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Complications After Anatomic Fixation and Reconstruction of the Coracoclavicular Ligaments

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Background: Reconstruction of the disrupted acromioclavicular (AC) joint has historically resulted in high complication rates. As a result, there has been a move toward anatomic coracoclavicular (CC) ligament fixation and reconstruction, owing to its numerous biomechanical advantages and perceived clinical advantages.

Purpose: To report and analyze the unique complications associated with these anatomic CC ligament procedures using either cortical fixation buttons (CFBs) or tendon grafts (TGs) and to evaluate the effect that these complications have on patient outcomes.

Study Design: Case series; Level of evidence, 4.

Methods: From January 2006 until May 2011, a total of 59 primary anatomic CC ligament procedures were performed using either CFBs or TGs. Demographic, surgical, subjective (including the American Shoulder and Elbow Surgeons [ASES], quick Disabilities of the Arm, Shoulder and Hand [QuickDASH], Short Form–12 [SF-12], and Single Assessment Numeric Evaluation [SANE] scores), and radiographic data along with surgical complications were prospectively collected and retrospectively analyzed. Construct survivorship, defined as the maintenance of reduction of the AC joint, was calculated using the Kaplan-Meier method at 12- and 24-month intervals.

Results: Surgical treatment for AC joint dislocations was performed in 3 women (4 shoulders) and 52 men (55 shoulders) with a mean age of 43.6 years (range, 18-71 years); 13 shoulders (22.0%) underwent fixation using the CFB technique, and 46 shoulders (78.0%) underwent reconstruction using the TG technique. The overall complication rate was 27.1% (16/59) in this study. There were 3 complications (23.1%) in the CFB group, including 1 coracoid fracture and 2 cases of hardware failure resulting in a loss of reduction. There were 13 complications (28.2%) in the TG group, including 4 graft ruptures, 2 clavicle fractures, 1 case of hardware failure, 1 hypertrophic distal clavicle, 2 cases of hardware pain, 1 suture granuloma, 1 case of adhesive capsulitis, and 1 case of axillary neuropathy. Twelve- and 24-month construct survivorship was calculated to be 86.2% and 83.2%, respectively. Of the 43 shoulders that did not have a complication, mean ASES scores significantly improved from 57.5 (range, 0-97) to 91 (range, 63-100) ($P < .001$), and mean SF-12 physical component summary scores significantly improved from 45 (range, 25-58) to 56 (range, 43-65.8) ($P < .001$) after a mean 2.4-year follow-up (range, 1.0-5.7 years). There were no significant differences in outcomes between those that did and did not experience a complication, with the exception that those with complications had significantly decreased median patient satisfaction compared with those without complications (3.5 vs 9, respectively; $P = .049$).

Conclusion: Anatomic procedures to treat disrupted CC ligaments using either CFBs or TGs resulted in an overall complication rate of 27.1% (16/59). Construct survivorship was calculated to be 86.2% at 12 months and 83.2% at 24 months. Good to excellent outcomes could only be reported in those patients who did not have a complication.

Keywords: acromioclavicular joint; AC joint; coracoclavicular; reconstruction; complications; survivorship; outcomes

Injuries to the acromioclavicular (AC) joint represent up to 12% of all traumatic shoulder girdle injuries.[14] In 1984, Rockwood[23] classified AC joint injuries into types I through VI. Type I and II injuries involve a simple strain or incomplete tear of the coracoclavicular (CC) ligament complex. In the vast majority of cases, nonoperative management results in a complete return to preinjury status.[7] Type III injuries are characterized by a complete disruption of both the AC and CC ligament complexes, resulting in 100% superior displacement of the distal clavicle relative to the acromion. Although the management of type III injuries is still controversial, many authors advocate early surgical reconstruction in select high-functioning patients such as manual laborers and overhead-throwing athletes.[5,7,18,24,27-30] Surgical reduction is indicated for AC joint injuries that result in a posterior, excessively superior, or subcoracoid clavicle dislocation (Rockwood grades

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IV, V, and VI, respectively) to prevent long-term sequelae such as pain, weakness, and stiffness.[1,11,13,24,35]

In 1972, transfer of the coracoacromial ligament to the distal clavicle was first performed by Weaver and Dunn[34] in an effort to reconstruct torn CC ligaments. Since then, a large number of modifications have been described for the surgical management of high-grade AC joint injuries to theoretically improve patient outcomes. However, many of these modified Weaver-Dunn procedures have since been abandoned because of their high complication rates.[3,18,27,35] As a result, newer, more anatomic techniques have been developed with hopes of decreasing complication rates and improving patient outcomes.

Several recent biomechanical studies have evaluated these new anatomic CC ligament reconstruction methods, reporting both their advantages and shortcomings.[2,4,6,8,15,16,21,29,32] These techniques typically involve cortical fixation devices,[9,20,26] free tendon grafts,[17,30] or a combination of the two,[3] each of which require holes to be drilled into the distal clavicle and/or the coracoid process. As a result, clavicle and coracoid fractures occurring through drill holes have been reported by several authors.[17,19,25,31] The purpose of this study was to report and analyze the unique complications associated with these new anatomic CC ligament procedures using either cortical fixation buttons (CFBs) or tendon grafts (TGs) and to evaluate the effect that these complications have on patient outcomes.

MATERIALS AND METHODS

Patient Selection

This study obtained prior institutional review board approval. From January 2006 until May 2011, a total of 59 shoulders (55 patients) underwent primary anatomic treatment of disrupted CC ligaments by the senior author (P.J.M.) using CFBs, TGs, or a combination of each. When a TG was used, the procedure was categorized as a TG reconstruction technique in all cases; when a TG was not used, the procedure was categorized as a CFB fixation technique in all cases. All CFB techniques with primary CC ligament fixation were performed within 2 weeks of the initial injury. The indications for reconstruction with TGs included chronic, symptomatic, and unstable AC joints with some acute injuries. Of note, open reconstruction with TGs occurred earlier in the study period, whereas arthroscopically assisted treatments using TGs and/or CFBs were utilized later in the series. Patients younger than 18 years of age, those less than 1 year removed from the primary surgery, those with prior diffuse glenohumeral osteoarthritis (Outerbridge grades 3 or 4), and those with a history of AC reconstruction on the index shoulder were excluded from the study.

Surgical Techniques

In the TG group, anatomic CC ligament reconstruction was performed using an open technique early in the study period. Later in the study period, surgeon preference shifted toward an arthroscopically assisted reconstruction technique. All patients in this study underwent initial diagnostic arthroscopy to identify and treat concomitant intra-articular injuries prior to reconstruction. The open technique involved development of the deltopectoral groove and reflection of the anteromedial deltoid to expose the coracoid and excise the distal clavicle before reconstruction. In those patients who underwent arthroscopically assisted reconstruction, the coracoid base was first identified using a 70° arthroscope before beginning the repair. The superior and middle glenohumeral ligaments were preserved. In cases where AC arthrosis was present, distal clavicle excision was performed by making a 3- to 4-cm incision within the Langer lines over the acromion, thus exposing the distal clavicle. Approximately 8 to 10 mm of the distal clavicle was excised to preserve the superior AC ligaments and to avoid injury to the trapezoid insertion site on the clavicle.

In both the open and arthroscopically assisted TG techniques, two 6-mm drill holes were created in the distal clavicle, corresponding with the conoid (posteromedial) and trapezoid (centrolateral) ligament insertion sites. No drill holes were placed in the coracoid. Fluoroscopy was used to confirm tunnel positions. A 6-mm allograft was passed through the posteromedial tunnel, shuttled around the coracoid, and finally passed through the centrolateral tunnel. After fixation of the graft in the posteromedial tunnel with a 5.5-mm tenodesis screw, the clavicle was manually reduced, and the graft was cycled. Tension was then applied to the graft to maintain anatomic reduction, while the graft was fixed in the centrolateral tunnel with another 5.5-mm tenodesis screw. The free ends of the fixed allograft were knotted together over the clavicle for additional security. A 9-strand polydioxanone (PDS) suture was looped around the coracoid and tied over the top of the clavicle to allow for maintenance of the reduction while the graft was incorporated. Fluoroscopy was utilized in all cases to ensure adequate reduction. The AC joint capsule was then meticulously repaired and imbricated.

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A similar arthroscopically assisted procedure was utilized for anatomic fixation using CFBs. After initial diagnostic arthroscopic surgery, identification of the coracoid base, and excision of the distal clavicle, two 4-mm drill holes were created in the distal clavicle and coracoid base, each corresponding with the conoid (posteromedial) and trapezoid (centrolateral) insertion sites as described by Rios et al.[22] Fluoroscopy was utilized to confirm tunnel positions. Two CFBs were shuttled through the drill holes and fastened tightly enough such that evidence of reduction could be seen with the aid of fluoroscopy. The 2 CFBs were secured using No. 5 permanent sutures in a standard manner.

Postoperative Management

Postoperative management was similar for all reconstruction techniques. Immediately after surgery, the shoulder was immobilized in an abduction sling, and full supine passive range of motion exercises were initiated. Active range of motion exercises were commenced 6 weeks after surgery, while strengthening exercises were delayed until at least 8 weeks postoperatively.

Radiographic Outcomes

Postoperative anteroposterior (AP) radiographs of both AC joints (without weights) were obtained as the standard of care, typically within 30 days of the index surgery. A second similar postoperative radiograph was obtained within approximately 60 days of the index surgery. Using these radiographs, CC distances for each AC joint (both injured and noninjured) were determined by measuring the shortest distance (in mm) from the most superior point of the coracoid process to the nearest point of the distal clavicle. On the first postoperative radiographs, side-to-side differences were calculated by subtracting the measured CC distance of the noninjured shoulder from that of the injured shoulder. A negative number therefore indicated an overreduction. In addition, the differences in CC distances of injured shoulders between the first and second postoperative radiographs were also determined. A side-to-side difference of $>$10 mm or a $>$10-mm increase in CC distance between the first and second postoperative radiographs was deemed to be a loss of reduction. A value of 10 mm was chosen to represent a loss of reduction because an a priori analysis revealed the intraobserver variability to be approximately 5 mm.

Subjective Outcomes

All patient data were prospectively collected, stored in a registry, and retrospectively analyzed. Data regarding patient characteristics, demographics, surgical history, and injury details were collected for all patients at a preoperative consultation. Injuries sustained more than 30 days before the surgery date were deemed to be chronic injuries. These patients also completed a standard preoperative subjective self-administered questionnaire containing an assortment of pain and functional questions that allowed for the calculation of preoperative American Shoulder and Elbow Surgeons (ASES) and Short Form–12 (SF-12) scores. During the postoperative period, data regarding complications were documented for each affected patient. In this study, a complication was defined as any adverse event occurring within the perioperative or postoperative period that deviated from the expected perioperative or postoperative course as a result of the surgical intervention.

At least 1 year after the index surgery, the same patients were asked to complete a similar questionnaire to evaluate their surgical outcomes. Those who did not complete the questionnaire within a reasonable period of time were contacted by telephone and were only questioned regarding further surgery for survivorship analysis. If a loss of reduction occurred, the date of radiographic evidence documenting the loss of reduction was recorded and included in the survivorship analysis. These patients were also encouraged to complete the questionnaire for outcome assessment. To reduce the potential for bias, no follow-up questionnaire data were documented by telephone interview.

The ASES (scale of 0-100, where 100 = best score)[12] and SF-12 (both physical component summary [PCS] and mental component summary [MCS])[33] scores were collected both preoperatively and postoperatively along with pain with activities of daily living, recreation, work, and sleep. At final follow-up, quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) (scale of 0-100, where 0 = best score) scores,[10] Single Assessment Numeric Evaluation (SANE) (scale of 0-100, where 100 = best score) scores,[36] and data regarding patient satisfaction with surgical outcomes (scale of 1-10, where 10 = very satisfied) were collected along with postoperative sports participation data.

Statistical Analysis

All statistical analyses were performed using statistical software SPSS version 11.0 (SPSS, Chicago, Illinois). Construct survivorship was calculated using the Kaplan-Meier method in which the log-rank test was used to compare survivorship between variables. This complex statistical calculation takes into account a beginning time point (index surgery) and a discrete time interval (12 and 24 months) and counts the number of construct failures occurring within that time frame. In this study, construct failure was defined as any complication in which a loss of reduction occurred. This calculation also corrects for those patients who were lost to follow-up (censored data). The result is an estimate of the probability that a patient will not experience a loss of reduction within 12 or 24 months after the index surgery. In those patients who experienced a loss of reduction requiring revision surgery, the date of revision surgery was used as the failure end point for survivorship analysis. If no revision surgery was required after a loss of reduction, the date of AP radiograph confirmation of the loss of reduction was used as the failure end point for survivorship analysis.

With regard to outcome scores, parametric and nonparametric univariate analyses were performed depending

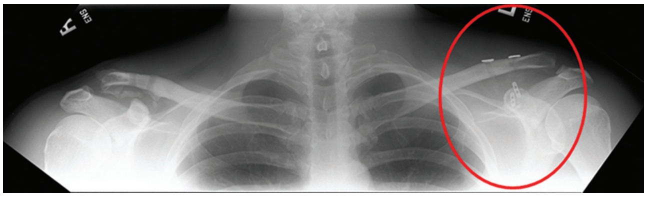

Figure 1. In this patient with bilateral treatment (tendon graft reconstruction on the right and cortical fixation button fixation on the left), a skiing injury in the immediate postoperative period against medical advice resulted in an acute left coracoid fracture, causing proximal migration of the fixation buttons. The patient was successfully treated nonoperatively.

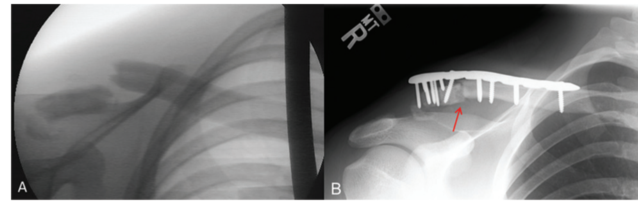

Figure 2. Intraoperative fluoroscopy image (A) and 3-month postoperative radiograph (B) of the right clavicle in a 21-year-old man who sustained a distal clavicle fracture after tendon graft reconstruction. This injury required bone grafting and superior plating.

on whether the data were normally distributed. Bivariate analysis was performed using the χ^2 method. Paired Student t tests were used to compare the differences between preoperative and postoperative outcome scores. All reported P values are 2-tailed, with a value of <.05 indicating a statistically significant difference.

RESULTS

Fifty-nine anatomic CC ligament procedures were performed in 3 women (4 shoulders) and 52 men (55 shoulders) with a mean age of 43.6 years (range, 18-71 years). Seventy-six percent (45/59) of shoulders were injured during either snow sports (skiing or snowboarding) or cycling (mountain or road biking). Seventy-three percent (40/55) of patients regularly participated in recreational sports before their injury.

Thirteen shoulders (22.0%) underwent primary fixation using the CFB technique, and 46 shoulders (78.0%) underwent primary reconstruction using the TG technique. Overall, 16 of the 59 shoulders (27.1%) had a complication, 14 of which (23.7%) were symptomatic and required reoperation. In the CFB group, 3 of 13 shoulders (23.1%) had a complication. These included 1 coracoid fracture (Figure 1) and 2 cases of hardware failure resulting in a loss of reduction. In the TG group, 13 of 46 shoulders (28.3%) had a complication. These included 7 construct failures resulting in a loss of reduction (4 graft failures, 1 case of hardware failure, and 2 clavicle fractures through drill holes [Figure 2]), 2 cases of hardware pain, 1 hypertrophic distal clavicle (Figure 3), 1 symptomatic PDS suture granuloma, 1 case of axillary nerve compression from scar tissue, and 1 frozen shoulder.

According to the classification system developed by Rockwood,[23] there were 19 grade III (32.2%), 6 grade IV (10.2%), and 34 grade V (57.6%) injuries. There were 3 postoperative complications (15.7%) related to grade III injuries, 1 postoperative complication (16.7%) related to grade IV injuries, and 12 postoperative complications (35.3%) related to grade V injuries.

Thirty-one shoulders (52.5%) were treated after an acute injury, and 26 shoulders (44.1%) were treated after a chronic injury. There were 9 postoperative complications (29.0%) in those with acute injuries and 7 postoperative complications (26.9%) in those with chronic injuries.

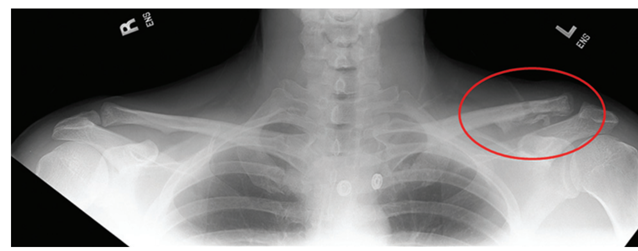

Figure 3. After reduction of the left acromioclavicular joint with a tendon allograft, this 39-year-old man slowly developed a painful hypertrophic distal clavicle that subsequently required distal clavicle excision. This radiograph was taken 4 months after the index surgery.

Radiographic data were obtained postoperatively to document adequate reduction. Overall, the mean difference in CC distances between the first and second postoperative radiographs was 0.614 mm (range, –4.7 to 12.1 mm), and the mean postoperative side-to-side difference was 0.37 mm (range, –14.69 to 14.70 mm). Shoulders that displayed radiographic evidence of a loss of reduction had significantly increased mean CC distances between the first and second postoperative radiographs (2.72 mm [95% confidence interval (CI), 0.46 to 4.98 mm] vs 0.23 mm [95% CI, –0.79 to 1.26 mm], respectively) (P = .050) and increased mean side-to-side differences (5.19 mm [95% CI, 2.09 to 8.29 mm] vs −1.51 mm [95% CI, –2.91 to −0.103 mm], respectively) (P < .001).

Survivorship data were available for 55 of 59 shoulders (93.2%). Of the 55 procedures included in this analysis, 10 resulted in a loss of reduction (18.2%), 8 of which (14.5%) required revision surgery and 2 of which were identified as a loss of reduction only by AP radiographs (one was mildly symptomatic, and the other was asymptomatic). Seven of the 10 construct failures (70%) occurred within 1 year of the primary surgery, 1 construct failure occurred approximately 1 year after the primary surgery, and 2 other construct failures occurred approximately 3.1 years and 4.4 years after the primary surgery. Survivorship at 12 and 24 months was calculated to be 86.2% and 83.2%, respectively (Figure 4). There were no significant differences in survivorship between Rockwood grades, acute

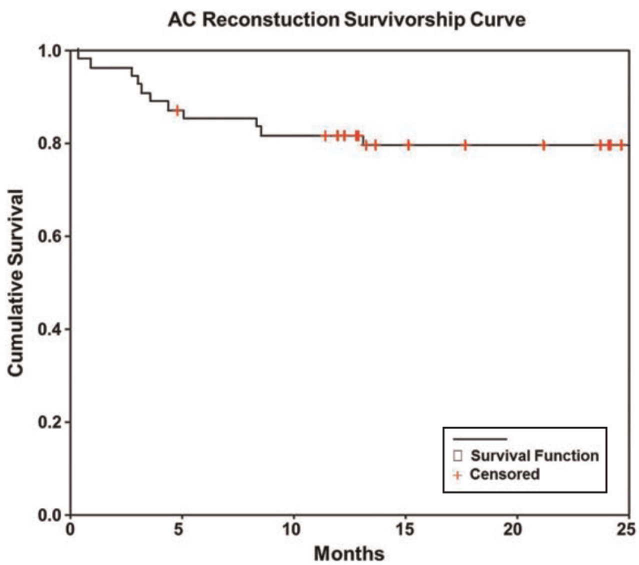

Figure 4. Calculated construct survivorship curve for anatomic acromioclavicular treatment using either the cortical fixation button or tendon graft technique. Construct survival occurred when a loss of reduction did not happen within the designated 12- or 24-month interval. Censored data points indicate the time at which a patient dropped out of the survivorship calculation because of a lack of follow-up. Survivorship was calculated to be 86.2% at 12 months and 83.2% at 24 months.

versus chronic injuries, arthroscopically assisted versus open techniques, or TG versus CFB techniques ($P > .05$).

Minimum 1-year postoperative subjective data were available for 49 of 59 shoulders (83.1%) with a mean follow-up of 2.4 years (range, 1.0-5.7 years). A summary of subjective outcome scores and other data for the 43 shoulders that did not experience a complication is provided in Table 1. Shoulders that did not have a postoperative complication showed statistically significant improvements in ASES and SF-12 PCS scores over preoperative baselines ($P < .001$). There were no statistically significant differences in preoperative to postoperative changes in ASES or SF-12 scores between the different Rockwood grades, between the CFB and TG groups, or between acute and chronic groups ($P > .05$). In addition, within the TG group, there were no statistically significant differences in preoperative to postoperative changes in ASES or SF-12 scores between those that were treated with the open or arthroscopically assisted technique ($P > .05$). However, our study was not sufficiently powered to detect differences in preoperative to postoperative ASES or SF-12 scores between different groups.

Table 2 summarizes the characteristics of each shoulder that experienced a complication other than a loss of reduction. Table 3 summarizes the outcomes for each shoulder that experienced a complication other than a loss of reduction. Shoulders with complications had lower mean postoperative ASES scores compared with shoulders without complications (85.0 [range, 66.6-100] vs 92.1 [range, 63.3-100], respectively); however, this difference did not reach statistical significance ($P = .190$). In addition, shoulders with complications had significantly decreased median satisfaction compared with those without complications (3.5 [range, 1-10] vs 9 [range, 1-10], respectively) ($P = .049$).

DISCUSSION

In this study, 16 of the 59 shoulders (27.1%) had a complication, 14 of which (23.7%) required a second surgery. Some of these complications, namely coracoid and clavicle fractures through drill holes, graft ruptures, hardware failure, and adhesive capsulitis, have been reported by other authors.[17,24,25,31] Ten of the 16 complications (62.5%) were attributable to a loss of reduction. When considered together, survivorship of the CFB and TG constructs was found to be 86.2% at 12 months and 83.2% at 24 months. There were no significant differences in outcomes between those that did and did not experience a complication with one exception: shoulders with complications had significantly decreased median satisfaction compared with those that did not experience a complication (3.5 vs 9, respectively; $P = .49$).

Using the CFB fixation technique, which required the placement of two 4-mm drill holes within both the clavicle and the coracoid, we encountered 1 case of symptomatic loss of reduction not requiring revision, 1 case of asymptomatic loss of reduction, and 1 traumatic coracoid fracture through drill holes that occurred as a result of a competitive skiing accident 27 days after the index surgery. The coracoid fracture was successfully treated nonoperatively without additional surgery. Salzmann et al[25] followed a series of 23 patients for a mean of 24 months after anatomic CC ligament reconstruction using a comparable CFB technique. The authors noted similar complications to those found in our study including coracoid fractures and button slippage resulting in a loss of reduction. In another study utilizing a comparable CFB technique, Scheibel et al[26] investigated the clinical outcomes in 37 patients after a mean follow-up of 26.5 months. Although the authors reported satisfactory outcomes without symptomatic complications, button slippage and/or button migration occurred in 89.3% (25/28) of patients on follow-up AP radiographs. Whether these patients eventually became symptomatic is unknown.

Using the TG reconstruction method, which required the placement of two 6-mm drill holes through the distal clavicle only, we encountered a total of 13 complications including 5 construct failures that resulted in a loss of reduction and 2 clavicle fractures through drill holes that also resulted in a loss of reduction. While 1 of the 2 clavicle fractures was the result of a traumatic snowboarding fall, the other occurred atraumatically as the patient abducted the affected arm over the head while reaching for an object. Both clavicle fractures required plate fixation. The 6 remaining complications in the TG group were not unique to this reconstruction technique (see Table 3).

TABLE 1
Summary of Outcomes for Shoulders That Did Not Experience a Complication (n = 43)[a]

	Preoperative	Postoperative	*P* Value
SF-12 PCS score	45 (25-58)	56 (43-65.8)	.000[b]
SF-12 MCS score	52 (25-65.5)	54 (28-61.4)	.465
ASES score (scale: 0-100)	57.5 (0-97)	91 (63-100)	.000[b]
Painless use of arm (scale: 0 = to waist, 1 = to chest, 2 = to neck, 3 = to head, 4 = overhead)	1	4	.000[b]
Pain with recreation (scale: 0 = none, 1 = mild, 2 = moderate, 3 = severe)	3	1	.000[b]
Pain with ADL (scale: 0 = none, 1 = mild, 2 = moderate, 3 = severe)	2	0	.000[b]
Pain with work (scale: 0 = none, 1 = mild, 2 = moderate, 3 = severe)	2	0	.000[b]
Pain with sleep (scale: 0 = none, 1 = mild, 2 = moderate, 3 = severe)	2	1	.000[b]
Ability to compete compared with preinjury level (scale: 1 = equal to preinjury, 2 = slightly below, 3 = moderately below, 4 = significantly below, 5 = unable to compete in usual sport, 6 = unable to complete in any sport)	6	2	.000[b]
SANE score (scale: 0-100)	NA	89 (2-100)	NA
QuickDASH score (scale: 100-0)	NA	7 (27.2-0)	NA
Median patient satisfaction (scale: 0-10)	NA	9 (1-10)	NA

[a]Values are expressed as mean (range) unless otherwise indicated. ADL, activities of daily living; ASES, American Shoulder and Elbow Surgeons; MCS, mental component summary; NA, not available; PCS, physical component summary; QuickDASH, quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12, Short Form–12.
[b]Significant difference ($P < .05$).

TABLE 2
Summary of Shoulders That Had a LOR After Primary TG and/or CFB Reconstruction[a]

Patient Age/Sex	Surgical Technique	Time From Injury to Primary AC Reconstruction, d	Allograft Type	Construct Failures	Reason	Time to Revision or LOR, d	Rockwood Grade	Surgical Approach
64/M	TG	4	Tibialis anterior	Graft failure	Repetitive motion, no trauma	399	III	Open
66/M	TG	1048	Tibialis anterior	Graft failure	Pain from repeatedly raising arm	1136	V	Open
23/M	TG	65	Tibialis anterior	Graft failure	No trauma	10	V	Arthroscopically assisted
66/M	TG	105	Tibialis Anterior	Graft failure	No trauma, asymptomatic	40	V	Arthroscopically assisted
21/M	TG	122	Tibialis anterior	Clavicle fracture	Snowboarding fall	252	V	Arthroscopically assisted
50/M	TG	3	Tibialis anterior	Clavicle fracture	Lifting arm overhead	203	V	Open
47/M	TG	422	Tibialis anterior	Hardware failure	No trauma, asymptomatic	489	V	Open
37/M	2 CFBs	3	—	Coracoid fracture	Competitive ski racing	27	V	Arthroscopically assisted
34/F	1 CFB	14	Tibialis anterior	Hardware failure	No trauma	110	V	Arthroscopically assisted
68/M	2 CFBs	1	—	Hardware failure	No trauma	97	IV	Arthroscopically assisted

[a]AC, acromioclavicular; CFB, cortical fixation button; F, female; LOR, loss of reduction; M, male; TG, tendon graft.

TABLE 3
Shoulders With a Complication Other Than a Loss of Reduction[a]

Technique	Complication	Reason/Injury	Follow-up, mo	ASES	Quick DASH	SANE	SF-12 PCS	SF-12 MCS	Satisfaction
TG	Adhesive capsulitis	No trauma, pain and decreased range of motion	22.6	93.0	15.9	85	54.0	50.8	9
TG	PDS suture granuloma	No trauma	27.3	86.6	9.0	95	59.6	41.2	10
TG	Hypertrophic distal clavicle	No trauma	14.5	91.6	15.9	93	53.8	61.4	9
TG	Nerve compression	None	17.7	63.3	22.7	80	42.7	48.7	3
TG	Painful hardware	Skiing fall	32.5	96.6	11.3	95	44.4	52.4	9
TG + 1 CFB	Painful hardware	Fall on shoulder while hiking	22.8	68.3	27.2	80	56.4	45.6	1
		Mean	22.9	83.2	17.0	83.0	51.8	50.0	6.8

[a]ASES, American Shoulder and Elbow Surgeons; CFB, cortical fixation button; MCS, mental component summary; PCS, physical component summary; QuickDASH, quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12, Short Form–12; TG, tendon graft.

In a series of 27 patients, Milewski et al[17] aimed to characterize the complications associated with anatomic CC ligament reconstruction using a TG with the addition of a single CFB. In their study, all reconstructions involved 1 or 2 graft tunnels in the clavicle. Ten of the 27 cases involved shuttling the graft through an additional tunnel in the coracoid base, while the remaining 17 cases involved looping the graft around the coracoid, similar to the TG technique described in our study. Two of the 10 shoulders (20%) in the coracoid tunnel group sustained atraumatic coracoid fractures. Of the remaining 8 shoulders in the coracoid tunnel group, 5 shoulders (50%) experienced a loss of reduction (defined as a >5-mm change in postoperative CC distance). In contrast, reconstruction that involved looping the graft around the coracoid (17 cases) resulted in no coracoid fractures and only 2 cases (11.8%) of loss of reduction. However, 3 shoulders (17.6%) sustained acute clavicle fractures through drill holes. The authors noted that each clavicle fracture occurred before 2007 prior to the implementation of procedural modifications that included optimization of the location and diameter of drill holes.

Using our TG technique, 2 of the 10 shoulders (20.0%) with complications sustained acute clavicle fractures, similar to that which was reported by Milewski et al.[17] Of the 3 patients with complications in our CFB group, 1 (33.3%) sustained an acute traumatic coracoid fracture through drill holes. Combining the results of the studies previously mentioned, it appears that anatomic CC ligament reconstructive procedures that involve the placement of bone tunnels in the clavicle are at a substantially increased risk of fractures, especially when drill holes are large and/or misplaced. As a result, the senior author (P.J.M.) no longer uses drill holes in the clavicle to decrease the risk of clavicle fractures.

While this study was meant to provide data on complication profiles, this study does have several limitations. First, although we present minimum 1-year subjective outcome data for this cohort, we were able to show the clinical efficacy of AC reconstruction using the CFB and TG techniques through survivorship analysis. Second, the outcome scores reported in this study (ASES, QuickDASH, SF-12, and SANE scores) have not been validated for use in AC joint injuries. Finally, although this study represents one of the largest cohorts of patients treated with AC joint procedures, we were underpowered to make solid statistical comparisons of outcomes or complication rates between different Rockwood grades, CFB and TG groups, acute and chronic groups, or arthroscopically assisted and open reconstruction groups.

CONCLUSION

Anatomic procedures to treat disrupted CC ligaments using either CFBs or TGs resulted in an overall complication rate of 27.1% (16/59). Construct survivorship was calculated to be 86.2% at 12 months and 83.2% at 24 months. Good to excellent outcomes could only be reported in those patients who did not have a complication.

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