Original Article

Better Radiographic Reduction and Lower Complication Rates With Combined Coracoclavicular and Acromioclavicular Ligament Reconstruction Than With Isolated Coracoclavicular Reconstruction

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Purpose: To determine whether combined acromioclavicular (AC) ligament reconstruction and coracoclavicular (CC) ligament reconstruction without bone tunnels would improve radiographic reduction maintenance and complication rates for type III to V AC dislocations. **Methods:** This single-institution retrospective study analyzed all patients who underwent a hybrid synthetic/graft wrap CC reconstruction without tunnels with additional AC reconstruction/repair from January 2013 to August 2019. This 26-patient cohort was compared with a 1:1 sex- and age-matched control group who underwent CC reconstruction without AC reconstruction. CC distances on postoperative radiographs were compared with normal contralateral shoulders. **Results:** Of the 93 patients who underwent AC reconstructive surgery during this time period, 26 patients (96% male) met the inclusion criteria. The AC/CC cohort had 23.5% type III injuries, 23.1% type IV injuries, and 53.8% type V injuries, similar to the control group. Final radiographs of the operative shoulder's CC distance were (mean ± standard deviation) 0.9 ± 4.0 mm greater than that of the contralateral shoulder (9.6 ± 8.7 mm) in the AC/CC cohort. Final radiographs of the operative shoulder's coracoclavicular distance were 4.0 ± 4.7 mm greater than that of the contralateral shoulder (13.3 ± 9.3 mm) in the CC control group, a significant difference ($P = .014$). The AC/CC reconstruction group had fewer patients with a loss of reduction >5 mm (11.5% versus 38.5%, $P = .025$). The complication rate in the CC control group was higher than in the AC/CC cohort (30.7% versus 7.7%, $P = .035$). The reoperation rate was also greater in the CC control group (8 versus 1, $P = .010$). **Conclusion:** This cohort study shows that the addition of AC reconstruction to CC reconstruction using synthetic tapes/grafts or allograft tissues without bone tunnels significantly improves durable radiographic outcomes, diminishes complication rates, and improves reoperation rates. **Level of Evidence:** III, retrospective comparative study.

Acromioclavicular (AC) dislocation continues to confound the orthopedic community as a notoriously difficult injury to treat with or without surgery. The Rockwood classification remains central to communication and treatment determination regarding this injury. Type I, II, and often III injuries are managed conservatively, and type IV, V, and VI injuries (with some type III injuries) are mostly managed operatively.[1] Controversy continues for all aspects of care, including operative versus nonoperative decisions, surgical timing and technique, rehabilitation and return to sport, need for concomitant surgery, etc.

Regarding type III, IV, and even V injuries, some studies have found no advantage of operative management in physical and mental health 2 years after injury.[2-5] However, other studies have shown significant health improvement at 2-year follow-up with surgery versus conservative management.[6] Although nonoperative treatment avoids the potential complications inherent to surgery, persistent pain, functional limitation, and scapular dyskinesis with its associated symptoms occurs in >70% of patients treated conservatively.[7]

Historically, AC joint injuries have been treated with >150 surgical variations, including Weaver-Dunn reconstruction, suture fixation, screw fixation, hook plate fixation, tendon allograft/autograft reconstruction, synthetic graft fixation, etc., focused on reconstruction of the coracoclavicular (CC) ligaments.[8-11] However, recurrent dynamic anterior/posterior translation occurs in nearly half of patients after isolated CC reconstruction.[12,13] Combined AC/CC ligament reconstruction has been advocated to improve shoulder girdle kinematics and maintain stability better than isolated CC reconstruction.[14,15]

One institution previously reported on its experience with surgical management of acute and chronic AC dislocations using isolated CC reconstruction techniques, citing a notable 30% overall complication rate and a 22% loss of reduction rate, roughly 20% of those complications being fractures in either the clavicle or coracoid.[16] Since that time, combined AC/CC ligament reconstruction open techniques that avoid both coracoid and clavicle tunnels have become our preferred surgical approach. We sought to determine whether combined AC ligament reconstruction and CC ligament reconstruction without bone tunnels would improve radiographic reduction maintenance and complication rates for type III to V AC dislocations. We hypothesized that the combined AC/CC reconstruction would improve radiographic reduction and decrease postoperative complications.
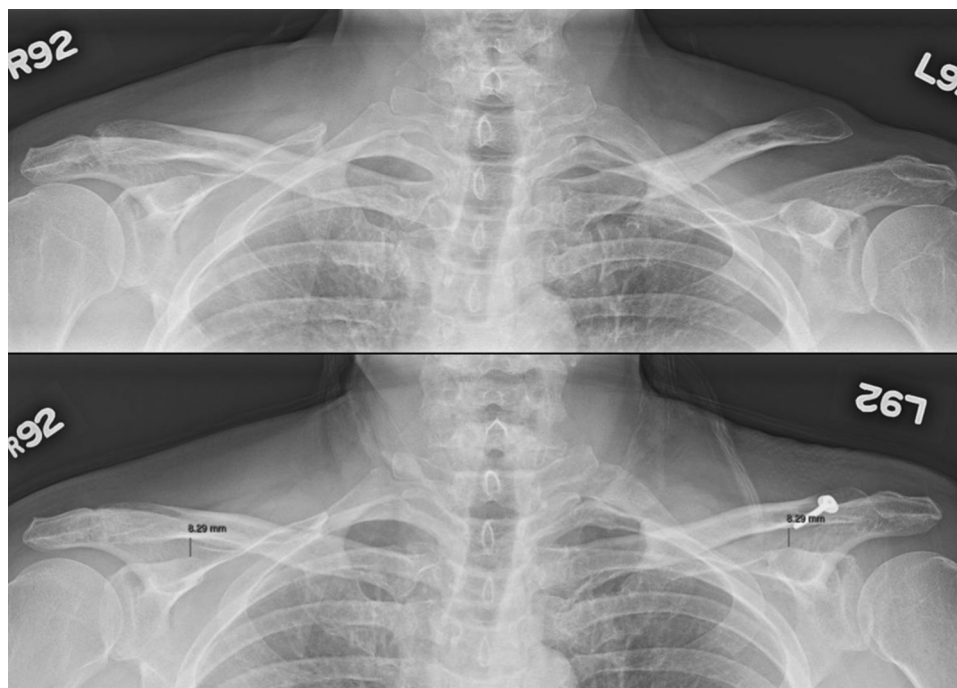
Methods

This study (institutional review board approval HSR # 21984) involved a retrospective review at a single institution of all operations for an acute or chronic closed AC dislocation using CC ligament reconstruction with or without AC ligament reconstruction from January 2013 to August 2019 using Current Procedural Terminology codes 23550 (open treatment of acromioclavicular dislocation, acute or chronic) or 23552 (open treatment of acromioclavicular dislocation, acute or chronic; with fascial graft [includes obtaining graft]). Inclusion criteria were skeletal maturity, preoperative and postoperative radiographic evidence of injury and reconstruction with inclusion of the contralateral shoulder for comparison, and specific documentation of reconstruction of both the CC and AC ligaments in the operative report. Patients undergoing concomitant procedures or revision AC/CC reconstruction were not excluded as long as the reconstruction met appropriate technique criteria. Surgeries for both acute (<6 weeks from injury) and chronic (≥6 weeks from injury) AC dislocations were included. An age- and sex-matched control group was established in a 1:1 ratio from patients who underwent isolated CC reconstruction without additional AC reconstruction at our institution. Each patient was matched within 3 years of the corresponding study patient's age.

The CC distance measurement based on a standing anteroposterior (AP) Zanca shoulder/bilateral AC joint radiograph was used to determine postoperative displacement/loss of reduction compared with the contralateral normal distance (Fig 1). Measurements were made from the superior coracoid in a vertical line to the inferior clavicle using our institution's digital picture archiving and communication system according to standard validated technique by an orthopedic surgery sports medicine fellow not involved in the care of these patients.[17] Complications and reoperations were determined based on chart review.

Several reconstructive methods were used during this study. For the study cohort, 2 surgeons (B.C.W. and S.F.B.) performed a hybrid synthetic graft plus autograft/allograft tendon open CC reconstruction procedure using either a synthetic graft/screw construct (Lockdown™, Worcestershire, UK) or a novel Fibertape™ (Arthrex, Naples, FL) construct with dual tapes using a luggage tag configuration wrapped around the coracoid and stabilized with a DogBone™ (Arthrex) superior to the clavicle (Fig 2). No coracoid drill holes were used. Semitendinosus or gracilis allograft (LifeNet Health, Virginia Beach, VA), wrapped around the coracoid and tied down over the clavicle, was used for 21 of 26 patients (81%) as additional fixation. The remaining 5 patients had semitendinosus autograft harvested from the ipsilateral leg for the procedure in similar fashion. No drill holes were used in the clavicle for graft placement; graft tissue was wrapped around the coracoid and the clavicle and secured with suture fixation. The remaining limbs of graft tissue were then pulled over and secured to the superior AC ligaments, which were previously dissected free, or secured to the superior acromion with a suture anchor (2.9-mm Pushlock biocomposite anchor; Arthrex) for AC ligament reconstruction (Fig 3). Distal clavicle excision was performed per surgeon's discretion based on the reducibility of the joint. Layered closure was performed with a secure deltotrapezial fascial closure. Postoperatively, a sling was worn for 6 weeks, and then gradual rehabilitation was performed with a goal of return to activities by 4 to 6 months.

Fig 1. (A) Preoperative upright bilateral standing anteroposterior (AP) acromioclavicular (AC) joint radiograph showing a left type V AC dislocation. (B) Postoperative upright bilateral standing AP AC joint radiograph showing appropriate reduction of left AC joint after combined hybrid coracoclavicular (CC) reconstruction using a Lockdown device with AC reconstruction with both left and right CC distances of 8.3 mm.

The control group consisted of multiple methods of CC reconstruction, including isolated synthetic graft (Lockdown), semitendinosus allograft/autograft reconstruction with drill tunnels through the clavicle, suspension button reconstruction, and allograft CC reconstruction augmented with hook plate fixation, that were performed during the same time period. Six surgeons (including B.C.W. and S.F.B.) at our institution performed the operations in this control group. No AC-specific reconstruction was performed for any patient in the control group. Layered closure and postoperative rehabilitation were performed similarly to the study group's methods. Routine hook plate hardware removal was not considered a reoperation.

Statistical analysis was performed using SPSS software (release 2017; IBM SPSS Statistics for Windows, version 25.0. IBM Corp., Armonk, NY). Chi-squared analysis or Fisher exact testing was performed for all comparisons as required for the data. P values $<.05$ were considered significant. A post hoc analysis showed 61.9% power.

Results

A total of 93 patients underwent open treatment for an acromioclavicular dislocation during the study period from January 2013 through August 2019. Sixty-seven patients underwent isolated CC reconstruction without the addition of AC reconstruction and were excluded. Twenty-six patients met all inclusion criteria and were included in our AC/CC reconstruction cohort. Age and sex matching were performed in a 1:1 fashion

to create an isolated CC reconstruction control group consisting of 26 patients who underwent surgery during the same time period. Each group's mean follow-up time was 6 months (range 6 weeks to 2.5 years).

Regarding demographics, the mean ages of each patient group were nearly identical (AC/CC cohort mean $\pm$ standard deviation, 36.5 ± 15.8 years versus CC control, 36.5 ± 16.3 year, $P = 1.000$). The vast majority of patients in each group were male (96.2% in AC/CC and 92.3% in CC control, $P = .552$). The mean body mass index (BMI) of the AC/CC cohort was lower than that of the CC control group (24.6 ± 2.9 kg/m^2 versus 27.2 ± 4.5 kg/m^2, $P = .017$). Operations involving the dominant arm were similar between groups (53.8% in AC/CC cohort versus 42.3% in CC control group, $P = .405$). Active tobacco smokers made up 11.5% of the AC/CC cohort and 34.6% of the CC control group, but the difference was not significant ($P = .071$) (Table 1).

Describing injuries, there were no significant differences regarding the specific Rockwood classification types between groups. There were 6 type III injuries (23.1%), 6 type IV injuries (23.1%), and 14 type V injuries (53.8%) in the AC/CC cohort. There were 4 type III injuries (15.4%), 4 type IV injuries (15.4%), and 18 type V injuries (69.2%) in the control group. No significant differences were seen in the proportion of acute versus chronic injuries in each group. There were 10 acute injuries (38.5%) treated surgically in the AC/CC cohort, and there were 13 acute injuries (50.0%) treated surgically in the CC control group ($P = .402$). Similar rates of concomitant arthroscopic procedures
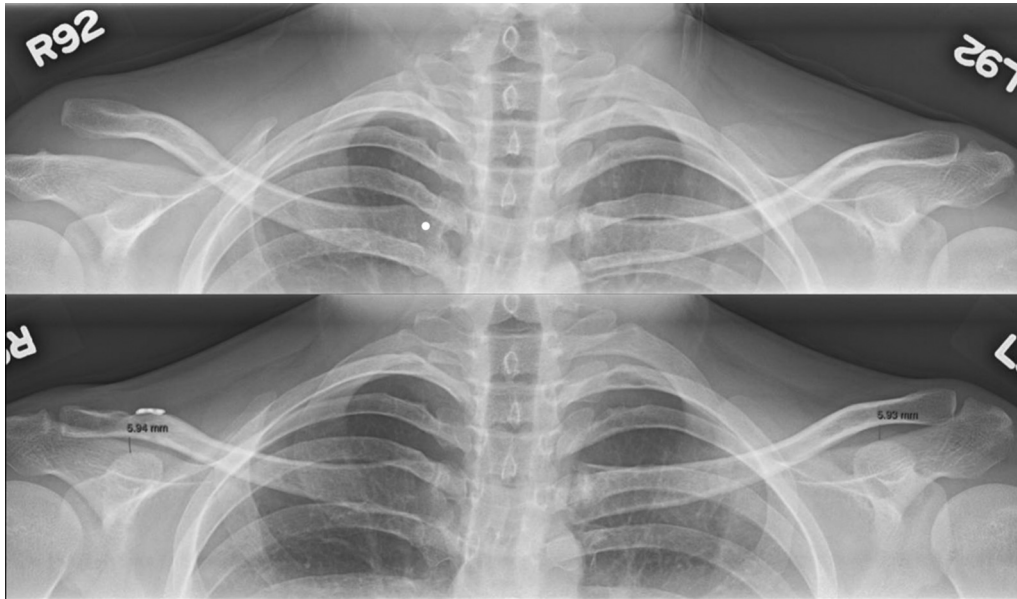
Fig 2. (A) Preoperative upright bilateral standing anteroposterior (AP) acromioclavicular (AC) joint radiograph showing a right type V AC dislocation. (B) Postoperative upright bilateral standing AP AC joint radiograph showing appropriate reduction of right AC joint after combined hybrid coracoclavicular (CC) reconstruction using double Fibertape plus Dogbone fixation with AC reconstruction with both left and right CC distances of 5.9 mm.

including rotator cuff repair, biceps tenodesis, and labral repair were performed in each group (Table 1).

Considering outcomes, final radiographs of the operative shoulder's CC distance were 0.9 ± 4.0 mm greater than the CC distance of the contralateral shoulder (9.6 versus 8.7 mm) in the AC/CC cohort. Final radiographs of the operative shoulder's CC distance were 4.0 ± 4.7 mm greater than the CC distance of the contralateral shoulder (13.3 versus 9.3 mm) in the CC control group, significantly greater than the difference in the AC/CC cohort ($P = .014$). Three patients (11.5%) in the study cohort had a loss of reduction >5 mm, whereas 10 patients (38.5%) in the control group had such a loss in reduction ($P = .025$). There were fewer complications in the AC/CC cohort than in the CC control group (2 versus 8, $P = .035$). The complications in the AC/CC cohort were a clavicle fracture in a ski accident 7 weeks postoperatively and 1 coracoid partial osteolysis that occurred from a prominent Lockdown screw in the clavicle. CC control group complications included acute loss of fixation in 2 patients, significant distal clavicle osteolysis leading to loss of fixation, postoperative wound infection, postoperative adhesive capsulitis of the shoulder in 2 patients, clavicle fracture, and a coracoid fracture. The reoperation rate was also greater in the CC control group than in the AC/CC cohort (8 versus 1, $P = .010$) (Table 2). The only reoperation in the AC/CC cohort was a Lockdown screw removal; notably, this patient had maintenance of reduction before and after hardware removal. Reoperations in the CC control group included a CC ligament reconstruction with hook plate

augmentation, clavicle open reduction/internal fixation (ORIF) with autograft and subsequent bone grafting revision, wound debridement and irrigation, shoulder arthroscopic lysis of adhesions and manipulation in 2 patients, clavicle ORIF, and coracoid ORIF. Routine planned hardware removals for hook plates (n = 6) were not considered reoperations related to complications and thus were not included in this analysis.

Discussion

The most important findings of this study were that combined AC and CC reconstruction better maintained radiographic reduction, with significantly decreased
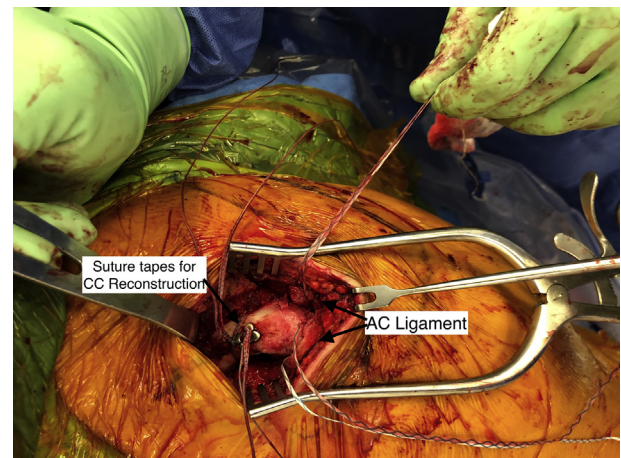
Fig 3. Dissection of acromioclavicular (AC) ligaments in preparation for AC reconstruction with suture anchor incorporating graft limbs.

Table 1. Study cohort and matched control demographics and characteristics

Variable	CC/AC Study Cohort (n = 26)	CC Control Cohort (n = 26)	Statistical Comparison (*P* Value)
Demographics			
Age (y)	36.5 ± 15.8	36.5 ± 16.3	1.000
BMI (kg/m^2)	24.6 ± 2.9	27.2 ± 4.5	.017
Male sex	25 (96.2)	24 (92.3)	.552
Dominant arm	14 (53.8)	11 (42.3)	.405
Nonsmoker	21 (80.8)	15 (57.7)	.071
Rockwood classification			
Type III	6 (23.1)	4 (15.4)	.482
Type IV	6 (23.1)	4 (15.4)	.482
Type V	14 (53.8)	18 (69.2)	.254
Chronicity			
Acute	10 (38.5)	13 (50.0)	.402
Chronic	16 (61.5)	13 (50.0)	
Concomitant procedures			
Rotator cuff repair	3 (11.5)	3 (11.5)	1.000
Biceps tenodesis	4 (15.4)	5 (19.2)	.714
Arthroscopic labral repair	5 (19.2)	1 (3.8)	.083

Data are mean ± SD or n (%).

AC, acromioclavicular; BMI, body mass index; CC, coracoclavicular.

rates of complications and reoperations compared with a CC reconstruction control group that did not include AC reconstruction for the treatment of type III to V AC dislocations. These findings suggest that combined AC/CC reconstruction may provide improved stability for this difficult injury.

Historically, many surgeons have debated the merits of nonoperative and operative treatment using various techniques for type III to V AC dislocations. A meta-analysis comparing operative to nonoperative treatment showed minimal functional differences, although cosmesis and radiographic reduction favored surgery whereas earlier return to work and lower complication rates favored nonoperative management.[18] A randomized clinical trial between nonoperative management and hook plate application for AC dislocation types III to V showed better radiographic reduction in the operative group but worse early clinical scores and more complications.[19] However, specific rehabilitation

is recommended to overcome the scapular dyskinesis that can result from AC dislocations. Although it typically resolves within 6 to 12 weeks, AC dislocation-associated scapular dyskinesis can take up to 12 months to resolve.[20] One systematic review has shown a return to sport rate of 94% to 100% after operative treatment, which is an improvement from the 83% to 94% rate of return to sport seen with conservative management.[21]

When surgery is indicated based on shared physical/patient decision making, it is important to limit negative outcomes. Because 77% of patients with type V injuries treated nonoperatively can return to work and activities, it is the surgeon's duty to avoid complications that could worsen the final result.[22] One study of isolated CC reconstruction cited a 94.5% return to work rate but noted an 18.5% revision rate and a 34.6% rate of persistent symptoms.[23] Postoperative complication rates >20% and loss of reduction rates >30% have

Table 2. Radiographic outcomes and complications

Variable	CC/AC Study Cohort (n = 26)	CC Control Cohort (n = 26)	Statistical Comparison (*P* Value)
Radiographic			
Final CC distance difference from contralateral (mm)	0.9 ± 4.0	4.0 ± 4.7	.014
Complications			
Overall	2 (7.7)	8 (30.8)	.035
Reoperation	1 (3.8)	8 (30.8)	.010
Revision CC ligament	0 (0.0)	2 (7.7)	.149
Hardware removal	1 (3.8)	5 (19.2)	.083
Infection/incision and drainage	0 (0.0)	1 (3.8)	.313
Adhesive capsulitis	0 (0.0)	2 (7.7)	.149
Fracture	1 (3.8)	2 (7.7)	.552

Data are mean ± SD or n (%).

AC, acromioclavicular; CC, coracoclavicular.

been found in multiple studies.[24,25] One meta-analysis showed an overall loss of reduction rate of 20.8% and complication rate of 14.2% with a revision rate of 9.5%.[11] Surgical complications include infection, loss of reduction, suture breakage with button migration, graft stretch, clavicular osteolysis, hardware pullout, adhesive capsulitis, and neuropathy.[26,27] Fractures of the clavicle or coracoid account for 5% to 20% of these complications, so we avoid tunnels altogether, opting for a graft wrapped around the clavicle and coracoid similar to Millett et al.[28-30] The clavicle fracture in the study group was suffered by a patient who engaged in sport activities early against medical advice. We believe that tunnel avoidance in the AC/CC cohort was key to limiting the major fracture complications seen in our control group that did include such drilling techniques.

Our understanding continues to improve of the spectrum of AC dislocation pathology. The Acromioclavicular Joint Instability Score (ACJI) is a recent classification that uses Alexander views of the shoulder to capture dynamic horizontal instability in addition to the vertical instability noted on standard bilateral standing AP AC joint views.[31] A Rockwood type III injury subclassification considers a type IIIA to be stable and IIIB to be unstable based on the presence or absence of an overriding distal clavicle with cross-arm adduction AP shoulder radiographs.[32] The posterior translation test, which evaluates the amount of posterior shift of the distal clavicle compared with the contralateral AC joint, also suggests horizontal instability.[33] Because the AC ligaments are key to horizontal stability, these studies suggest that AC ligament reconstruction in addition to CC ligament reconstruction may improve stability and outcomes.

Although 1 biomechanical study failed to show improved fixation with additional AC joint reconstruction, most studies have shown greater horizontal and vertical stability plus decreased stress on the CC fixation.[14,32,34,35] Using arthroscopically assisted continuous loop fixation, combined AC/CC fixation has shown decreased rates of dynamic posterior translation compared with isolated CC fixation.[12] A semitendinosus autograft weave technique to reconstruct the CC and AC ligaments has shown promising outcomes as well.[33] Similar to our study, Tauber et al.[36] found that AC/CC reconstruction with a triple-bundle technique had a lower complication rate than the isolated CC single-bundle reconstruction (16.7% versus 35.7%). Beitzel et al.[14] showed that suturing 1 excess limb of the CC reconstruction allograft anteriorly, posteriorly, and superiorly around the AC joint best limited translation in the horizontal and vertical planes when comparing AC reconstruction techniques.

Related to postoperative outcomes, glenohumeral joint pathology has been found in 15% to 53% of patients who suffer type III to V AC dislocations.[37-40] We

therefore obtain magnetic resonance imaging (MRI) preoperatively of our AC dislocation patients and perform diagnostic arthroscopy before open AC/CC reconstruction if any doubt exists for rotator cuff injury, biceps/SLAP injury, etc., to address all pathology of the shoulder girdle. There were no significant differences in intra-articular pathology or arthroscopic concomitant procedures between groups in this study.

Operative timing and its relationship to graft use is another area of debate for AC dislocations. Although tendon graft CC reconstruction is generally accepted for chronic AC dislocation treatment, acute treatment with a graft may or may not be beneficial with regard to loss of reduction. One group showed that graft reconstructions had a 42% displacement rate, whereas continuous loop button constructs without a graft had a 23% displacement rate.[10] Although some biomechanical studies suggest that such loop button CC reconstruction techniques decrease translation of the AC joint compared with coracoid graft sling techniques, the testing frames are unable to recreate all of the muscle forces and fascial healing associated with clinical healing and rehabilitation environments.[41] Another group showed a 47% loss of reduction rate with a 20% complication rate for acute AC dislocations treated with autograft tendon CC reconstruction using a single tunnel, believed to be due to elongation of the graft tissue.[28] Based on these studies, our hybrid techniques set the CC fixation length with inelastic suture tape or synthetic graft and use graft tissue as backup fixation to incorporate collagen for ultimate tissue healing, limiting elongation concerns.

Multiple techniques were used for our control group, including CC reconstruction with graft. However, a systematic review has shown no complication rate or failure rate differences between ligament/tendon transfers such as Weaver-Dunn, autograft/allograft CC reconstruction, and synthetic CC reconstruction grafts.[8] Hook plate fixation was used as backup fixation to CC reconstructions using allograft tissue for some in our control group. Such extra fixation would be expected to improve overall reduction maintenance in this group, thus strengthening the study findings. No complications were noted related to hook plates. Routine hook plate removal was not included as part of our reoperation rate for the control group.

Limitations

Limitations do exist for this study. This retrospective review has bias risks inherent to such work, including limited power. Our operative cohort included patients from 2 surgeons, but patients from 6 surgeons were included in the control group. Although this diversity may limit comparability, we believe that this increases the generalizability of our findings. We created as homogeneous a study group as possible, including only

those patients who specifically underwent a strong repair or reconstruction of the AC ligament tissues in addition to stable hybrid CC reconstruction without bone tunnels. Our follow-up time period is variable, but this represents orthopaedic practice in the real-world setting. Some of these limitations exist because surgical treatment of AC dislocations is relatively uncommon, as evidenced by our small study groups in a group of subspecialty sports medicine surgeons in a high-volume tertiary practice setting. We included both acute and chronic AC dislocations in this study, but there were no significant overall treatment timing differences between the matched groups. Despite the statistically significant difference in BMI between groups, we do not believe that a difference of 2.6 within a healthy BMI range is clinically meaningful. Also, a wide range of age was evident for the patients in this study. However, all patients were symptomatic from their AC dislocation and desired to return to activity and/or work.

Conclusion

This study shows that the addition of AC reconstruction to CC reconstruction using synthetic tapes/grafts and/or allograft tissues without bone tunnels significantly improves durable radiographic outcomes, diminishes complication rates, and improves reoperation rates.

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