RESEARCH ARTICLE

Structural Failure After Acromioclavicular Joint Reconstruction: Factors Affecting Clinical Outcomes

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Abstract

Objectives: Management of acromioclavicular (AC) joint injuries remains controversial regarding ideal surgical indications and technique. While loss of reduction following AC reconstruction is common, its relationship to clinical outcomes is uncertain. The purpose of this study was to evaluate outcomes and potential predictors of suboptimal results in patients with structural failure following AC reconstruction.

Methods: Patients with structural failure following AC reconstruction from 2013-2019 were identified, defined as 50% loss of coronal AC joint reduction between immediate and final postoperative radiographs. Failures were categorized by degree of displacement and mechanism, which included traumatic reinjury versus spontaneous subsidence of AC reduction. Suboptimal clinical outcomes were defined as undergoing reoperation or postoperative American Shoulder and Elbow Surgeons (ASES) score less than 80. Bivariate analyses were performed to identify risk factors for suboptimal clinical results and compare outcomes between operative versus nonoperative management of structural failure.

Results: Twenty-nine patients were evaluated with mean follow-up of 7.4 years (range 4.0-10.5 years). 21% underwent revision surgery (n = 6) and 79% were treated nonoperatively (n = 23). Mean postoperative ASES, Numerical Rating Scale (NRS), and Single Assessment Numeric Evaluation (SANE) scores at final follow-up were 82 +/- 20 (range 33-100), 1.6 +/- 2.2 (range 0-7), and 82 +/- 20 (range 22-100) respectively. 41% of the total cohort (n = 12) had a suboptimal clinical result. On bivariate analysis, structural failure following acute reinjury was associated with suboptimal clinical outcomes (50% vs 6%, p = 0.011) and a higher likelihood of reoperation (67% vs 13%, p = 0.018).

Conclusion: Structural failures of AC reconstruction following an acute injury are more likely to experience suboptimal clinical outcomes and undergo reoperation compared to spontaneous loss of reduction. Larger analyses are warranted to determine if there are additional factors which may affect outcomes and guide management in these clinical scenarios.

Level of evidence: IV

Keywords: AC joint, Acromioclavicular injury, Acromioclavicular reconstruction, Coracoclavicular reconstruction, Loss of reduction, Radiographic failure, Structural failure

Introduction

Acromioclavicular (AC) joint injuries account for up to 12% of all shoulder injuries.[1] Traumatic dislocation of the AC joint alters the biomechanics of the shoulder girdle and can lead to discomfort, functional limitations, and dissatisfaction with the associated deformity that leads many patients to consider surgical options. Surgical intervention of these injuries remains controversial, and there is currently no established consensus regarding the ideal technique or indications. Since its inception in the early 1900s, numerous techniques for stabilization of AC injuries have been described which vary widely in their utilization of implants and methods of fixation.[2,3] Regarding indications for surgery, reconstruction is often considered in Rockwood Type III -

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VI injuries which involve compromise of both the AC and coracoclavicular (CC) ligaments.[4] However, some prior randomized controlled trials and systematic reviews have reported minimal clinical difference between operative and nonoperative treatment of these injuries, even some studies including Type V injuries, which has made the optimal management strategy unclear.[5-9]

Despite some evidence of satisfactory outcomes following AC joint reconstruction, there is also a relatively high rate of complications and structural failure, which have been reported as high as 35% and 25%, respectively.[10-16] Other studies do not always define a separate rate of structural failure but note that many constructs will demonstrate some degree of loss of reduction and increased coracoclavicular distance postoperatively.[10,14,17] While these radiographic findings are not always associated with worse clinical outcomes,[10,13,14,18] it remains one of the most common reasons for revision surgery, and decision making in these situations can be particularly difficult in the setting of continued pain.[10,13,14,18,19] Additionally, rate of reoperation following AC stabilization remains low despite a high rate of complications and structural failure, and there is a paucity of literature evaluating possible risk factors for suboptimal clinical outcomes and reoperation when loss of reduction occurs.[12]

The purpose of the study was to report the outcomes of patients following structural failure of primary AC joint reconstruction and to evaluate for potential predictors of suboptimal clinical outcome or reoperation. This information may assist with counseling patients regarding prognosis and determining optimal treatment strategies for surgeons when deciding between operative and nonoperative management of postoperative loss of AC reduction.

Materials and Methods

This study was a single center retrospective case series evaluating type III-V AC joint injuries that experienced structural failure following primary AC joint reconstruction. Surgeries were conducted by a fellowship-trained sports medicine or shoulder and elbow surgeon between the years 2013-2019, which were identified from an established institutional database via CPT codes 23550 and 23552.[16] Patients with previous ipsilateral shoulder surgery, concomitant fractures, inadequate perioperative imaging, age less than 18 years, or postoperative outcome scores less than 4 years after index surgery and 2 years after diagnosis of structural failure were excluded from the analysis.

Chart review was conducted to obtain patient demographic information as well as injury characteristics such as time to initial surgery and time to structural failure. In our analysis, injuries which underwent surgical intervention within 6 weeks were considered “acute”, between 6 weeks to 3 months was considered “subacute”, and greater than 3 months was considered “chronic”.[16] Operative notes were reviewed to assess the surgical approach (arthroscopic-assisted or open), operative technique, and pertinent surgical details (ie. use of allograft, placement of drill tunnels in the clavicle, or additional procedures such as distal clavicle excision).

AC joint injuries were initially diagnosed via standard orthogonal shoulder radiographs for all patients. Preoperative and postoperative anteroposterior (AP) shoulder radiographs were reviewed to identify patients who experienced structural failure, which was defined as a loss of coronal plane AC joint reduction of 50% or greater between immediate and final postoperative radiographs. AP radiographs were utilized in attempt to limit the projectional variability between measurements of the AC joint displacement.[20,21] Amount of deformity was assessed based upon superior-inferior distance measured between the inferior surface of the distal clavicle and inferior surface of the acromion [Figure 1].[17] The mode of fixation failure of each patient on postoperative radiographs was noted. Subsidence was defined as constructs that demonstrated radiographic loss of reduction without evidence of bony failure, whereas device cut through or pullout described cases with complete separation of the construct from either the coracoid or clavicle. Structural failure was further stratified by loss of reduction greater or less than 100%, and whether failure was related to an acute injury versus spontaneous loss of reduction. Patients who were treated with revision surgery versus nonoperative management following identification of structural failure were also assessed. The decision to proceed with revision surgery was made at the discretion of the operative surgeon and based upon persistent pain or functional limitations following failure of AC reconstruction.

Preoperative outcomes scores including American Shoulder and Elbow Surgeons (ASES), Simple Assessment Numeric Evaluation (SANE), and Numerical Rating Scale (NRS) scores were collected via chart review. Patients were subsequently contacted via email and/or telephone to obtain a minimum 4-year postoperative ASES, SANE, and NRS scores. Following calculation of postoperative outcome scores, patients with suboptimal results were identified, which was defined as an ASES score of less than 80 or those who underwent reoperation.[22-24]

Statistical Analysis

Bivariate analyses were performed to determine if there are demographic or surgical factors which may affect outcomes following structural failure after AC joint reconstruction and to compare outcomes between patients who underwent revision surgery versus those treated nonoperatively. Continuous data is presented as mean (standard deviation (SD)) and categorical data is presented as percentage (%). T-tests or Mann-Whitney U tests were used to compare continuous data and Fisher’s Exact tests were used to compare categorical data.

Results

From 2013-2019, 279 patients who underwent operative management of Type III - V AC joint injuries were evaluated, of which structural failure was identified in 69 (25%). Of these, 29 patients with structural failure were deemed eligible for this study [Table 1], with mean age of 44 +/- 16 years and mean follow-up of 7.4 years after index surgery (range 4.0-10.5 years) and 7.2 years following diagnosis of structural failure (range 3.9-10.5 years). The remaining 40 patients were ineligible for the study as they were unable to be successfully contacted to obtain patient reported outcome scores. Ninety percent were male and 80% of cases were Type V injuries (n = 23). Median time from injury to surgery was 7.0 weeks (range 0.1 - 330 weeks). 41% (n = 12) of injuries were reconstructed

acutely (less than 6 weeks post-injury), 24% (n = 7) were subacute (6 weeks - 3 months post-injury), and 35% (n = 10) were chronic (greater than 3 months post-injury). Surgical techniques included Modified Weaver-Dunn (7%; n = 2), CC reconstruction with suspensory fixation (28%; n = 8), and CC reconstruction with suture fixation (65%; n = 19). Surgery was performed via open techniques in 83% (n = 24) and arthroscopic-assisted techniques in 17% (n = 5). All cases involved drill holes in either the clavicle or coracoid. Allograft was used in 55% (n = 16), distal clavicle excision was conducted in 14% of cases (n = 4), and concomitant superior labral anterior posterior (SLAP) repair was conducted in one patient. There were otherwise no additional concomitant procedures.

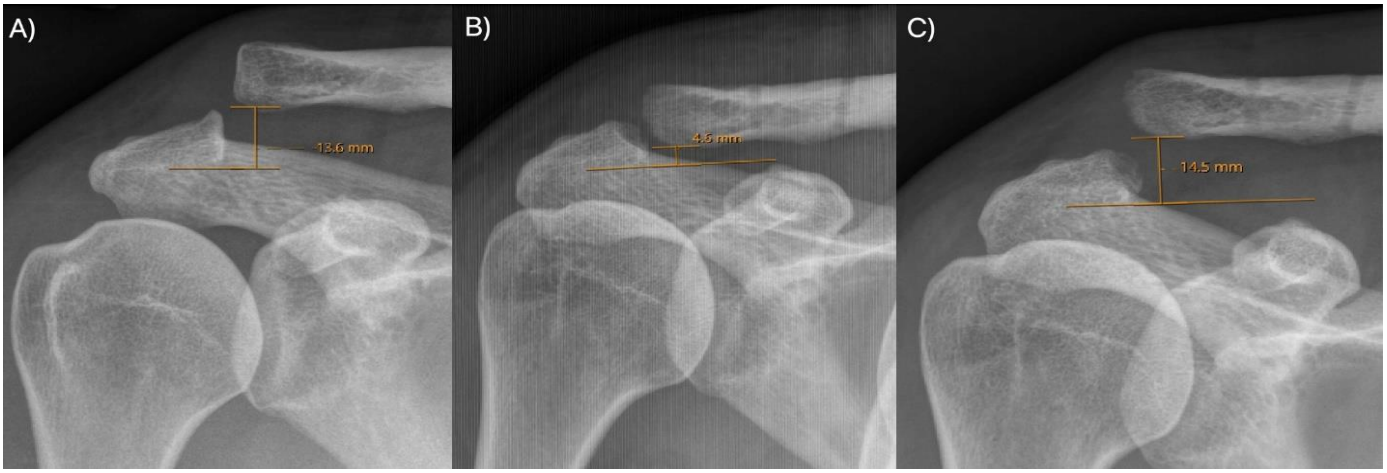

Figure 1. Preoperative (A), immediate postoperative (B), and final postoperative (C) shoulder radiographs for a 27-year-old female who experienced structural failure following open suture reconstruction of a chronic type V acromioclavicular joint injury

Table 1. Demographics, Injury, and Surgical Characteristics of Included Patients

	N=29
Sex:	
Female	3 (10%)
Male	26 (90%)
Age (years)	44 (16)
BMI	27 (5)
Rockwood Classification Grade:	
3	5 (17%)
4	1 (3%)
5	23 (80%)
Surgical Approach:	
Scope	5 (17%)
Open	24 (83%)
Operative Technique:	
Modified Weaver-Dunn	2 (7%)
Suspensory Fixation	8 (28%)
Suture	19 (65%)
Surgical Details:	
Allograft Used	16 (55%)
Distal clavicle excision	4 (14%)
Clavicular drill holes	29 (100%)

BMI: body mass index

Structural failure was identified at an average of 17 +/- 16 weeks (range 1-85 weeks) after index surgery with mean

loss of reduction of 97% from initial preoperative films (range 51-236%, SD 46%). Most mechanical failures occurred in the setting of device loosening or subsidence (n = 24, 83%), while 5 cases were the result of device cut through from the clavicle or coracoid (17%). Forty-three percent of patients (n = 12) had greater than or equal to 100% displacement compared to initial postoperative radiographs, equivalent to a type V injury. Twenty-four percent of failures were caused by acute trauma or injury (n = 7) and 76% were related to spontaneous subsidence of the AC joint reduction (n = 22). Of the seven patients who had an acute injury, five were related to blunt trauma to the shoulder as the result of a fall (n = 4) or from firing heavy artillery weaponry (n = 1). Two were the result of events involving indirect force to the shoulder: one was sustained after throwing a frisbee with the operative arm, while the other was caused by weight bearing on the arm while getting out of a chair early in the postoperative period. After structural failure was identified, 21% were treated with revision surgery (n = 6) at mean of 32 weeks after the index procedure (range 3-103 weeks), while 79% were treated nonoperatively (n = 23). For cases of reoperation, four patients underwent revision CC reconstruction and two underwent conversion to DCE.

Mean ASES, NRS, and SANE scores for the entire cohort were 82 +/- 20 (range 33-100), 1.6 +/- 2.2 (range 0-7), and 82 +/- 20 (range 22-100) respectively [Table 2]. Forty-one percent (n = 12) were deemed to have a suboptimal clinical result. These patients had a worse mean ASES score of 66 vs 94 ($p < 0.001$), NRS score of 2.9 vs 0.7 ($p = 0.087$), and SANE score of 68.1 vs 90 ($p = 0.059$) when compared with the remainder of the group. On bivariate analysis, structural failure due to acute injury was correlated with a higher likelihood of sustaining suboptimal outcome (50% vs 6%, $p = 0.011$) and undergoing reoperation (67% vs 13%, $p = 0.018$) when compared to patients who experienced spontaneous, atraumatic loss of reduction [Tables 3 and 4]. Patients with redisplacement of greater than 100% were over twice as likely to have suboptimal outcome, however this was not statistically significant (67% vs 33%, $p = 0.069$). There were otherwise no significant predictors of outcomes or reoperation when based on patient demographics, time to surgery, injury characteristics, or surgical techniques. A separate analysis evaluating effect of mode of fixation failure on outcomes was deferred due to the limited sample size within the "device cut through" group.

Table 2. Clinical Outcomes of Patients Following Structural Failure After Primary AC Joint Reconstruction

	N=29
Time to structural failure (weeks)	17 (16)
Mean Loss of Reduction (%)	97 (46)
Percent Reduction Lost by Severity: (n)	
< 100%	16 (57%)
> 100%	12 (43%)
Reoperation:	6 (21%)
Time to Revision Surgery: (weeks)	32 (36)
Postoperative ASES score	82 (20)
Postoperative VAS score	1.6 (2.2)
Postoperative SANE score	82 (20)
Poor Outcome	12 (41%)
Cause of Failure:	
Injury	7 (24%)
Spontaneous	22 (76%)

ASES: American Shoulder and Elbow Surgeons; VAS: visual analog scale; SANE: single assessment numeric evaluation; Δ: delta or change

Table 3. Comparison of Variables Between Patients with Suboptimal Outcomes Versus Satisfactory Outcomes Following Structural Failure of AC Joint Reconstruction

	Satisfactory Outcome *(N=17)*	**Poor Outcome *(N=12)***	**P Value**
Sex:			1.000
Female	2 (12%)	1 (8%)	
Male	15 (88%)	11 (92%)	
Age (years)	41.6 (16.2)	46.4 (16.2)	0.506
BMI	28 (6)	27 (5)	0.241
Injury to Dominant Arm	9 (64%)	9 (75%)	0.683

Table 3. Continued			
Involved In Sports	10 (59%)	6 (50%)	0.927
Rockwood Classification Grade:			0.465
3	4 (24%)	1 (8%)	
4	1 (6%)	0 (0.00%)	
5	12 (70%)	11 (92%)	
Percent Loss of Reduction (%)	85% (34)	114% (56)	0.227
Percent Reduction Lost by Severity:			0.069
< 100%	12 (75%)	4 (33%)	
> 100%	4 (25%)	8 (67%)	
Time between Injury and Surgery (days)	229 (563)	92.7 (100)	0.425
Technique Used:			1.000
Scope	3 (18%)	2 (17%)	
Open	14 (82%)	10 (83%)	
Allograft Used	7 (41%)	9 (75%)	0.154
Distal Clavicle Excision	3 (18%)	1 (8%)	0.622
Time to Failure (weeks)	16 (9)	18 (23)	0.452
Postoperative ASES Score	94 (5)	66 (22)	0.001
Postoperative VAS Score	0.7 (0.8)	2.9 (2.9)	0.087
Postoperative SANE Score	90 (9)	68 (27)	0.059
Cause of Failure:			0.011
Injury	1 (6%)	6 (50%)	
Spontaneous	16 (94%)	6 (50%)	

Mm: millimeters; %: percentage; ASES: American Shoulder and Elbow Surgeons; VAS: visual analog scale; SANE: single assessment numeric evaluation

Table 4. Comparison of Variables Between Operative and Nonoperative Management Following Structural Failure of AC Joint Reconstruction

	No Reoperation (N=23)	Reoperation (N=6)	P Value
Sex:			1.000
Female	3 (13%)	0 (0%)	
Male	20 (87%)	6 (100%)	
Age (years)	45 (17)	40 (14)	0.360
BMI	27 (6)	28 (5)	0.767
Injury to Dominant Arm	14 (70%)	4 (67%)	1.000
Involved In Sports	14 (61%)	2 (33%)	0.364
Rockwood Classification Grade:			1.000
3	4 (17%)	1 (17%)	
4	1 (4%)	0 (0%)	
5	18 (79%)	5 (83%)	
Initial Coronal Displacement (mm)	15.9 (5.0)	15.6 (6.7)	0.924
Immediate Postoperative Coronal Displacement (mm)	3.8 (5.1)	0.8 (3.5)	0.127
Final Postoperative Coronal Deformity (mm)	14.8 (6.0)	14.8 (4.0)	0.983
Percent Loss of Reduction (%)	93% (39)	116% (67)	0.557
Percent Reduction Lost by Severity:			0.354
< 100%	14 (64%)	2 (33%)	
> 100%	8 (36%)	4 (67%)	
Time between Injury and Surgery (days)	204 (485)	49 (44)	0.609
Technique Used:			1.000
Scope	4 (17%)	1 (17%)	

Table 4. Continued			
Open	19 (83%)	5 (83%)	
Allograft Used	12 (52%)	4 (67%)	0.663
Distal Clavicle Excision	4 (17%)	0 (0%)	0.553
Time to Failure (weeks)	15 (9)	23 (32)	0.726
Postoperative ASES Score	84 (18)	76 (27)	0.466
Δ ASES	25 (30)	30 (40)	0.813
Postoperative VAS Score	1.6 (2.0)	1.6 (3.1)	0.477
Δ VAS	-2.4 (3.6)	-2.8 (4.7)	0.862
Postoperative SANE Score	83 (19)	77 (25)	0.653
Δ SANE	35 (35)	29 (63)	0.862
Cause of Failure:			0.018
Injury	3 (13%)	4 (67%)	
Spontaneous	20 (87%)	2 (33%)	

mm: millimeters; %: percentage; ASES: American Shoulder and Elbow Surgeons; VAS: visual analog scale; SANE: single assessment numeric evaluation; Δ: delta or change

Discussion

Despite improvements in operative techniques for AC joint injuries, indications for surgery remain controversial, and there has continued to be high rates of perioperative complications, especially structural failure. While the clinical impact of loss of AC joint reduction is unknown, it is one of the most common reasons for revision surgery and reflects a lack of understanding of which factors may affect outcomes in these scenarios. This series evaluated patients who experienced structural failure following reconstruction of type III - V AC joint injuries to determine risk factors for a suboptimal clinical outcome and subsequent reoperation.

Our results found that 59% of patients with loss of reduction had satisfactory outcomes. The findings presented reaffirm that many patients have satisfactory outcomes following loss of reduction after AC joint stabilization. While the criteria used to define radiographic failure varies widely among studies, the general findings have remained consistent. Shin & Kim reported loss of reduction of at least 50% of the CC distance in one-third of patients following arthroscopic-assisted CC reconstruction, with no significant difference in Constant scores at mean follow-up of 2 years.[18] Mori et al had vertical instability in 19%, which did not result in any subsequent reoperations or notable differences to clinical outcomes.[13] However, our data suggests that results following structural failure may be more unpredictable, as 41% had a suboptimal result, based on our study definition.

Despite the high rate of structural failure, the revision rate following AC joint reconstruction remains low, which suggests that many patients tolerate loss of reduction well enough to not undergo further surgery. However, many studies lack patient reported outcomes and there has been limited evaluation of why certain patients have worse outcomes. The revision rate among our cohort was 20% which is similar to previously reported data. Chen et al found a revision rate of 14% among patients with structural failure. While chronic injuries and arthroscopic-assisted techniques were identified as possible risk factors for structural failure, their analysis did not include patient reported outcomes or further subgroup analysis regarding reoperation.[16] Spencer et al had a radiographic failure rate of 21% of 154 patients following AC joint reconstruction, of which 24% underwent revision surgery. Outside of their analysis on specific surgical techniques, there were no patient factors, injury characteristics, or surgeon factors associated with loss of reduction or reoperation.[25] Other studies mention rates of structural failure as high as 47% with minimal effect on clinical outcomes, but do not include further evaluation of potential risk factors.[26-28]

The association of an acute injury during the postoperative period with worse clinical outcomes and higher revision rate is a novel finding regarding structural failure after AC reconstruction. While not commonly evaluated, we believe the mechanism of reduction loss is an important factor in the assessment of these patients that can affect treatment strategy. There are numerous possibilities for these findings which are based mostly on the nature of traumatic injuries. Similar to primary AC reconstruction, acute injuries are thought to be associated with improved biological conditions, less scar tissue, and less contraction of the surrounding tissues than chronic injuries, which may allow for improved ease in joint reduction and soft tissue repair even in the revision setting.[29,30] It is also possible that rapid recurrence of AC joint deformity and instability is harder to tolerate for patients when compared to a more gradual loss of reduction over a longer period. Mean time to failure in our group with suboptimal clinical outcomes was 18 weeks, which suggests loss of reduction most commonly occurred following initiation of range of motion and strengthening exercises but prior to unrestricted activity.[31] Therefore, it seems acute injury in these settings occurs more as a "second hit" on a shoulder that has not yet developed adequate dynamic support, which could offer rationale for why these patients demonstrate worse outcomes.[32] Finally, there are

also likely psychological factors which may contribute to worse outcomes following an acute traumatic reinjury, however this was not possible to evaluate with this study design. Given the small size of our cohort, it is certainly possible that these findings are hypothesis generating, and further analysis on this topic is warranted within this and many other types of orthopaedic injuries.[33]

The effect of degree of displacement following structural failure has not been commonly evaluated, as few studies stratify reduction loss based on severity. Choi et al classified loss of AC reduction according to the Rockwood classification on postoperative radiographs and found 23% had "failure of surgery" with either type III or V injuries, however these patients did not have significantly worse outcome scores.[26] Shin & Kim did not classify postoperative loss of reduction, but stratified percent reduction loss based on the Rockwood grade of the original injury and reported that type V injuries comprised 83% of radiographic failures, with no difference in patient reported outcomes.[18] We found that patients with greater than 100% displacement compared to initial postoperative films, equivalent to a type V injury, were over twice as likely to have suboptimal outcomes. While these findings were not statistically significant, they may have clinical relevance and are worthy of further evaluation in future studies. Our analysis also found that a majority of patients with over 100% displacement were originally type V (n = 9, 75%) compared to Type III (n = 3, 25%) injuries, which suggests that amount of original displacement may have an impact, however larger studies are required to confirm this association.

There are several limitations present in this analysis. Retrospective design and exclusion criteria create risk of selection bias. Multiple surgeons limit standardization of operative techniques and postoperative rehabilitation protocols which may provide confounding variables. We also understand that including revision surgery as criterion defining outcomes in our study creates bias due to differing indications among surgeons for reoperation. Use of outcome scores such as ASES, NRS, and SANE to define satisfactory outcomes may serve as a source of bias, as the decision to perform revision surgery is complex and multifactorial, and patient reported outcome scores are not always directly correlated with patient satisfaction. Use of multiple analyses does increase the chance of type I error, as no statistical correction was made for the multiple comparison groups. Finally, our study is limited by small sample size and likely underpowered results, which may lead to some hypothesis-generating conclusions. However, our statistically significant findings in separate bivariate analyses, long follow-up period, and in-depth analysis of a poorly understood complication of AC joint reconstruction are pertinent strengths of this study. Additional larger, prospective studies are recommended to improve our understanding of this complex issue.

Conclusion

Structural failure following surgical management of AC joint injuries is common but poorly understood. While most patients have a satisfactory result, loss of AC joint reduction remains the most common cause of reoperation and can be associated with declining clinical outcomes. Our study found that 59% of patients with structural failure had adequate outcomes, however loss of reduction in the setting of an acute reinjury to the shoulder was associated with a higher likelihood of worse clinical outcomes and subsequent reoperation. We believe this information will be helpful in the evaluation and management of these patients and allow surgeons to better educate patients regarding prognosis when considering revision surgery.

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