Surgical Technique Affects Outcomes in Acromioclavicular Reconstruction

Jason A. Grassbaugh, MD; Chad Cole, PA-C; Kurt Wohlrab, MD; and Josef Eichinger, MD

Optimal treatment for acromioclavicular (AC) dislocation is unknown. Numerous surgical procedures for AC injuries have been described with little comparison. This study sought to compare the clinical and radiographic results of various surgical techniques in order to identify the optimal surgical technique. Ninety patients met inclusion criteria of AC reconstruction at this institution. A retrospective review of outcomes was performed using the electronic records system. Radiographs were measured for pre- and postoperative grade and percent elevation versus the contralateral side. Overall revision rate was 9%. Suture button fixation had a revision rate of 0% compared to 14% ($p = .01$). Reconstruction procedures performed with distal clavicle excision showed a higher revision rate, 17% compared to 0% ($p = .003$). There were no statistically significant clinical differences. AC reconstructions performed with suture button construct were superior to other surgical techniques. Procedures performed with distal clavicle excision were inferior to those without. (Journal of Surgical Orthopaedic Advances 22(1):71–76, 2013)

Key words: acromioclavicular, dislocation, distal clavicle resection, reconstruction, shoulder separation

Acromioclavicular (AC) joint disruption is a relatively uncommon injury typically seen in younger athletic patients. Tossy et al. and Allman established the classification of this injury as type I, II, and III for nondisplaced, slightly displaced, and up to 100% displacement of the clavicle in comparison to the acromion (1, 2). Rockwood subsequently added types IV, V, and VI to describe posterior dislocation, 100% to 300% cephalad translation, and infracoracoid dislocation, respectively (3).

Optimal treatment for these injuries has not been delineated. Although surgery for high-grade disruptions is generally accepted, much controversy exists over the optimal treatment of grade III injuries (4–6). A significant portion of the literature supporting nonoperative management of grade III injuries involves older surgical techniques such as K-wire and Bosworth screw fixation (4, 5, 7, 8). Newer techniques involving suture buttons and suture anchors have been introduced recently and may represent an improvement in technique (9). At least two prospective randomized trials comparing surgical and nonoperative treatment of severe AC joint injuries recommended surgical treatment for injuries with greater than 2 cm of displacement (4, 7). These studies demonstrated superior outcomes for high-grade injuries treated surgically. Additional controversy exists as to the best surgical technique among over 70 different described procedures (4, 9–16). Timing of optimal treatment is debated as well, because it seems to be more difficult to maintain reduction of the AC joint with chronic tears.

AC joint injuries occur in the young athletic population through falls directly onto the shoulder. A military population includes this patient demographic and activities that lead to frequent AC joint injuries. Furthermore, the military population commonly wears rucksacks, load-bearing equipment, and parachutes, placing different demands on the shoulder girdle than many other traditional sports, leading to a high rate of AC joint repair and reconstruction in the military.

This study sought to determine whether newer surgical techniques resulted in better radiographic and clinical function than historic techniques. A second research question was whether distal clavicle resection affected outcomes. The null hypothesis was that there would be no difference in clinical or radiographic outcomes between any compared group.

Materials and Methods

Institutional review board approval was obtained for a retrospective review of all AC joint repairs and reconstructions from 2004 through January 2010. Inclusion criteria included active duty service members with a primary or revision AC joint repair or reconstruction. AC injuries in

From Department of Orthopedics, Womack Army Medical Center, Fort Bragg, North Carolina. Address correspondence to: Jason Grassbaugh, 611 North 5th Street, Tacoma, WA 98403; e-mail: grassbaugh@gmail.com.

Received for publication June 30, 2012; revision received November 17, 2012; accepted for publication November 20, 2012.

For information on prices and availability of reprints, e-mail reprints@datatrace.com or call 410-494-4994, x232.

1548-825X/13/2201-0071$22.00/0

DOI: 10.3113/JSOA.2013.0071

association with fractures about the shoulder girdle were excluded. Demographic measures, such as patient age, gender, and surgery-specific information, were obtained for each procedure, as well as type of procedure performed and whether a distal clavicle resection was done in conjunction with the reconstruction. Digital radiographic evaluation (Centricity 3.0, GE, United Kingdom) was performed pre- and postoperatively and at final follow-up. Both isolated shoulder views and AC views were reviewed to allow grading of injury in accordance to Rockwood classification and for the measurement of coracoclavicular (CC) distance. Two board-certified orthopedic surgeons performed grading of all preoperative and postoperative radiographs independently. Differences were resolved by consensus at second viewing. The CC distance for statistical comparison was defined as a percentage of the contralateral side based on bilateral AC views of the shoulder. This eliminated magnification error and standardized for different viewing angle between preoperative and postoperative radiographs.

Clinical outcomes were evaluated by a unique outcome measure based on clinical notes in our electronic records system. The outcome measure was adapted from the outcome measure developed by Larsen et al. for AC injuries (4). Both functional and pain outcomes were judged excellent, good, fair, or poor and given a corresponding score of 1 to 4 (Tables 1 and 2). Records were also reviewed for further operative procedures, complications, or subsequent separation from the military.

Statistical Analysis

The main outcomes included functional outcome (as adapted from Larsen), rate of successful reduction as a percentage of AC joint, and grading improvement. All statistical analyses were performed using commercially available software (Excel version 2007, Microsoft Corporation, Redmond, WA). Postreduction comparisons were performed using paired Student *t*test. Significance for all comparisons was set at $p < .05$.

TABLE 1 Clinical outcome scoring

Clinical Function	Score	Clinical Description
Excellent	4	Full function No symptoms
Good	3	Minor complaint No limitations
Fair	2	Activity limiting Able to perform MOS
Poor	1	Unable to perform MOS Discharge from military because of shoulder

MOS, military occupational specialty.

TABLE 2 Pain outcome scoring

Pain	Score	Clinical Description
Excellent	4	No pain No pain medications
Good	3	Minor pain Occasional NSAID use
Fair	2	Pain requiring daily NSAID, Tylenol Pain requiring occasional narcotic use
Poor	1	Daily narcotic use Medical discharge because of shoulder pain

NSAID, nonsteroidal anti-inflammatory drug.

Results

A total of 96 operative procedures on 88 patients were identified in the 6-year window. Four of the patients were excluded because of fractures and two others were excluded because AC reconstruction was abandoned intraoperatively in favor of distal clavicle resection. The remaining 90 surgical procedures involved 82 primary repairs or reconstructions and eight revision reconstructions. Seventy-nine patients were male and three were female. All surgeries were categorized based on type of procedure performed (Fig. 1).

Twenty AC repair procedures used two AC TightRope (Arthrex, Naples, FL) devices (2TR). The 2TR group underwent a repair technique that incorporated two TightRopes placed in one drill hole in the coracoid and two separate drill holes in the clavicle (Fig. 1). Fifteen AC repair procedures used one AC TightRope device (1TR). Eight AC reconstruction procedures used the Graft Rope (Arthrex, Naples, FL) device with allograft tissue (GR). Twelve AC reconstruction procedures used a single TightRope with an allograft tissue loop around the coracoid and fixed to the clavicle in two drill holes (TR + GL). Six AC reconstructions used an isolated allograft tissue loop with radiolucent supplementary fixation such as suture loop (GL). Eight procedures used a Bosworth screw (partially threaded stainless steel screw) with fixation between the clavicle and coracoid (BS). Two procedures used suture anchor fixation to the coracoid (SA). Nineteen procedures were Weaver–Dunn-type procedures involving transfer of the acromioclavicular ligament to the end of the clavicle supplemented with various suture and suture anchor constructs (WD).

Four separate comparisons were performed. The first comparison evaluated outcomes between primary suture button procedures (2TR and 1TR) versus all other groups (GR, TR + GL, GL, BS, SA, WD). This comparison revealed statistically significant improvement in final

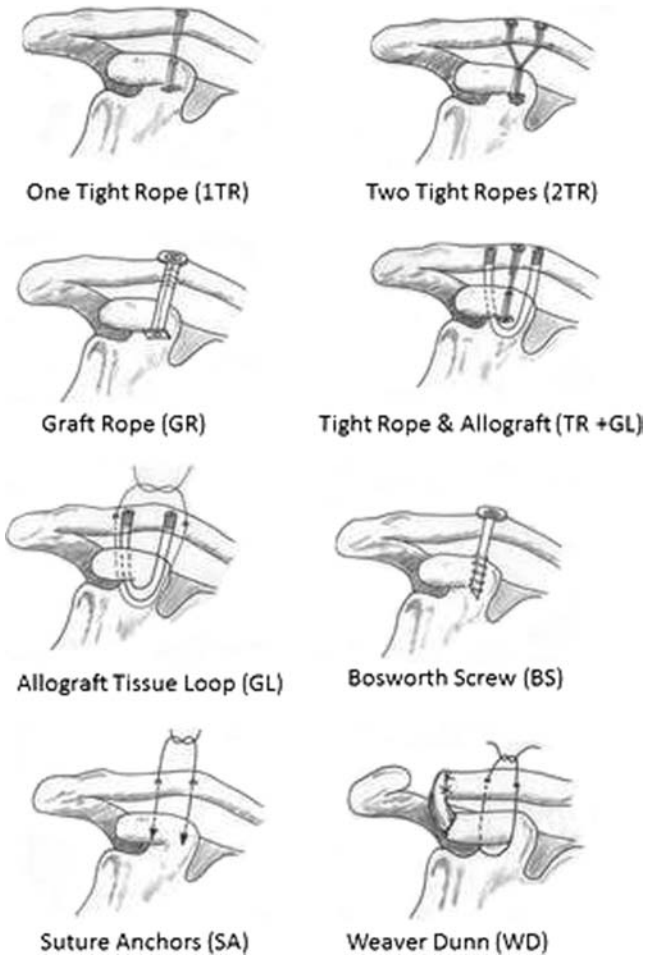

FIGURE 1 Repair configurations used in this study.

postoperative reduction and revision rate (Table 3). The second comparison evaluated outcomes between 2TR versus 1TR, which found no statistically significant differences. The third comparison was between chronic suture button constructs (GR, TR + GL) compared with all other chronic techniques (GL, BS, SA, WD). The chronic suture button group showed statistically significant improvement in postoperative reduction. The fourth comparison evaluated all procedures that included a distal clavicle resection regardless of technique versus all repairs that did not include a distal clavicle resection.

None of 35 primary suture button procedures (1TR and 2TR) went on to revision surgery versus 8 of 55 other surgeries (0% vs. 15%, $p = .004$). Preoperative CC distance was similar between the two groups: 216% for suture button groups versus 208% for all other repair groups. Comparison of the final postoperative CC distance was 118% for suture button groups versus 160% for all other repair groups ($p = .001$). The suture button groups showed a mean improvement of 1.8 grades improvement at final radiographic follow-up versus 0.9 grade for the historic groups ($p = .00001$). Fifty-one percent of suture button groups were AC type I on final radiographs versus 13% of all other repair groups ($p = .0002$). Clinical function and pain scores were similar for the two groups: 3.4 and 3.2 for the suture button group and 3.2 and 3.0 for the historic group with trend for improvement in both categories for the suture button group ($p = .32$ and $p = .59$, respectively).

TABLE 3 TightRope reconstruction compared with all other surgical procedures

	TightRope (TR)	All Other Procedures	*p* Value
Number of procedures	35	55	
Preop % grade V	40%	38.2%	.87
Preop % elevation	216%	208%	.56
Postop % elevation	118%	160%	.001
Grade improvement	1.7	.9	>.0001
Grade I at final follow-up	51%	13%	>.0001
Revision surgery	0	8 (15%)	.008
Functional score	3.4	3.2	.32
Pain score	3.2	3.0	.59

Table 4 shows the results of the comparison between the 1TR and 2TR groups. The groups showed similar preoperative CC distance, 213% for 1TR and 216% for 2TR ($p = .82$). Final postoperative CC distance was 129% for 1TR versus 108% for 2TR ($p = .22$). The 1TR group showed on average 1.5 grades improvement at final radiographic follow-up versus 2.0 grades for 2TR ($p = .07$). Forty-six percent of 1TR group was AC type I on final radiographs versus 55% of 2TR group ($p = .64$). Clinical function and pain scores were similar for both groups.

Table 5 shows the results of the comparison between the chronic suture button groups and all other chronic groups. Comparison between the GR and TR + GL group and the remainder of historic surgeries showed similar preoperative CC distance, 194% and 216% respectively ($p = .24$). Final postoperative CC distance was statistically improved for the chronic suture button groups

TABLE 4 Double TightRope reconstruction compared with single TightRope reconstruction

	Double TightRope	Single TightRope	*p* Value
Number of procedures	20	15	
Preop % grade V	50%	26.7%	.16
Preop % elevation	218%	213%	.82
Postop % elevation	108%	129%	.22
Grade improvement	2.0	1.5	.06
Grade I at final follow-up	55%	47%	.64
Revision surgery	0	0	
Functional score	3.5	3.4	.69
Pain score	3.2	3.1	.89

versus historic surgeries, 131% versus 178% ($p = .01$). The chronic suture button group showed on average 1.1 grades improvement at final radiographic follow-up versus 0.8 grade for the historic chronic group ($p = .21$). Eighteen percent of the suture button historic group was AC type I on final radiographs versus 9% of the historic chronic group ($p = .27$). Clinical function and pain scores were similar for the two groups: 3.5 and 3.3 for the chronic suture button group and 3.0 and 2.8 for historic chronic group.

Forty-eight procedures were performed with a distal clavicle resection and 42 procedures did not have this done (Table 6). The group without a distal clavicle resection included 27 of the suture button procedures, only two revision Weaver–Dunn procedures, and five Bosworth screw procedures. The distal clavicle resection group included only eight patients using suture button fixation, the remainder of the Weaver–Dunn procedures, and three of the Bosworth screw procedures. The distal clavicle resection and nondistal clavicle resection comparison showed a statistical difference in the amount of preoperative CC displacement. The group that underwent a distal clavicle resection as a part of the procedure had on average a CC displacement of 200% versus 223% ($p = .02$). Final postoperative CC displacement was superior for the nondistal clavicle resection group versus the distal clavicle resection group but not statistically significant, 132% versus 153% ($p = .31$). The nondistal clavicle resection group showed on average 1.5 grades improvement at final radiographic follow-up versus 1.1 grades for the distal clavicle resection group ($p = .02$). Thirty-six percent of the nondistal clavicle resection group was AC type I on final radiographs versus 21% of distal clavicle resection group ($p = .10$). Clinical function and pain scores were similar for the two groups: 3.3 and 3.1 for the nondistal clavicle resection group and 3.3 and 3.0 for the historic chronic group. All eight failures occurred in patients receiving distal clavicle resections, for a revision rate of 17%. This was compared to zero of 42 patients who required revision AC reconstruction in the nondistal clavicle resection group ($p = .004$).

TABLE 5 Chronic TightRope reconstruction compared with all other chronic techniques

	GR, TR + GL	BS, WD, SA, GL	*p* Value
Number of procedures	20	35	
Preop % grade V	35%	40%	.71
Preop % elevation	194%	216%	.24
Postop % elevation	131%	178%	.01
Grade improvement	1.1	.8	.21
Grade I at final follow-up	20%	8.6%	.22
Revision surgery	3 (15%)	5 (14%)	.9
Functional score	3.5	3.0	.07
Pain score	3.3	2.8	.17

TABLE 6 Distal clavicle resection compared with no distal clavicle resection

	Distal Clavicle Resection	No Distal Clavicle Resection	*p* Value
Number of procedures	48	42	
Preop % grade V	40%	38%	.77
Number TR repair	8 (17%)	27 (64%)	.0001
Preop % elevation	199%	223%	.01
Postop % elevation	153%	132%	.31
Grade improvement	1.1	1.5	.02
Grade I at final follow-up	21%	36%	.09
Revision surgery	8 (17%)	0 (0%)	.003
Functional score	3.3	3.3	.9
Pain score	3.0	3.1	.89

Discussion

This study is the first study to our knowledge to show improved surgical outcomes with suture button fixation compared with historic surgical techniques. Statistically significant improvement was seen in a lower revision rate for suture button repairs and improvement in grade of AC separation at final radiographic follow-up, as well as overall percentage of procedures that resulted in type I AC joint appearance at final radiograph. The suture button groups restored 55% of patients to type I, normal anatomic alignment, versus 13% for all other historic surgeries.

A surgical procedure that better restores AC anatomy should result in superior clinical outcomes. However, we did not observe any statistically significant differences in our measurement of clinical function or pain between any groups in our retrospective review. There was a trend toward improvement with suture button repairs but it failed to achieve statistical significance. The clinical outcome measure may not have been a sensitive enough measure when applied retrospectively to detect differences in clinical outcome. Significant challenges exist in our ability to obtain direct follow-up from patients, given the mobility and transient nature of the military population.

Another concrete outcome measure particularly important for a military population is the occurrence of a medical board resulting in separation from the military because of disability from the AC joint injury. Based on this reference measure, surgery for AC joint injuries in our population overall was successful because only five of 82 patients went on to require a medical board because of their AC injury. Of the five, four patients were from the historic group and one was from the suture button group. Significant limitations exist in our electronic medical record system, including inconsistencies between

various providers, lack of objective measurements of clinical function, and high degree of variability in follow-up time. This limits the ability of a retrospective study to detect functional differences in this type of injury. In the absence of a prospective study with a validated objective outcome measure, we can draw no conclusion of difference in clinical outcome between any of the study groups.

Despite a lack of consensus in the management of this diverse group of injuries, most providers support reconstruction in the most severe AC injuries. Although multiple techniques exist, there is a trend toward a greater use of suture button techniques. Among those surgeons using suture buttons, there is debate as to the best means of employing this implant for AC joint repair and reconstruction. This debate led to the evaluation of single versus double suture button repair. Two suture buttons increase the working distance of the construct, better allowing it to resist superior translation with loading as well as better mimicking the native anatomy of the coracoclavicular ligaments (17, 18). The trapezoid and conoid divisions of the CC ligaments represent the location of placement of the suture buttons in this repair technique.

The suture button technique also showed a beneficial effect in the management of chronic AC injuries. Historic surgeries included multiple augments of allograft tissue to assist in maintaining the reduction until allograft tissue incorporated into the native CC ligaments. The GR and TR + GL groups represented chronic reconstruction that included any suture button into the reconstruction. This subset of the historic group showed statistically significant improvement in radiographic outcomes.

Another finding in our study was the improvement in outcomes noted for surgeries performed without distal clavicle resections. All eight failures occurred in procedures performed with a distal clavicle resection. Procedures not utilizing a distal clavicle resection resulted in a superior improvement of radiographic grade and a trend toward improvement in CC distance. No differences in clinical outcome or pain outcome grading were observed between groups with or without distal clavicle resection.

Some authors have speculated that the distal clavicle plays an important role in stability of the AC joint and resection should be limited (19). The trend at our institution has been to decrease the use of the distal clavicle resection in AC reconstruction, as illustrated by 27 of the suture button reconstructions not including a distal clavicle resection. This indicates selection bias is likely present in this analysis. However, this is the first study in vivo that shows distal clavicle resection as being deleterious to the ultimate results in AC reconstruction.

Limitations of this study include the retrospective nature of the review. Retrospective studies include various selection biases based on the surgeon experience, operation provided, and surgical indications. There are also inconsistencies in the clinical data available, making clinical outcome measures difficult to discern. Another significant limitation in this study was difficulty in identifying chronicity of injury. The charting was nonspecific for dating injuries and therefore it is unavailable for analysis. We therefore combined our results for acute and chronic injury. We recognize that this represents another selection bias but attempted to take this into account in our analysis of the data. Based on the practice characteristics of the surgeons at our institution, all of the suture button surgeries were acute in nature because all surgeons at this practice augment repairs with allograft tissue after 6 weeks of chronicity. We assume that chronic injuries are more difficult to maintain in a reduced position. So the comparison of suture button to all other surgeries likely represents the difference that can be achieved with acute management of severe AC injuries versus management of chronic injuries. This has led to a change in philosophy within our group toward more aggressive early treatment to prevent chronic deformity, which is more difficult to manage. The analysis of chronic suture button surgeries versus other historic surgeries was the attempt to eliminate the bias from chronicity of injury.

This study highlights the experience of our institution with management of AC injuries. Our institution has largely abandoned the distal clavicle resection in conjunction with the AC reconstruction, except in the instance of irreducible injury or radiographic evidence of arthrosis with preinjury history of pain at the AC joint. We have moved toward suture button fixation with earlier and more aggressive management of AC dislocation because of the poorer results with chronic injury. We believe that these results are important and relatively unrepresented in the orthopedic literature.

References

1. Allman, F. L., Jr. Fractures and ligamentous injuries of the clavicle and its articulation. J. Bone Joint Surg. Am. 49:774–784, 1967.
2. Tossy, J. D., Mead, M. C., Sigmond, H. M. Acromioclavicular separations: useful and practical classification for treatment. Clin. Orthop. Relat. Res. 28:111–119, 1963.
3. Williams, G. R., Jr., Nguyen, V. D., Rockwood, C. A., Jr. Classification and radiographic analysis of acromioclavicular dislocations. Appl. Radiol. 18:29–34, 1989.
4. Larsen, E., Bjerg-Nielsen, A., Christensen, P. Conservative or surgical treatment of acromioclavicular dislocation. A prospective randomized study. J. Bone Joint Surg. Am. 68:552–555, 1986.
5. Phillips, A. M., Smart, C., Groom, A. Acromioclavicular dislocation. Clin. Orthop. Relat. Res. 353:10–17, 1998.
6. Simovitch, R., Sanders, B., Ozbaydar, M., et al. Acromioclavicular joint injuries: diagnosis and management. J. Am. Acad. Orthop. Surg. 17:207–219, 2009.
7. Bannister, G. C., Wallace, W. A., Stableforth, P. G., et al. The management of acute acromioclavicular dislocation: a randomized prospective controlled trial. J. Bone Joint Surg. Br. 71:848–850, 1989.

8. Taft, T. N., Wilson, F. C., Oglesby, J. W. Dislocation of the acromioclavicular jJoint. J. Bone Joint Surg. Am. 69:1045–1051, 1987.
9. Choi, S. W., Lee, T. J., Moon, K. H., et al. Minimally invasive CC stabilization with suture anchors for acute AC dislocation. Am. J. Sports Med. 36:961–968, 2008.
10. DeBerardino, T. M., Pensak, M. J., Ferreira, J., et al. Arthroscopic stabilization of AC joint dislocation using the AC graftrope system. J. Shoulder Elbow Surg. 19:47–52, 2010.
11. Dimakopoulos, P., Panagopoulos, A., Spyros, A., et al. Double-loop suture repair for acute acromioclavicular joint disruption. Am. J. Sports Med. 34:1112–1119, 2006.
12. Khan, L. A., Bradnock, T. J., Scott, C., et al. Fracture of the clavicle. J. Bone Joint Surg. Am. 91:447–460, 2009.
13. Morrison, D. S., Lemos, M. J. Acromioclavicular separation. Reconstruction using synthetic loop augmentation. Am. J. Sports Med. 23:105–110, 1995.
14. Pearsall, A. W., Hollis, J. M., Russell, G. V., et al. Biomechancial comparison of reconstruction techniques for disruption of the AC and CC ligaments. J. South. Orthop. Assoc. 11:12–17, 2002.
15. Wellmann, M., Zantop, T., Peterson, W. Biomechancial evaluation of minimally invasive reparis for complete AC joint dislocation. Am. J. Sports Med. 35:955–961, 2007.
16. Wellmann, M., Zantop, T., Peterson, W. Minimally invasive coracoclavicular ligament augmentation with a flip button. Arthroscopy 23:1132e1–1132e5, 2007.
17. Fukuda, K., Craig, E. V., An, K. N., et al. Biomechanical study of the ligamentous system of the acromioclavicular joint. J. Bone Joint Surg. Am. 68:434–440, 1986.
18. Jerosch, J., Filler, T., Peuker, E., et al. Which stabilization technique corrects anatomy best in patients with AC separation? An experimental study. Knee Surg. Sports Traumatol. Arthrosc. 7:365–372, 1999.
19. Corteen, D. P., Teitge, R. A. Stabilization of the clavicle after distal resection: a biomechanical study. Am. J. Sports Med. 33:61–67, 2005.