# Two-Year Outcomes After Primary Anatomic Coracoclavicular Ligament Reconstruction

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**Purpose:** The purpose of this study was to report the clinical and structural outcomes after anatomic coracoclavicular ligament reconstruction (ACCR) with free tendon allografts in patients with grade III and grade V acromioclavicular (AC) joint dislocations. **Methods:** Thirty-one shoulders underwent primary ACCR with tendon allografts for Rockwood grade III and grade V AC joint dislocations. Preoperative data included patient demographic characteristics, injury characteristics, and surgical history, along with American Shoulder and Elbow Surgeons (ASES) scores, Short Form 12 Physical Component Summary (SF-12 PCS) scores, and various pain scales. Outcome measures were also collected a minimum of 2 years postoperatively with the addition of Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) scores; Single Assessment Numeric Evaluation (SANE) scores; and patient satisfaction. In addition, preoperative and postoperative coracoclavicular distances were analyzed using standard anteroposterior radiographs. **Results:** ACCR was performed in 31 patients (31 shoulders) with a mean age of 43.9 years (range, 21 to 71 years). In 7 patients (22.6%) a complication occurred that required a subsequent surgical procedure including graft rupture/attenuation (2), clavicle fractures (2), distal clavicle hypertrophy (2), and adhesive capsulitis (1). Of the remaining 24 patients, 20 (83.3%) had subjective outcome data available after a minimum 2-year follow-up period (mean, 3.5 years; range, 2.0 to 6.2 years). The mean postoperative ASES and SF-12 PCS scores significantly improved when compared with the preoperative baseline values (58.9 *v* 93.8 for ASES scores [$P < .001$] and 45.3 *v* 54.4 for SF-12 PCS scores [$P = .007$]). At final follow-up, the SANE and QuickDASH scores were 89.1 and 5.6, respectively, with a median patient satisfaction rating of 9 of 10. **Conclusions:** Patients who did not require revision surgery showed excellent postoperative outcome scores: The mean ASES score was 93.8, the mean SANE score was 89.1, and the mean QuickDASH score was 5.6, with a median patient satisfaction rating of 9 of 10. Further study regarding ACCR techniques should focus on decreasing the risks of complications and maintaining reduction of the AC joint. **Level of Evidence:** Level IV, therapeutic case series.

Acromioclavicular (AC) joint injuries account for up to 50% of all shoulder injuries, with an overall incidence of 9.2 injuries per 1,000 person-years in young athletes.[1-5] These injuries most commonly result from a direct blow to the acromion in an adducted shoulder. The AC capsuloligamentous structures initially fail, followed by failure of the coracoclavicular (CC) ligaments when there is sufficient force. The classification of AC joint injuries was described by Rockwood[6]—grade I and grade II injuries are typically treated nonoperatively, whereas grade IV, grade V, and grade VI injuries are typically treated operatively. The mode of treatment for grade III injuries is currently controversial; however, many surgeons offer surgery acutely to high-level athletes and manual laborers with grade III injuries in addition to patients whose shoulders become chronically symptomatic.[7-13]

Transfer of the coracoacromial ligament to the distal clavicle was first performed by Weaver and Dunn[14] in 1972 as a method to restore AC joint stability in patients with AC joint dislocations. The so-called Weaver-Dunn method of AC joint reconstruction has since undergone several modifications because of significant complication rates and poor clinical results. Recently, anatomic coracoclavicular ligament reconstruction (ACCR) with soft-tissue grafts has become a popular method of reconstruction because it yields superior biomechanical

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strength and stability when compared with the Weaver-Dunn method.[14-20] In 2006 Mazzocca et al.[19] randomly allocated 42 fresh-frozen cadaveric shoulders into 3 reconstruction groups looking at time-zero load to failure: (1) ACCR with allograft, (2) arthroscopic suture sling, and (3) open modified Weaver-Dunn technique. The open modified Weaver-Dunn reconstruction resulted in significantly increased laxity and anteroposterior translation compared with either the ACCR technique with tendon graft or the arthroscopic suture sling technique. In addition, the ACCR technique afforded improved posterior stability compared with the arthroscopic suture sling technique. ACCR was therefore found to be the most stable of the 3 tested AC reconstruction methods.

It has since been theorized that because ACCR techniques with soft-tissue grafts more closely approximate the native biomechanics of the intact state, these techniques may result in improved clinical results and patient satisfaction. The purpose of this study was to report the clinical and structural outcomes after ACCR with free tendon allografts in patients with grade III and grade V AC joint dislocations. We hypothesized that primary ACCR in patients with grade III and grade V AC joint dislocations would provide excellent clinical and structural outcomes after a minimum 2-year follow-up period.

## Methods

Institutional review board approval was obtained before initiation of this study.

### Study Population

Between October 2006 and January 2011, the senior surgeon (P.J.M.) performed 31 primary ACCR procedures with tendon allografts for patients with Rockwood[6] grade III or grade V AC joint dislocations. All reconstructions were performed with free tendon allograft and were subsequently augmented with polydioxanone sulfate cerclage to maintain reduction and offload the graft during incorporation. Patients with minor concomitant pathologies such as small rotator cuff tears, labral tears, or biceps tendinopathy were included. Patients were excluded if they were aged younger than 18 years or had major concomitant pathologies such as fractures, massive rotator cuff tears, or sternoclavicular joint instability.

### Surgical Indications and Treatments

After a thorough clinical evaluation, each patient was counseled regarding the decision to pursue operative or nonoperative management for the injury. In general, surgery was recommended acutely for patients with grade V injuries, as well as patients with grade III injuries who were active or had clinical evidence of concomitant injuries. During the study period, 19 patients (18 grade III and 1 grade V) declined to proceed with surgical treatment. All patients included in this study were treated using identical methods regardless of their Rockwood classification.

All shoulders included in this study underwent ACCR with a 6-mm non-irradiated allograft (tibialis anterior or peroneus longus according to graft availability) by either an open or arthroscopically assisted technique. The surgical technique evolved over the duration of the study period such that earlier cases received open treatment whereas later cases received arthroscopically assisted treatment. When compared with the open technique, the arthroscopically assisted technique allowed for a smaller superior incision and limited detachment of the deltoid muscle. Otherwise, the final constructs were identical for both the open and arthroscopically assisted techniques, including identical graft diameters, tunnel diameters, and methods of fixation (Fig 1). All patients underwent initial diagnostic arthroscopy to identify and address any concomitant intra-articular or subacromial lesions before reconstruction.[21-23] Arthroscopic distal clavicle

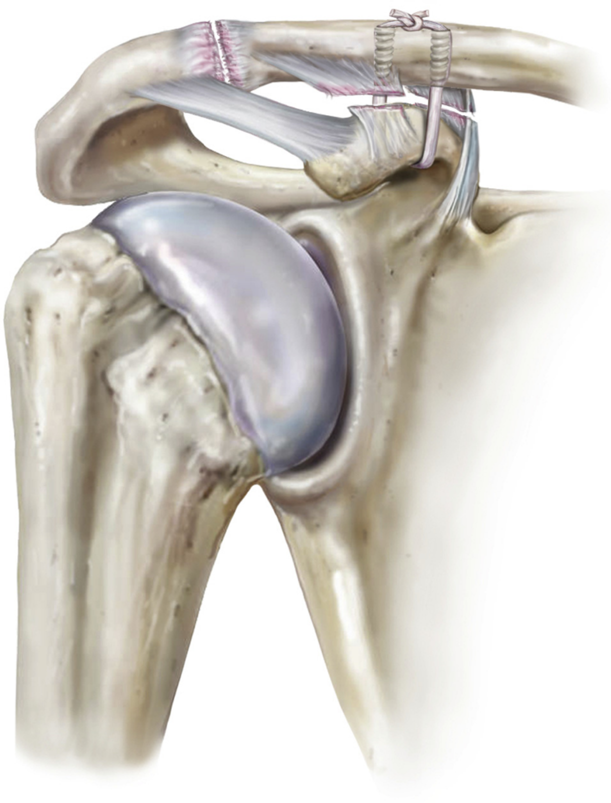

**Fig 1.** Final graft position after either open or arthroscopically assisted anatomic coracoclavicular ligament reconstruction. An additional polydioxanone sulfate cable, composed of 9 strands of polydioxanone sulfate suture, is passed beneath the coracoid and tied over the top of the clavicle to help maintain joint reduction.

excisions were routinely performed in this cohort to prevent post-traumatic osteoarthritis of the AC joint.

*Diagnostic Arthroscopy.* After the administration of a regional interscalene block and the induction of general anesthesia, the patient was placed in the modified beach-chair position. Under sterile conditions, the index shoulder was prepared and draped with the arm secured in a pneumatic arm holder. Standard posterior and anterosuperior portals were established. Diagnostic arthroscopy was performed, and all intra-articular pathologies were treated as necessary. An accessory lateral portal was established when access to the subacromial space was necessary for the treatment of rotator cuff or other subacromial pathologies.

*Open ACCR.* The open ACCR technique was performed using a method described by Carofino and Mazzocca.[24] In brief, an incision was made beginning approximately 3.5 cm medial to the AC joint line and extending inferiorly toward the coracoid. The deltotrapezial fascia was subperiosteally elevated from the distal clavicle and split in line with its fibers along the long axis of the distal clavicle. Interposed soft tissues were mobilized to allow for joint reduction. Two 6-mm bone tunnels were created through the distal clavicle, each corresponding to the infraclavicular insertion sites of the conoid (posteromedial) and trapezoid (centrolateral) ligaments, as described by Rios et al.[25] Fluoroscopy was used to ensure correct tunnel placement—the lateral tunnel was placed vertically, and the medial tunnel was obliquely oriented from posterosuperior to anteroinferior on the distal clavicle. The previously whipstitched 6-mm graft was looped around the coracoid, and its free limbs were passed through the corresponding bone tunnels in the distal clavicle: The posteromedial limb reconstructed the conoid ligament, and the centrolateral limb reconstructed the trapezoid ligament. The graft was then cycled, and the AC joint was reduced. While the joint was held in a reduced position, each graft limb was fixed in its respective bone tunnel using a 5.5-mm PEEK (polyether ether ketone) tenodesis screw. Fluoroscopy was used to confirm adequate joint reduction.

The ends of the graft were looped together in an overhand configuration and sewn together with high-strength nonabsorbable No. 2 suture to provide additional fixation. The remaining ends of the graft were then excised. Nine strands of No. 1 polydioxanone sulfate suture were intertwined into a single suture cable that was used as an internal brace to augment the repair.[26] The suture cable was passed around the coracoid and tied over the top of the clavicle to maintain joint reduction during the process of graft incorporation. Dynamic examination was then performed under both direct visualization and fluoroscopy to ensure maintenance of joint reduction. The deltotrapezial fascia and superior AC joint capsule were imbricated and subsequently repaired prior to wound closure.

*Arthroscopically Assisted ACCR.* After diagnostic arthroscopy, a window was created within the rotator interval between the superior and middle glenohumeral ligaments. An accessory anteroinferolateral portal was established through this window under direct visualization to facilitate adequate dissection around the inferior coracoid. Through the posterior portal, a 70° arthroscope was routinely used to visualize the inferior coracoid arch and the subcoracoid space during dissection.

Approximately 3.5 cm medial to the AC joint line, a 2.5-cm incision was made parallel to the long axis of the distal clavicle. The remaining deltotrapezial fascia was incised along the central long axis of the distal clavicle and subperiosteally elevated to allow for adequate imbrication and repair at the conclusion of the procedure. In preparation for graft passage, two 6-mm bone tunnels were created through the distal clavicle as described earlier. Cannula dilators were then used to create soft-tissue tracts medial and lateral to the coracoid. A passing suture was inserted through the medially placed cannula dilator from superiorly, passing medial to the coracoid and exiting the accessory anteroinferolateral portal. By use of the same technique, a second passing suture was then inserted through the laterally placed cannula dilator, passing lateral to the coracoid and also exiting the anteroinferolateral portal.

The graft was whipstitched and, using the previously placed medial passing suture, was shuttled through the posteromedial (conoid) bone tunnel and the medial soft-tissue tract to emerge along the medial aspect of the coracoid base under direct arthroscopic visualization. The previously placed lateral passing suture was looped around the graft whipstitch, and the lateral passing suture was pulled superiorly through the clavicle, thus shuttling the graft around the base of the coracoid and upward until it emerged from the centrolateral (trapezoid) bone tunnel. The graft was secured in the posteromedial bone tunnel with a 5.5-mm PEEK tenodesis screw. After the graft was cycled to remove creep, the distal clavicle was manually reduced and the graft was simultaneously fixed in the centrolateral (trapezoid) bone tunnel using a second 5.5-mm PEEK tenodesis screw. Adequate joint reduction was confirmed by fluoroscopy. The free ends of the graft were then looped together in an overhand configuration and secured to one another using high-strength sutures, which were passed through the graft and tied. A suture cable was fashioned and applied as described for the open ACCR technique. To ensure the maintenance of joint reduction with shoulder motion, dynamic examination was performed under both direct arthroscopic visualization and fluoroscopic imaging. The deltotrapezial fascia and superior AC joint capsule were imbricated and repaired. The primary incision was closed in layers with absorbable sutures.

## Postoperative Rehabilitation

The postoperative management protocols were identical for both the open and arthroscopically assisted reconstruction techniques. To reduce tension on the reconstruction, an abduction sling was applied immediately postoperatively and continued to be used for 4 to 6 weeks. Supine active range-of-motion exercises were begun in the immediate postoperative period. Active and active-assisted motion was begun at 6 weeks, whereas strengthening was delayed until at least 8 weeks postoperatively. In patients who underwent concomitant subpectoral biceps tenodesis, additional avoidance of resisted elbow flexion was advised for at least 6 weeks postoperatively. Patients were typically allowed to return to full activities after approximately 16 weeks of rehabilitation.

## Data Collection

All data were collected prospectively, stored in a surgical registry, and retrospectively retrieved for analysis. Demographic data included patient demographic characteristics (age, sex, dominant shoulder), surgical history (previous surgical procedures on the injured shoulder), and injury characteristics (mechanism of injury, Rockwood grade, timing of reconstruction). Surgical data included the type of reconstruction (open *v* arthroscopically assisted), the type of allograft used (tibialis anterior or peroneus longus), concomitant pathologies, ancillary treatments, and perioperative complications. Primary ACCRs performed less than 30 days after the date of injury were considered early reconstructions, whereas primary ACCRs performed more than 30 days after the date of injury were considered delayed reconstructions.[27] American Shoulder and Elbow Surgeons (ASES) scores and Short Form 12 (SF-12) Physical Component Summary (PCS) scores were collected both preoperatively and postoperatively. In addition, patients were asked several questions regarding their level of pain with various activities including sleep, recreation, activities of daily living, work, and competition, both preoperatively and postoperatively. In addition to data regarding complications and further surgical interventions, Single Assessment Numeric Evaluation (SANE) scores; Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) scores; and patient satisfaction were only collected postoperatively.

All clinical assessments were performed by the senior surgeon (P.J.M.). According to the standard of care for our institution, patients were asked to return for postoperative clinical assessments at approximately 30-day intervals. Standing anteroposterior radiographs were obtained (without weights) during each clinic visit to confirm the maintenance of joint reduction and to evaluate for heterotopic bone formation. Preoperative and postoperative anteroposterior radiographs were reviewed by 2 of the authors (M.P.H. and R.J.W.), who independently measured CC distances (in millimeters) of both the injured and uninjured shoulders on 2 separate occasions separated by more than 2 weeks to determine inter-rater and intrarater reliability. The CC distance corresponded to the length (in millimeters) of a precisely vertical line beginning at the most superior point of the coracoid and ending at the most inferior point of the clavicle (Fig 2). All measurements were made using Stryker OfficePACS Power 4.1 Express Edition (Stryker, Kalamazoo, MI). Radiographic loss of reduction occurred when the CC distance of the injured shoulder increased by 10 mm or greater between the first postoperative radiograph and any subsequent radiographs or when a side-to-side difference of 10 mm or greater was found (CC distance of injured shoulder − CC distance of uninjured shoulder). A level of 10 mm was chosen to represent a loss of reduction because the overall intraobserver variability was found to be approximately ±5 mm. Early graft stretch was defined as a 5- to 10-mm increase in the CC distance of the operative shoulder between the first and second postoperative radiographs. Late graft stretch was defined as a 5- to 10-mm increase in the CC distance of the

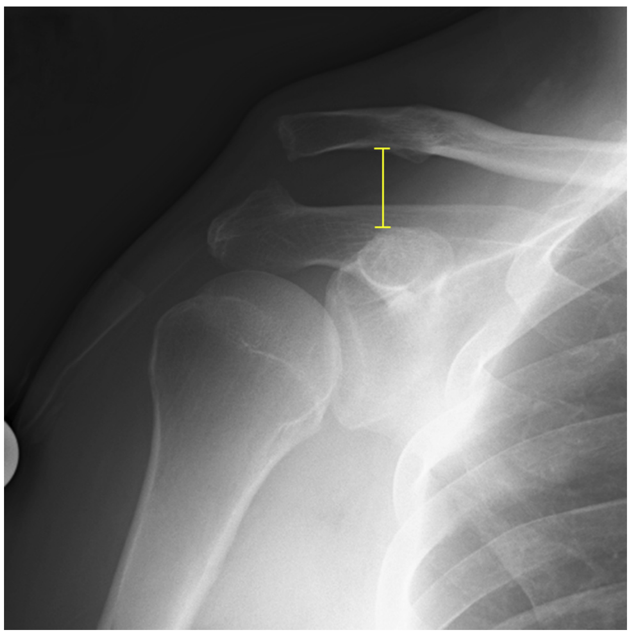

**Fig 2.** Coracoclavicular distances were measured using standard anteroposterior radiographs without weights. A vertical line was drawn connecting the most superior point of the coracoid process and the most inferior point of the distal clavicle. The length of this line was measured in millimeters using standard radiographic imaging software.

**Table 1.** Summary of Patient Demographic Characteristics, Injury Characteristics, and Surgical Variables

| | Data |
|---|---|
| Patient demographic characteristics* | |
| No. of shoulders | 31 |
| Mean age, yr (SD) | 43.9 (14.1) |
| Injured shoulder | |
| Right | 17 (54.8) |
| Left | 14 (45.2) |
| Dominant shoulder | |
| Right | 16 (51.6) |
| Left | 15 (48.4) |
| Dominant shoulder injured | 15 (48.4) |
| Prior surgical procedures on injured shoulder† | 1 (3.2) |
| Injury characteristics | |
| Mechanism of injury | |
| Skiing/snowboarding | 15 (48.4) |
| Road or mountain biking | 10 (32.3) |
| Other mechanisms | 6 (19.3) |
| Rockwood grade | |
| Grade III | 9 (29.0) |
| Grade V | 22 (71.0) |
| Timing of reconstruction | |
| Early (<30 d after injury)‡ | 14 (45.2) |
| Delayed (>30 d after injury)§ | 17 (54.8) |
| Surgical variables | |
| Reconstruction type | |
| Open | 10 (32.3) |
| Arthroscopically assisted | 21 (67.7) |
| Allograft used | |
| Tibialis anterior | 29 (93.5) |
| Peroneus longus | 2 (6.5) |
| Concomitant pathologies | |
| Outerbridge grade I or II chondral defects | 18 (58.1) |
| Small labral tears | 16 (51.6) |
| Partial-thickness rotator cuff tears | 4 (12.9) |
| Concomitant procedures | |
| Distal clavicle excision | 30 (96.8) |
| Subacromial decompression | 22 (71.0) |

NOTE. Data are presented as number of patients (percent) unless otherwise indicated.

*All patients were men.

†All previous surgical procedures were unrelated to the acromioclavicular joint.

‡Median of 7 days after injury (range, 1 to 18 days).

§Median of 7.3 months after injury (range, 55 days to 38.3 months).

operative shoulder between the first postoperative radiograph and any subsequent radiograph obtained at least 3 months after the index surgical procedure.

### Statistical Methods

Statistical analyses were performed with the aid of SPSS software, version 11.0 (SPSS, Chicago, IL). Univariate analyses were performed when data were normally distributed, and nonparametric analyses were performed when data were not normally distributed. Bivariate data were analyzed using $\chi^2$ tests, and data with continuous variables were analyzed using Spearman $\rho$ coefficients. The paired Student $t$ test was used to detect differences between preoperative and postoperative outcome scores and pain scales. Inter-rater and intrarater reliability values were calculated for CC distances using intraclass correlation coefficients. The resulting inter-rater and intrarater intraclass correlation coefficients were classified as excellent (0.75 to 1.00), fair to good (0.41 to 0.74), or poor (0.00 to 0.40) according to the widely used grading scale originally developed by Fleiss.[28] Statistical significance was declared when $P < .05$.

## Results

### Demographic and Surgical Data

ACCR was performed in 31 male patients (31 shoulders) with a mean age of 43.9 years (range, 21 to 71 years; SD, 14.1 years). Table 1 summarizes the pertinent patient demographic characteristics, injury characteristics, and surgical variables. Of the 31 patients included in this study, 26 (83.9%) had minor concomitant intra-articular pathologies that were addressed during diagnostic arthroscopy. There were 18 minor chondral defects (58.1%; all were debrided), 16 small labral tears or SLAP tears (51.6%; 10 were debrided, 3 underwent biceps tenodesis, and 3 underwent suture anchor repair), and 4 small partial-thickness rotator cuff tears (12.9%; all were

**Table 2.** Summary of Preoperative and Postoperative Radiographic Data

| | Radiographic Data | | | |
|---|---|---|---|---|
| | Preoperative | | Postoperative | |
| Measurement | Injured | Uninjured | Injured | Uninjured |
| Mean intraclass correlation coefficient (95% CI)* | | | | |
| Inter-rater reliability (range) | 0.899 (0.790 to 0.959) | 0.722 (0.377 to 0.921) | 0.806 (0.656 to 0.921) | 0.666 (0.435 to 0.836) |
| Intrarater reliability (range) | 0.860 (0.717 to 0.934) | 0.857 (0.628 to 0.950) | 0.727 (0.510 to 0.856) | 0.486 (0.158 to 0.717) |
| Mean overall coracoclavicular distance, mm (range)† | 21.0 (10.6 to 31.9) | 9.3 (5.2 to 15.7) | 12.0 (3.3 to 25.0)‡ | 8.9 (5.9 to 12.4)‡ |
| Mean side-to-side difference, mm (range)† | 6.6 (−5.8 to 17.9) | | 2.3 (−6.1 to 14.7) | |

CI, confidence interval.

*The scale was as follows[28]: 0.00 to 0.40, poor; 0.41 to 0.74, fair to good; and 0.75 to 1.00, excellent.

†Calculated as injured shoulder minus uninjured shoulder.

‡Calculated from radiographs taken during last postoperative clinic visit.

**Table 3.** Summary of Revisions and Complications Encountered After Primary ACCR

| Age, yr | Initial Injury | Index Surgery* | Second Surgery | Time After Index Surgery, mo | Presenting Complaint | Diagnosis | Intervention |
|---|---|---|---|---|---|---|---|
| 39 | Grade III | Early, open ACCR | Revision ACCR | 13.3 | Insidious-onset posterior shoulder pain | Horizontal AC joint instability with impingement on scapular spine; graft was intact but significantly stretched | Revision ACCR with allograft looped around coracoid and tied over distal clavicle |
| 66 | Grade V | Delayed, open ACCR | Revision ACCR | 37.9 | Pain with external rotation and ski pole use after skiing fall | Recurrent superior AC joint instability | Revision ACCR and revision DCE; underwent re-revision ACCR and re-revision DCE because of inferiorly protruding PEEK screw and possible impingement on medial rotator cuff |
| 49 | Grade V | Early, open ACCR | Clavicle ORIF | 6.7 | Heard "pop," immediate pain/swelling over clavicle after lifting heavy object | Clavicle fracture through centromedial bone tunnel | Clinical union after nonoperative treatment; subsequent reinjury from fall occurred 3 mo later and required clavicle ORIF with plate, screws, and bone grafting |
| 21 | Grade III | Delayed, A-A ACCR | Clavicle ORIF | 8.4 | Pain/deformity of clavicle after snowboarding fall | Clavicle fracture through centromedial bone tunnel | Clavicle ORIF with plate, screws, and bone grafting |
| 39 | Grade V | Early, A-A ACCR | Revision DCE | 5.1 | Painful nodule deeply below healed incision over distal clavicle | Distal clavicle hypertrophy | Open revision DCE, distal claviculoplasty, excision of soft callus/hypertrophic bone |
| 42 | Grade V | Early, A-A ACCR | Revision DCE, hardware removal | 2.7 | Painful bump over distal clavicle | Distal clavicle exostosis, granuloma formation involving PDS sutures | Revision DCE, excision of granulomatous tissue, removal of PDS suture cable |
| 48 | Grade V | Early, A-A ACCR | LOA, hardware removal | 2.8 | Continued pain and gradually decreased ROM | Adhesive capsulitis, prominent suture material | MUA, LOA, posterior capsular release, removal of PDS suture cable |
| 65 | Grade V | Delayed, A-A ACCR | NA | 1.4 | Painless deformity over distal clavicle | Graft rupture and loss of AC joint reduction | Nonoperative management given normal function and lack of symptoms |

A-A, arthroscopically assisted; AC, acromioclavicular; ACCR, anatomic coracoclavicular reconstruction; DCE, distal clavicle excision; LOA, lysis of adhesions; MUA, manipulation under anesthesia; NA, not applicable; ORIF, open reduction−internal fixation; PDS, polydioxanone sulfate; PEEK, polyether ether ketone; ROM, range of motion.

*Non-irradiated 6-mm tibialis anterior allografts were used in all cases.

debrided). Subacromial decompression was performed in 22 patients (71.0%). Distal clavicle excisions were also performed in 30 patients (96.8%; median, 10 mm excised; range, 6 to 15 mm excised).

## Radiographic Data

Relevant preoperative and postoperative radiographic data were available for 25 of the 31 patients (80.6%) in this study. A summary of pertinent radiographic data is presented in Table 2. Inter-rater agreement was deemed excellent for the injured shoulder on both preoperative and postoperative radiographs. Intrarater agreement was deemed excellent for preoperative radiographs and fair to good for postoperative radiographs. Radiographic loss of reduction occurred in 3 of 25 patients (12.0%): 2 of these were found during routine postoperative clinic visits and were asymptomatic, whereas the third patient presented with symptom recurrence approximately 9 months after the index surgical procedure and eventually underwent revision ACCR. No cases of early graft stretch were identified radiographically. In 1 asymptomatic patient, late graft stretch was identified on a radiograph obtained 4.2 months postoperatively (increased CC distance of 7 mm [approximately 58% increased CC distance when compared with uninjured shoulder]); however, this remained stable on a subsequent radiograph obtained approximately 1.9 years later.

## Outcome Analyses

Table 3 summarizes the revisions and complications that occurred in 8 of the 31 patients (25.8%) after primary ACCR in this study. At 12 months and 33.7 months, 2 patients (6.5%) had a loss of reduction and required revision ACCR. At 3.6 months and 8.2 months postoperatively, 2 patients (6.5%) sustained distal clavicle fractures and required plate fixation. Each fracture occurred through the centromedial bone tunnel (Fig 3). Other minor complications occurred in 4 patients (12.9%). At approximately 1.4 months after the index surgical procedure, 1 additional patient (3.2%) presented with painless loss of AC joint reduction and mild cosmetic deformity. This patient was treated nonoperatively.

After exclusion of the 4 patients who underwent subsequent revision surgery or had a clavicle fracture postoperatively (12.9%), subjective outcome data were available for 22 of the remaining 27 patients (81.5%) after a mean follow-up period of 3.5 years (range, 2.0 to 6.2 years; SD, 12.5 months). Table 4 summarizes the preoperative and postoperative outcome scores and pain scales for these patients. Overall, the mean ASES and SF-12 scores, along with the medians for each of the pain scales, showed significant improvements when compared with the preoperative baseline values ($P < .05$). The mean SANE score, mean QuickDASH score, and median patient satisfaction rating were also excellent at final follow-up. Patients who underwent early reconstruction showed lower ASES scores and higher pain scores preoperatively when compared with those who underwent delayed reconstruction ($P < .05$); there were no significant differences in postoperative outcome scores or pain scales between these groups ($P > .05$) (Table 5).

## Discussion

After a mean 3.5-year follow-up period, patients who underwent primary ACCR with tendon allografts showed significant improvements in ASES scores, SF-12 PCS scores, and each of the pain scales when compared with the preoperative baseline values. The postoperative SANE and QuickDASH scores were also excellent, with a high median satisfaction rating of 9 of 10. Patients who underwent delayed reconstruction showed no significant differences in postoperative clinical or radiographic results compared with those

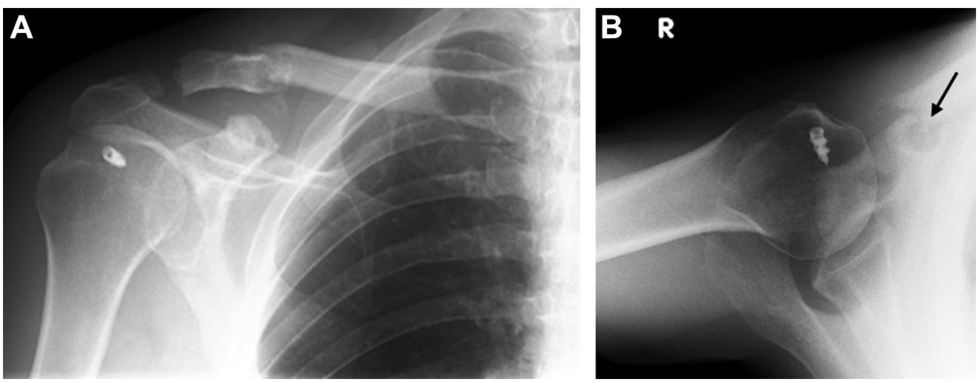


**Fig 3.** (A) Anteroposterior radiograph in a 49-year-old male patient who sustained a right clavicle fracture while lifting a moderately heavy object approximately 3.7 months after anatomic coracoclavicular ligament reconstruction with a 6-mm tibialis anterior allograft. (B) Axillary radiograph of same shoulder. One should note that the fracture line crosses through the previously placed 6-mm centromedial bone tunnel that was used for graft passage during the index surgical procedure (arrow). The humeral anchor in these images was used to repair a concomitant partial-thickness rotator cuff tear.

**Table 4.** Summary of Subjective Outcome Scores After Minimum 2-Year Follow-up Period (20 of 24 patients)

| | Preoperative | Postoperative | *P* Value |
|---|---|---|---|
| Outcome measures | | | |
| ASES score | 58.9 (27.3) | 93.8 (9.1) | < .001* |
| SF-12 PCS score | 45.1 (9.0) | 54.4 (6.6) | .007* |
| SANE score | — | 89.1 (13.6) | — |
| QuickDASH score | — | 5.6 (8.1) | — |
| Satisfaction† | — | 9 (5-10) | — |
| Pain scales‡ | | | |
| Pain today§ | 3 (0-10) | 0 (0-5) | .005* |
| Pain with sleep | 2 (0-3) | 0.5 (0-2) | < .001* |
| Pain with recreation | 3 (1-3) | 0 (0-3) | .001* |
| Pain with ADLs | 2 (0-3) | 0 (0-2) | < .001* |
| Pain with work | 2 (0-3) | 0 (0-2) | .001* |

NOTE. Data are presented as mean (standard deviation) unless otherwise noted.

ADLs, activities of daily living; ASES, American Shoulder and Elbow Surgeons; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, Short Form 12 Physical Component Summary.

*Statistically significant.

†Satisfaction data are presented as median (range). The scale ranged from 1, unsatisfied, to 10, completely satisfied.

‡Pain scale scores are presented as median (range). Unless otherwise noted, 0 indicates no pain; 1, mild pain; 2, moderate pain; and 3, severe pain.

§The pain today scale ranges from 0, no pain, to 10, maximal pain.

who underwent early ACCR. Complications occurred in 8 of the 31 patients (25.8%), including 3 cases with loss of reduction (9.7%), 2 clavicle fractures (6.5%), 2 cases of distal clavicle hypertrophy (6.5%), and 1 instance of painful hardware (3.2%).

Since the first description of ACCR in a case report by Jones et al.[29] in 2001, numerous studies have reported good to excellent clinical outcomes after ACCR with biological grafts (Table 6).[23,30-40] Nicholas et al.[30] and Tauber et al.[31] both reported mean postoperative ASES scores of 96 after mean follow-up periods of 2 years and 3 years, respectively. Moreover, Carofino and Mazzocca[23] reported excellent clinical results in 17 patients who were treated with ACCR with tendon allografts. In their study the mean ASES score improved from 52 preoperatively to 92 postoperatively after a mean follow-up period of 21 months. Several other authors have found similar results after ACCR with tendon grafts.[32-40] In our study the mean ASES score improved from 58.9 preoperatively to 93.8 postoperatively, with a high median patient satisfaction rating of 9 of 10.

Although excellent results and more rapid recovery can be achieved after surgical treatment for AC joint instability, high complication rates have hindered the enthusiasm for early operative management in patients with grade III dislocations. As a result, these patients are often treated nonoperatively, potentially leading to scapular dyskinesis,[41-44] subsequent rotator cuff tears,[45-49] and long-term functional

**Table 5.** Comparison of Preoperative Versus Postoperative Change in Outcome Scores and Pain Scales for Patients Who Underwent Early Versus Delayed Reconstruction

| | Early ACCR | Delayed ACCR | *P* Value |
|---|---|---|---|
| Outcome measures | | | |
| ASES score | | | |
| Preoperative | 36.8 (26.3) | 76.1 (12.7) | < .001* |
| Postoperative | 90.7 (13.2) | 96.1 (4.0) | .261 |
| SF-12 PCS score | | | |
| Preoperative | 44.4 (11.6) | 44.1 (6.1) | .806 |
| Postoperative | 58.5 (5.4) | 52.9 (7.1) | .209 |
| SANE score | | | |
| Preoperative | — | — | — |
| Postoperative | 82.7 (20.8) | 92.5 (6.2) | .268 |
| QuickDASH score | | | |
| Preoperative | — | — | — |
| Postoperative | 7.6 (11.6) | 4.1 (3.9) | .416 |
| Satisfaction† | | | |
| Preoperative | — | — | — |
| Postoperative | 10 (5-10) | 9 (7-10) | .292 |
| Pain scales‡ | | | |
| Pain today§ | | | |
| Preoperative | 6 (2-10) | 1 (0-3) | .004* |
| Postoperative | 0 (0-5) | 0 (0-1) | .635 |
| Pain with sleep | | | |
| Preoperative | 3 (1-3) | 2 (0-3) | .383 |
| Postoperative | 0 (0-2) | 1 (0-1) | .911 |
| Pain with recreation | | | |
| Preoperative | 3 (2-3) | 3 (1-3) | .378 |
| Postoperative | 0 (0-3) | 0.5 (0-2) | .783 |
| Pain with ADLs | | | |
| Preoperative | 3 (1-3) | 2 (0-3) | .006* |
| Postoperative | 0 (0-2) | 0 (0-1) | .520 |
| Pain with work | | | |
| Preoperative | 3 (1-3) | 1 (0-3) | .019* |
| Postoperative | 0 (0-2) | 0 (0-1) | .123 |

NOTE. Data are presented as mean (standard deviation) unless otherwise noted.

ACCR, anatomic coracoclavicular reconstruction; ADLs, activities of daily living; ASES, American Shoulder and Elbow Surgeons; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, Short Form 12 Physical Component Summary.

*Statistically significant.

†Satisfaction data are presented as median (range). The scale ranged from 1, unsatisfied, to 10, completely satisfied.

‡Pain scale scores are presented as median (range). Unless otherwise noted, 0 indicates no pain; 1, mild pain; 2, moderate pain; and 3, severe pain.

§The pain today scale ranges from 0, no pain, to 10, worst possible pain.

decline.[50] Therefore careful patient selection is necessary to balance the high rate of complications following AC reconstruction with the potential risks for long-term shoulder dysfunction after nonoperative treatment.

Among the 12 studies (including our study) that have reported on complications after ACCR with biological grafts (Table 5), the overall complication rate is 39.8% (103 of 259 patients). The most consequential of these complications included graft ruptures, hardware failure,

**Table 6.** Summary of Reported Outcomes and Complications After ACCR Using Biological Tendon Grafts

| Authors | Year | No. of Shoulders | Age, yr* | Acute/ Chronic | Technique | Revisions and Complications | Follow-up* | Preoperative Status | Postoperative Outcomes |
|---|---|---|---|---|---|---|---|---|---|
| Nicholas et al.[30] | 2007 | 9 | 41.4 (28-63) | NR | Open | NR | 23.7 mo (15-46 mo) | NR | ASES score: 96<br>SST score: 11.9 |
| Tauber et al.[31] | 2009 | 12 | 41.6 (24-58) | NR | Open | LOR (1): fall 2 wk postoperatively | 34.9 mo (24-44 mo) | ASES score: 74<br>Constant score: 71 | ASES score: 96<br>Constant score: 93 |
| Carofino and Mazzocca[23] | 2010 | 17 | 44 ± 14 | NR | Open | LOR (1)<br>Infection (1)<br>AC arthrosis (1) | 21 mo (6-61 mo) | ASES score: 52<br>SST score: 7.1<br>Constant score: 66.6 | ASES score: 92<br>SST score: 11.8<br>Constant score: 94.7<br>SANE score: 94.4 |
| Yoo et al.[32] | 2010 | 21 | 39.8 (18-70) | 17/4 | Open | Superficial infection (3) | 33 mo (18-47 mo) | NR | VAS pain rating: 1.9<br>Constant score: 84.7<br>UCLA score: 30.0 |
| Yoo et al.[33] | 2011 | 13 | 27.8 (18-41) | 13/0 | A-A | LOR (3) | 17 mo (12-26 mo) | VAS pain rating: 7.9<br>Constant score: 73.4 | VAS pain rating: 1.2<br>Constant score: 96.6 |
| Milewski et al.[34] | 2012 | 27 | 33.7 (19-54) | 9/18 | Open/A-A | LOR (7)<br>Clavicle fracture (3)<br>Coracoid fracture (2)<br>Other (2) | NA | NA | NA |
| Cook et al.[35] | 2012 | 10 | 25.9 (20-49) | NR | A-A | LOR (8): hardware failure (7) and coracoid fracture (1) | 9.7 mo | NR | Excellent: 5<br>Fair: 1<br>Poor: 4 |
| Cook et al.[36] | 2013 | 28 | 26.5 (19-40) | 5/23 | Open/A-A | LOR (8): all chronic injuries | Minimum 12 mo | NR | Return to military duty: 84% |
| Martetschläger et al.[37,†] | 2013 | 46 | 43.6 (18-71) | 31/26 | Open/A-A | LOR (7): 4 graft ruptures, 2 clavicle fractures, and 1 hardware failure<br>Other complications (6) | 2.4 yr (1.0-5.7 yr) | ASES score: 57.5<br>SF-12 PCS score: 45 | ASES score: 91<br>SF-12 PCS score: 56<br>SANE score: 89<br>QuickDASH score: 7<br>Satisfaction: 9 |
| Fauci et al.[38] | 2013 | 20 | 36 ± 4.3 | 0/20 | Open | LOR (7)<br>AC arthritis (12)<br>Clavicle osteolysis (13) | Minimum 4 yr | Constant score: 43.5 | Constant score: 94.2<br>UCLA score: 18.2<br>Satisfaction: 3.9 |
| Jensen et al.[39] | 2013 | 16 | 41.8 (21-60) | 0/16 | A-A, additional horizontal graft | Revision (2)<br>Hardware pain (10) | 13 mo (4-27 mo) | NR | Constant score: 84<br>VAS pain rating: 4.6<br>SST score: 9 |
| Mardani-Kivi et al.[40] | 2013 | 18 | 33.4 ± 11.2 | NR | Open, supplemental K-wire fixation | Pin-tract infection (10) | 25.7 mo (12-49 mo) | NR | Constant score: 92<br>VAS pain rating: 0 |

A-A, arthroscopically assisted; AC, acromioclavicular; ACCR, anatomic coracoclavicular reconstruction; ASES, American Shoulder and Elbow Surgeons; LOR, loss of reduction; NA, not applicable; NR, not reported; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, Short Form 12 Physical Component Summary; SST, Simple Shoulder Test; UCLA, University of California, Los Angeles; VAS, visual analog scale.

*Data are presented as mean (range) or mean ± standard deviation unless otherwise indicated.

†Postoperative outcome scores reported by Martetschläger et al. include 3 patients who underwent acromioclavicular joint fixation with cortical fixation buttons without graft reconstruction.

and fractures of the clavicle or coracoid through bone tunnels. Recently, several studies independently showed a significantly increased risk of fracture when large bone tunnels were created in the distal clavicle or coracoid to allow for graft passage.[51-55] Specifically, clavicular bone tunnels of 5 mm or greater in diameter and coracoid bone tunnels of 4 mm or greater in diameter were associated with bony failure. As a result, many surgeons have begun to prepare the distal clavicle and coracoid using bone tunnels with smaller diameters to decrease the risk of fractures. However, this method also necessitates the use of grafts with smaller diameters, potentially increasing the risk of graft rupture, hardware failure, and loss of reduction.

To reduce the risk of clavicle and coracoid fractures, the senior author (P.J.M.) now prefers to loop the allograft around both the coracoid base and distal clavicle, thus avoiding the use of bone tunnels altogether for the purposes of graft passage.[56,57] This method also allows for the passage of a larger graft when increased fixation strength is necessary without compromising the strength of the distal clavicle. The graft is tied in an overhand configuration over the top of the clavicle, and high-strength sutures are placed through the tendon knot to provide additional graft security. In addition, 2 cortical fixation buttons with 4 limbs of suture tape are secured through a single 3-mm tunnel placed through the distal clavicle and the coracoid base to maintain AC joint reduction during the process of graft incorporation. These 3-mm tunnels did not result in a significant change in clavicular load to failure when compared with the intact state in a recent study performed by Spiegl et al.[51] To date, we have not observed any fractures of the clavicle or coracoid more than 2 years after the implementation of this modified technique.

### Limitations

This study has several limitations. First, the ability to compare our results with other published studies is difficult because of widely varying techniques and outcome measures. Second, the outcome measures reported (ASES, QuickDASH, SF-12 PCS, and SANE scores) have not been formally validated for use in AC joint injuries, although they have been widely and commonly used in the literature.[23,30,31,37] Third, because of the limited sample size and retrospective design of this study, our results may have been affected by selection bias. Fourth, the delineation between patients who underwent early ACCR and those who underwent delayed ACCR was based only on the number of days between the date of injury and the date of surgery and did not necessarily reflect the senior surgeon's recommendations at the time of consultation. Therefore those who underwent delayed reconstruction may have been candidates for early reconstruction had they presented to the clinic at an earlier time point.

## Conclusions

Patients who did not require revision surgery showed excellent postoperative outcome scores: The mean ASES score was 93.8, the mean SANE score was 89.1, and the mean QuickDASH score was 5.6, with a median patient satisfaction rating of 9 of 10. Further study regarding ACCR techniques should focus on decreasing the risks of complications and maintaining reduction of the AC joint.

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