which is similar to the rate in the present study (P<.0001). CCL rupture was observed in 7 patients with type I CF, of whom 6 also had AC injury,[6,14,35,74,75,81] and 1 had fractures of the distal clavicle and lateral scapular spine.[47] Patients with type I CF and avulsion fracture at the angle with the abovementioned concurrent injuries often have multiple disruptions of the SSSC.[25] Therefore, if a physician finds type I CF, he/she should suspect other injuries of the SSSC.

Anterior shoulder instability is a well-known cause of CF, and was present in 22 out of 197 cases (11%) included in the present review. Although most CF were type II, fractures of the coracoid base were described in 4 cases.[10,23,65,77] In large case series of CF, the total rate of anterior shoulder instability was 8.4% (19 out of 225 patients),[3,11,18,20,31,55,56,62] which is similar to the rate in the present study (P<.0001).

Possible mechanism of CF

As the CF is found under the clavicle and is protected from direct blows, the mechanism of CF is controversial. Among the 151 type I CFs, 43 cases (28%) were isolated fractures. Furthermore, there has been a report of a patient who sustained a type I CF following a simple but forceful throw.[5] Therefore, isolated type I CF is probably caused by the traction force of the muscles attached to the CF. In the 4 cases of type I CF associated with anterior shoulder dislocation, this mechanism may be adapted.

For CF with shoulder girdle complications, the mechanism that simultaneously causes these complications and CF must be considered. Based on an analysis of 28 CFs, Ogawa et al proposed that the mechanism of injury could be the horizontal shearing force acting between the scapula shifting inward due to a blow from the lateral aspect of the shoulder and the clavicle countering this movement.[62,63] This concept was supported by later research.[18] However, it was impossible in the present study to determine whether the immediate cause of type I CF with concurrent shoulder girdle injuries was due to traction by the CCL or traction by the attached muscles.[43] It is likely that both types of traction are involved.

In type I CF with CCL rupture, some researchers supposed that the abovementioned mechanism caused the concurrent shoulder girdle injuries including CCL rupture, and the CF was simultaneously fractured by the traction force of the muscles attached to the CF.[74,75] We agree with this supposition, and consider that the mechanism of CF in this scenario is the same as that of isolated type I CF. As 8 of 9 patients with avulsion fracture at the angle had concurrent AC dislocation and/or distal clavicular fracture, this suggests that avulsion fracture at the angle is caused by the traction force of the CCL secondary to concurrent injuries such as AC dislocation and clavicular fracture.[51] In type I CF with multiple disruptions, the location of the CCL injury (ie, the CCL attachment, the coracoid base, or the coracoid including the superior glenoid) seems to be determined by the difference in the relative mechanical strength of these sites or tissues.[51] In addition, the damage caused solely by the traction force of the CCL is the avulsion fracture at the

Figure 4 Atypical fracture of the coracoid in a 31-year-old man. His right shoulder was injured in a traffic accident. Plain radiographs showed fractures from the vertical to the horizontal parts of the coracoid, and non-displaced fractures of the scapular neck and body. He had symptoms of traumatic tendinitis of the rotator cuff, but no other shoulder girdle injury. Although CF was thought to be functionally type I, conservative treatment was indicated because of the wide fracture surface. After bone union was confirmed, he returned to his former job in 3 months. Six months after the accident, he had no symptoms and his Constant score was 95. *CF*, coracoid process.

angle, while the fracture of the base of the coracoid is caused mainly by the traction of the attached muscles (similarly to the mechanism of isolated CF), with the traction of the CCL playing a secondary role.

Isolated CF and CF with AC injury or acromion/scapular spine fracture accounted for 51% (19 of 37) of the cases of type II CF. The cause of these CFs must be the traction force of the muscles attached to the CF.[21] However, the mechanism in type II CF associated with anterior shoulder dislocation is debatable.[16] One of the proposed mechanisms is that strong traction on the muscle attached to the CF results in avulsion fracture.[18,21,63] Another proposed mechanism is that direct impact of the dislocated humeral head causes CF[21]; however, this is unlikely because there have been no reports of damage to the subscapularis muscle/tendon, which is sandwiched between the dislocated humeral head and coracoid. The mechanism of all type II CFs must be the traction force of the attached muscles.

Treatment and outcomes

Early studies show equally favorable results after both operative and nonoperative treatment of CF associated with AC dislocation,[30] and report no difference in the results between the operative and nonoperative groups or between type I and type II CF.[62] However, one study showed that conservative treatment resulted in nonunion in 4 of 9 cases of type I CF associated with AC dislocation, and their results were rated as good and fair.[56] Another study described a patient with a conservatively treated double disruption (type I CF and distal clavicular fracture) who required corrective osteotomy of both injured areas because of the limitation of elevation and persistent pain at the coracoclavicular interval.[80] Therefore, it is not possible to discuss the treatment of CF unconditionally.

Conservative treatment was applied in 71% of isolated type I CFs in the present review. The functional result of such conservative treatment is usually good, even in instances where the CF fails to unite,[39] and there are very few reports of nonunion of an isolated coracoid with serious symptoms.[2,59,61] Conservative treatment may achieve satisfactory results because the wide base of the CF usually guarantees satisfactory healing.[46] Therefore, conservative treatment is basically applied for isolated type I CF, but surgical treatment is indicated if symptomatic nonunion subsequently occurs.

Type I CF forming multiple disruptions of the SSSC creates a potentially unstable anatomic situation that often leads to adverse healing and long-term functional consequences;[24] thus, surgery was performed in 76% of the reviewed cases. The aim of surgery is reconstruction of a firm link between the clavicle and scapula to allow early physiotherapy,[62] and the engaged physician must decide which part of the complex injury should be reduced/fixed in which order. In CF with double disruption, reducing and stabilizing one disruption will indirectly adequately reduce and stabilize the second disruption.[25] Actually, no procedures were performed on the CF itself in 17 of 71 patients (24%) with multiple disruptions, although the concurrent SSSC injuries were reduced and fixed.[25,30,31,36,47,53,57,61,76] One study recommended first performing reduction and internal fixation of the displaced injury of the strut, as the stability and degree of displacement of the constituents of the bony/soft tissue ring cannot be accurately appraised until the strut injury is reduced and stabilized.[60] By reducing and fixing all unstable and displaced sites of the ring constituents other than the CF, the positional relationship of the clavicle and scapula is recovered and the displacement of the CF diminished.[60] When the surgeon desires a firm fixation of the CF, it seems better to use a partial threaded lag screw with a washer penetrating the posterior cortex of the scapular neck to compress the fracture, or multiple lag screws offering rotational control. Some studies report the fluoroscopy-guided fixation method for CF, which allows the physician to insert the screw in the proper position and orientation.[12,38] For type I CF involving the glenoid fossa (Eyres type V), which is the same as a type III glenoid fracture using Ideberg's classification,[33] the surgical method should be determined by the size of the involved glenoid fossa. When the glenoid fracture includes only its anterosuperior portion, an approximate anatomical reduction of the glenoid fracture is obtained when the CF itself is reduced.[60] In this scenario, the surgical method is the same as for CF at the base. However, one study showed that the size of the avulsed upper articular surface of the glenoid was more than one-third of its total surface in 10 of 14 patients (71%).[8] In these situations, accurate anatomical reduction is required, as the center of the principal contact surface of the glenoid with the humeral head is near the glenoid center.[48,70] Glenoid fracture should be reduced under direct vision.[18,31] Fixation is performed by inserting screws or plating.[3,6]

There is no absolute indication for surgery in for type II CF, except in athletes.[24] As conservative treatment resulted in favorable outcomes, conservative treatment is recommended for type II CF. However, late surgical treatment may be necessary if the displaced bony fragment causes serious symptoms such as irritation to the surrounding soft tissue or subacromial impingement.[59] Acceptable fixation methods include various screws with or without a washer, and tension band wiring.[3,22,65,69] A relative indication for surgical treatment may exist for young and active athletes engaging in vigorous overhead activity who desire a rapid and steady recovery and wish to avoid the possibility of late surgery. For avulsion fracture at the angle, only one study performed open reduction and internal fixation using a suture anchor after the reduction and fixation of concurrent injuries.[51] If the fractured fragment is approximately reduced by reduction and fixation of the concurrent injuries, fixation of the fractured fragment is unnecessary.

In the present study, 107 of 119 patients (90%) had a satisfactory outcome classified as excellent or good. When the details of the 12 patients with fair and poor outcomes (all of whom were surgically treated) were analyzed, anterior shoulder dislocation with 19% glenoid fracture and greater tuberosity fracture were present in 1 of 2 patients with isolated type I CF.[65] In type I CF with multiple disruptions, the poor outcome resulted from severe brachial plexus injury in 2 patients,[57,76] and failure to reconstruct the firm connection between the scapula and clavicle in 1 patient.[61] All 3 patients with poor outcomes after type II CF had anterior shoulder dislocation with 15%-28% glenoid fracture and greater tuberosity fracture.[65] In the above mentioned 7 cases, the cause of the fair and poor outcomes seems to be the concurrent injuries to structures other than the SSSC constituents and the wrong choice of surgical method; however, the causes of the fair and poor outcomes in the other 5 cases are uncertain.

Limitations

The present review has several limitations. First, most studies are case reports or retrospective case series with small numbers of patients. Second, some studies did not report the patient's characteristics, medical history, and treatment method. Third, in some case series, although the total number of analyzed items was described, the items analyzed in individual cases could not be confirmed. Therefore, the number of cases that could be analyzed differed for each analyzed item. Fourth, the variability in the reported outcome evaluation methods made it extremely difficult to perform meaningful comparisons between the outcomes of different treatment methods. Finally, the coexistence of various injuries made it unclear whether the analysis of the residual symptoms caused by the CF itself was successful.

Conclusions

CF predominantly occurred in men, and was most common in the age group with higher social activity. CF was classified as type I in 77% of patients, type II in 19%, and avulsion fracture at the angle in 5%. There were many concurrent shoulder girdle injuries in patients with type I CF, comprising 7 quadruple disruptions of the SSSC, 23 triple disruptions, and 73 double disruptions; however, there were no multiple disruptions in patients with type II CF. Among those with type I CF, 71% of isolated CFs were conservatively treated, 76% of cases with multiple disruptions were surgically treated, and 23% were nonoperatively treated for both the CF itself and concurrent SSSC disruption. Although the evaluation methods varied, 60% of patients were followed up for more than 6 months, and their outcomes were generally excellent after both conservative and surgical treatment. In about half of the cases with a fair/poor outcome, the cause of deterioration seemed to be concurrent injuries of structures other than the SSSC constituents. The most likely mechanism of CF is severe traction of the attached muscles. Type I CF with multiple disruptions of the SSSC should be treated surgically.

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