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Clinical and radiographic outcomes following anatomic coracoclavicular ligament reconstruction using 4-strand taped suspensory fixation in an active-duty military population

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Background: Acromioclavicular (AC) joint injuries are common in young, active populations. However, there is a paucity of literature reporting surgical outcomes following the treatment of AC joint injuries in the military population. Therefore, the purpose of this study was to evaluate the clinical and radiographic outcomes of active-duty military members who underwent arthroscopic-assisted anatomic coracoclavicular ligament reconstruction using a 4-strand suspensory fixation with taped sutures for treatment of high-grade AC joint injuries with a minimum 1-year follow-up.

Methods: A retrospective review was performed on all patients with Rockwood grade IIIB-V AC joint separations who underwent anatomic coracoclavicular ligament reconstruction using a 4-strand suspensory fixation with taped sutures at a single military treatment facility between January 2015 and May 2022. Clinical outcome measures included the Single-Assessment Numerical Evaluation (SANE) score and patient satisfaction using the Likert Scale. Radiographic outcomes were measured by classifying the amount of residual AC joint separation on postoperative radiographs utilizing the Rockwood classification.

Results: Coracoclavicular ligament reconstruction a using 4-strand suspensory fixation with taped sutures was performed in 15 consecutive patients, all of which were active-duty military males with a mean age of 35.8 years. Preoperatively, there were 10 patients with grade IIIB injuries, 1 patient with a grade IV injury, and 4 patients with grade V injuries. The average preoperative SANE score was 40.0. The average length of time from injury to surgery was 46.5 weeks. Patient-reported outcomes were available for 12 of the 15 patients (80%) at an average of 4.9 years postoperatively with an average postoperative SANE score of 77.1 ($P = .0002$); 11 of these 12 patients (92%) reported they were either satisfied or extremely satisfied with the outcome of the surgery. Postoperative radiographs were available for 14 of the 15 patients (93%) at an average of 2.7 years postoperatively revealing 13 patients had maintained grade I reduction while 1 patient had a grade III separation.

Conclusion: Coracoclavicular ligament reconstruction a using 4-strand suspensory fixation with taped sutures resulted in significantly improved radiographic and patient-reported outcomes in this retrospective review of active-duty military members with grade IIIB-V AC joint separations.

Acromioclavicular (AC) joint injuries are among the most common injuries to the shoulder girdle in young, active populations.[6,20,27] This is especially true in contact-sport athletes and active-duty military members.[8,9,15,23] These injuries are commonly classified according to the Rockwood classification system, with low-grade injuries (I and II) usually being managed nonoperatively and high-grade injuries (IV-VI) often requiring surgical intervention.[7,21,26] There remains debate regarding the most appropriate management of grade III injuries with multiple studies showing acceptable outcomes with both operative and nonoperative treatment. There is a subcategorization of type III injuries, which takes into account horizontal instability. Type IIIB injuries are unstable in

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Department of Clinical Investigations Institutional Review Board at Madigan Army Medical Center approved this study as IRB exempt (Protocol: 223006).

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the axial (horizontal) plane and do poorly with nonoperative management.[2,8,11,25]

There have been many described surgical techniques for repair of AC joint separations. Historical techniques include K-wires, screws, and plates for temporary fixation of the AC joint.[17] More modern procedures aim at anatomic reconstruction of the coracoclavicular (CC) ligaments using bone tunnels and suspensory fixation with or without the use of allograft augmentation, first described by LaPrade and Hilger as a treatment for a previously failed AC joint surgery.[1,12,14] Recent studies have also reported positive clinical and radiographic outcomes following primary repair of high-grade, including grade III, AC joint injuries with arthroscopic-assisted reconstructive procedures.[5,16] A systematic review by Moatshe et al evaluated the clinical and radiographic outcomes following surgical treatment of AC joint injuries with either CC ligament reconstruction with a free tendon graft, suspensory devices, synthetic ligament devices, CC ligament transfer, hook plates or K-wires.[17] They found the reported surgical techniques had comparable outcomes with low rates of reoperation; however, hook plates and Kirschner-wires were associated the higher complication rates, and CC ligament transfer had the highest rate of unplanned reoperation. Although there have been studies showing good clinical outcomes following repair of high-grade AC joint injuries with this surgical technique[5,16]; there is concern that the reduction is often lost with suspensory fixation techniques. Of note, there is a paucity of literature reporting surgical outcomes following the treatment of AC joint injuries in active military populations, with unique functional demands.

The purpose of this study is to report the clinical and radiographic outcomes following arthroscopic-assisted anatomic CC ligament reconstruction using a 4-strand suspensory fixation with taped sutures for the treatment of high-grade (IIIB-V) AC joint separations in an active-duty military population. We believe this study will add valuable information to the recent literature regarding the surgical treatment of AC joint injuries using reconstructive techniques, with the goal of optimizing the management of these injuries in high-demand athletic and military populations. Our hypothesis is that patients will maintain radiographic reduction of the AC joint, and report improved patient reported outcome at a minimum follow-up of 1 year.

Materials and methods

After obtaining institutional review board approval, a retrospective review of patients from 2015 to 2022 who underwent an arthroscopically assisted anatomic CC ligament reconstruction using 4-strand suspensory fixation with taped sutures by the senior author was performed. Records were reviewed for age, gender, chronicity, and Single-Assessment Numerical Evaluation (SANE) scores. The operative report was reviewed to verify surgical technique. All patients were contacted via telephone or email to collect patient-reported outcome measures (PROMs) including SANE scores and Likert scale. The primary outcome was radiographic maintenance of reduction. Postoperative maintenance of reduction was measured by the senior author on shoulder, AC or chest X-rays. The secondary outcomes were the postoperative SANE score, need for revision surgery, and patient satisfaction using the Likert scale.

Surgical technique

All patients underwent CC ligament reconstruction using 4-strand suspensory fixation with taped sutures. The patient is placed in the beach-chair position and a 4-6 cm incision over the distal clavicle and AC joint is created. A subperiosteal peel of the trapezial and pectoralis attachments is performed to expose the AC joint. All residual scar blocking reduction is removed, but the bony architecture is not changed. Once manual anatomic reduction of the AC joint is achievable, a diagnostic arthroscopy is performed. To facilitate a more direct approach to the subcoracoid space, a laterally based anterior portal is created. The rotator interval is opened, and the undersurface of the coracoid is exposed.

With the AC joint anatomically reduced, a CC drill guide is used to drill a 3.5-mm quadricortical tunnel through the clavicle and coracoid. A 4-strand tape construct is passed through the osseous tunnel to hold the AC joint and CC interval reduced. Proximally and distally, the 4 strands are secured with metallic buttons. For the reconstruction, a soft tissue allograft is wrapped around the coracoid and tied over the clavicle. Finally, the trapezial and pectoral attachments on the clavicle are repaired in a pant-over-vest configuration, thereby creating another layer of stability over the AC joint.

Table I
Cohort characteristics.

	N = 15
Age (yr)	
Mean (SD)	35.8 (8.13)
Time to surgery (Weeks)	
Mean (SD)	46.5 (48.0)
Preoperative rockwood classification	
IIIB	10 (66.7%)
IV	1 (6.7%)
V	4 (26.7%)
Radiographic follow-up (Mo)	
Mean (SD)	32.6 (28.9)
Postoperative rockwood classification	
I	13 (92.9%)
III	1 (7.1%)

SD, standard deviation; *IRB*, Institutional Review Board.

Postoperative management

All patients are strictly immobilized in a sling for 6 weeks following surgery, with no physical therapy and no active or passive range of motion. After 6 weeks, progressive range of motion and physical therapy are initiated. Strengthening exercises are implemented at 3 months followed by clearance for full activities as early as 6 months postoperatively.

Analysis

Maintenance of AC joint reduction was assessed by the senior author with postoperative radiographs, a maintained reduction was determined by the presence of a Rockwood grade I reduction whereas grade III or more was considered a loss of reduction. Statistical analysis was performed using Microsoft Excel. An unpaired, nonparametric t-test was used to compare preoperative and postoperative SANE scores. Statistical significance was assumed for P values <0.05.

Results

From 2015 to 2022, the senior author performed 15 consecutive anatomic CC ligament reconstruction using the described surgical technique at a mean of 46.5 weeks postinjury (Table I). All patients were active-duty military males with a mean age of 35.8 years. Preoperatively, there were 10 patients with grade IIIB injuries, 1 patient with a grade IV injury, and 4 patients with grade V injuries. Twelve of the 15 patients (80%) were successfully contacted, and patient-reported outcomes were collected. Preoperatively, the average SANE score was 40.0 and postoperatively the average SANE

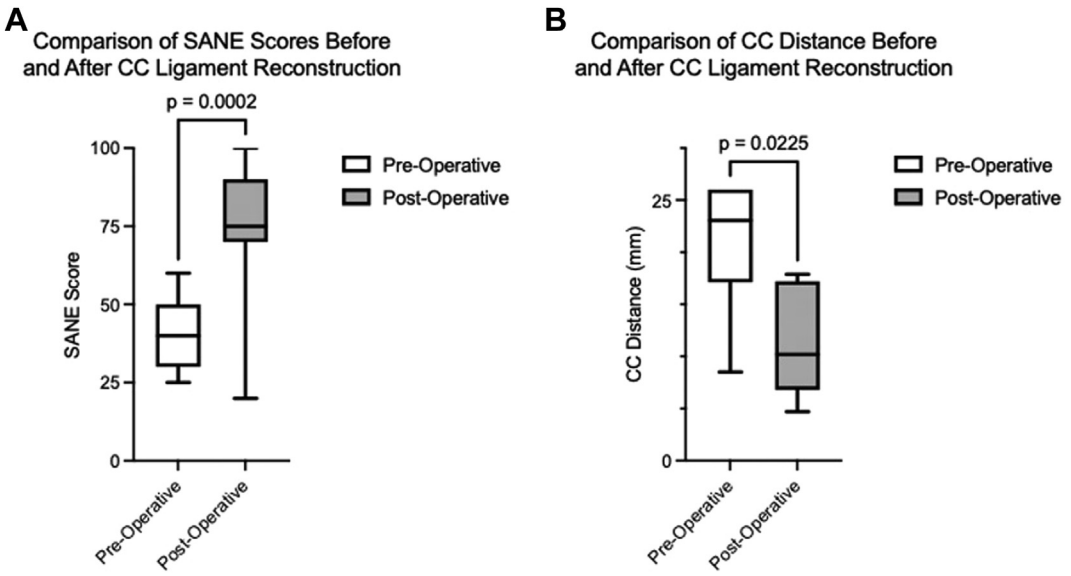

Figure 1 (**A**) Comparison of SANE scores before and after anatomic CC ligament reconstruction at a mean of 4.9 months postoperatively. (**B**) Comparison of CC distance before and after anatomic CC ligament reconstruction. *SANE*, Single-Assessment Numerical Evaluation; *CC*, coracoclavicular.

score was 77.1 ($P = .0002$; Fig. 1, *A*). The average follow-up for PROMs duration was 4.9 years.

Eleven of these 12 patients (92%) reported they were either satisfied or extremely satisfied with the outcome of the surgery. Postoperative radiographs were available for 14 of the 15 patients (93%) at an average of 2.7 years postoperatively revealing 13 patients had maintained grade I injuries while 1 patient had a grade III injury secondary to a traumatic event after surgery resulting in reinjury to his AC joint, this was the only case requiring revision surgery in the cohort. The mean CC distance decreased from 16.7-mm to 11.3-mm postoperatively ($P = .0225$; Fig. 2, *B*). Of note, there was no correlation between time from injury to surgery and postoperative SANE scores ($P = .71$; Fig. 2).

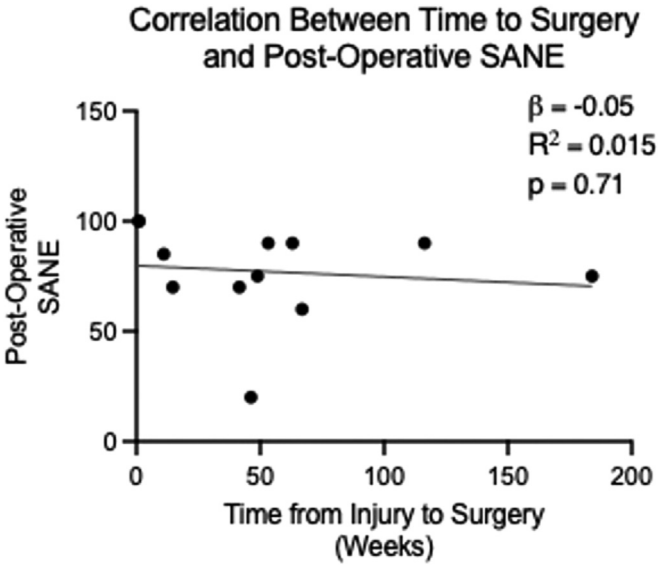

Figure 2 Correlation between time to surgery and postoperative SANE scores. *SANE*, Single-Assessment Numerical Evaluation.

Discussion

The findings of the current study suggest that a CC ligament reconstruction using a 4-strand suspensory fixation with taped sutures results in significantly improved radiographic and patient-reported outcomes in a cohort of athletic, active-duty military patients with grade IIIB-V AC joint separations. At a mean of 50.4 months postoperatively, 92% of patients were at least "satisfied" with their shoulder function following surgery, and anatomic reduction of the AC joint were maintained in 93% of patients at final radiographic follow-up.

AC joint separations are common injuries to the shoulder girdle, representing up to 10% of shoulder injuries in an urban population.[19] In general, low-grade injuries (Rockwood grades I and II) are managed conservatively with positive outcomes.[2] Higher-grade injuries (grades IIIB-VI) tend to do poorly with conservative management and often require surgical intervention to minimize pain and allow for a timely return to activity, especially in young active individuals and athletes, which can be generalized to also include active-duty military members. Functional outcomes after anatomic CC joint reconstruction in a military population have not been previously described.

There is a lack of a consensus regarding the optimal treatment of grade III injuries, and decisions are often made on a case-by-case basis for the individual patient.[2,10] There is significant controversy surrounding not only whether to operate on type III AC joint injuries, but also what the best fixation method is for AC joint injuries in general. Korsten et al conducted a systematic review comparing operative to nonoperative management of grade III injuries showing improved functional outcomes in the operative group, which also had a higher rate of complications.[24] However, failed conservative management of these injuries can result in poor long-term outcomes eventually requiring surgical intervention, with functional deficits and pain-related symptoms lasting from 6 months to 5 years post-injury.[4,22] This presents a problem especially in high-demand patients that are looking to have their injury treated in a manner that will provide them with symptomatic relief and the ability to return to their baseline activities in a timely manner. The findings of the current study suggest that in patients with grade III injuries, a reconstructive procedure allows for return to activity around 4 months postoperatively, with >90% satisfaction at a mean of 50 months

postoperatively. Previous studies have reported high rates of return to sport, but this is the first study to demonstrate return to duty in the military setting.[13]

Recent studies have shown similar promising results regarding clinical and radiographic outcomes following reconstructive procedures, such as those described by Mazzocca et al, for high-grade (IV-VI) AC joint separations as well as grade III separations.[2,3,5,16,18] Reconstructive procedures have also shown to have lower complication rates compared to fixation using K-wires and hook plates and lower unplanned reoperation rates compared to CC ligament transfer (modified Weaver-Dunn) procedures, with suspensory devices and synthetic ligament techniques having the lowest rates of complications.[17] In the current study cohort of 15 patients, only 1 (6.7%) complication requiring revision surgery occurred which was the result of a subsequent injury the operative shoulder resulting in a recurrent grade III AC joint separation.

The current study is not without limitations. First, the retrospective nature of this study has inherent bias. Furthermore, our study does not address the question of anatomic CC ligament reconstruction in the setting of acute management of AC joint separations, as the average length of time from injury to surgery in our study was 46.5 weeks. Additionally, the patients in the present study were active-duty military members and a small sample size, which may decrease the generalizability of the current study, as there are increased pressures and demands to return to full duty status in the military. Future, large-cohort prospective studies are warranted to address anatomic CC ligament reconstruction as a surgical treatment for the patient with an acute grade III AC joint separation, as opposed to an initial trial of nonoperative management requiring failure prior to proceeding with surgical intervention.

Conclusion

CC ligament reconstruction using a 4-strand suspensory fixation with taped sutures of high-grade AC joint separations in active-duty military patients is a safe technique resulting in high patient satisfaction, significantly improved PROMs, and maintenance of AC joint reduction with low rates of complications and unplanned reoperations.

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