Arthroscopically assisted 2-bundle anatomic reduction of acute acromioclavicular joint separations: 58-month findings

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Arthroscopically Assisted 2-Bundle Anatomic Reduction of Acute Acromioclavicular Joint Separations

58-Month Findings

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Background: Currently, no clinical midterm results have been reported on arthroscopically assisted reduction of the acutely dislocated acromioclavicular (AC) joint using suture-button devices for fixation.

Hypothesis: Athroscopically assisted reduction of the acutely dislocated AC joint yields satisfactory clinical outcomes without loss of reduction, clavicle migration, or AC joint degeneration at midterm follow-up evaluation.

Study Design: Case series; Level of evidence, 4.

Methods: The clinical and radiographic outcomes of 23 of 30 consecutive patients (21 men, 2 women) who underwent anatomic reduction for acute AC joint dislocation using 2 suture-button devices between 2006 and 2007 were reviewed. Radiographic evaluation was performed by measurement of coracoclavicular (CC) distance and AC displacement. Clinical evaluation included a visual analog scale (VAS) for pain, the Constant score, the simple shoulder test, and the Short Form–36. Previously, this same patient collective was reviewed after 2 years of follow-up using similar methods.

Results: All 23 patients were available for midterm follow-up examination 58 months postoperatively. There were 3 Rockwood type III, 3 type IV, and 17 type V acromioclavicular joint separations. Mean ± SD follow-up was 58 ± 5.6 months (range, 51-67 months). Most patients (96%) remained very satisfied or satisfied with the procedure outcome. The VAS and Constant score improved significantly when compared with baseline (0.3 ± 0.6 and 91.5 ± 4.7 at 58 months postoperatively vs 4.5 ± 1.9 and 34.5 ± 6.9 at baseline) and remained essentially unchanged when compared with the 2-year outcome scores (0.3 ± 0.6 and 91.5 ± 4.7 at 58 months postoperatively vs 0.25 ± 0.5 and 94.3 ± 3.2 at 2 years). Radiographs showed 8 radiographic failures (undercorrection, posterior displacement, or both) and 4 additional overcorrections of the CC distance. When comparing with 24-month data, 17 of 20 radiographs remained unchanged; 1 case of previous overcorrection drifted into normal AC alignment and 2 cases increased in posterior subluxation of the clavicle.

Conclusion: Arthroscopically assisted reduction of the acutely dislocated AC joint provides satisfactory clinical results 58 months after surgery. Compared with the baseline, all patients improved significantly. Two of 23 patients revealed an increased posterior dislocation compared with evaluation 24 months after surgery. No further migration of the clavicle or AC joint degeneration was observed.

Keywords: acromioclavicular; acromioclavicular joint; subluxation; acromioclavicular separation; anatomic reconstruction; shoulder

Multiple techniques have been reported for restoring acromioclavicular (AC) joint anatomy in vitro** or in clinical studies.[5,6,27,31,34,41,44] Although some techniques require open incisions, other arthroscopic techniques have been reported.[5,6,29,31,38] At least 1 published technique has advocated the use of 2 suture-button devices (TightRope; Arthrex, Naples, Florida) to anatomically replace the torn coracoclavicular (CC) ligaments separately with a nonabsorbable construct. Two-year results of this technique have been published.[29] The authors noted that tunnel and button placement are of utmost importance to avoid postoperative failure or loss of reduction, and substantial arthroscopic experience is preferred for this technique.[29] Previous work on anatomic ligament reconstruction in different clinical injury models[1,14,33,36,37] indicates improved outcomes, which may bode well for the reduction of a separated AC joint.

**References 2, 9, 12, 13, 16, 17, 22, 23, 35, 39, 42.

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The conoid and trapezoid ligaments have unique anatomic alignments, allowing them to have different functions. Each ligament should be considered when being reconstructed or replaced.[11,20,24] The CC ligaments are considered the prime suspensory restraint against translation in the horizontal and vertical plane.[10,15,18] Despite this, only a few reconstruction methods have focused on CC replacement techniques that account for both ligament locations.[5,6,31,34]

Previously, our group developed an arthroscopic reconstruction technique designed to be deployed in the immediate postinjury period. The short-term (2-year) clinical outcomes of the technique were encouraging. Our aim is to report the midterm (58-month) clinical and radiographic outcomes of the same patient collective in an effort to determine if the good clinical outcomes are sustained over the longer term.[29]

We hypothesized that the patient collective had maintained satisfactory clinical outcomes without loss of reduction, clavicle migration, or AC joint degeneration.

MATERIALS AND METHODS

Between April 2006 and July 2007, a total of 30 consecutive patients with acute (<3 weeks) AC joint dislocation were operatively treated with an AC joint reconstruction using 2 suture-button devices (TightRope; Arthrex). In all cases, the first-generation TightRope system was used consisting of a round calvicular (6.5 mm in diameter) and 1 oblong coracoid titanium button (10 × 3.5 mm). Both buttons were connected by No. 5 FiberWire sutures (Arthrex). Chronic separations were excluded from this study as well as patients who had previous operative treatment of the injured shoulder.

Of these initial 30 patients, 7 were excluded: 2 demonstrated failure of fixation and required surgical revision, 1 patient underwent implant removal because of superficial infection before the 6-month evaluation, and 4 patients were lost to follow-up before the 6-month clinical follow-up. Twenty-three patients were prospectively assessed both clinically and radiographically preoperatively, as well as 6, 12, and 24 months postoperatively, and these data were published in 2010.[29] All 23 patients who were evaluated at the latest follow-up (24-month follow-up data; Table 1) were available for repeat examination. No patients from the 24-month follow-up group were lost to follow-up.

Clinical and radiographic data from the 58-month follow-up were statistically compared with baseline and 24-month follow-up data.

Clinical outcome measures included a visual analog scale (VAS) for pain (0 representing *no pain* and 10 representing *maximal imaginable pain*), the Constant score,[8] the simple shoulder test,[21] the Short Form–36[43] (compared with a healthy German control group at the 50th percentile),[4] and an overall 4-part satisfaction scale (very satisfied = 1, satisfied = 2, partially satisfied = 3, not satisfied = 4). The study was approved by the local institutional review board (project number: 2083/08), and all patients again signed an informed consent form before assessment.

Surgical Technique

The technique has been described previously.[30,42] Patients were placed in a beach-chair position, and general anesthesia was performed. A standard posterior, anterior, and anterolateral portal was established and a thorough diagnostic arthroscopy of the shoulder was performed, including any possible therapeutic intervention. By radiofrequency, the arch and base of the coracoid process were prepared with the arthroscopic camera placed in the anterolateral portal and the preparation device in the anterior portal. A 3-cm incision perpendicular to the clavicle was made about 3.5 cm medial to the AC joint. Next the AC joint was reduced manually by elevating the arm against the scapula to avoid offset of the bone tunnels. Two K-wires were placed through the clavicle and the coracoid in anatomic position. Exact positioning had been measured according to data by Rios et al[26] and Salzmann et al.[28] Subsequently, 2 independent 3.5-mm bone tunnels were drilled over the K-wires through the clavicle and through the coracoid, and 2 TightRope devices were inserted to independently replace the conoid and trapezoid ligaments and hold the AC joint in reduction. The free limbs of the suture-button devices were secured with alternating surgical knots in a reduced and fluoroscopically controlled position of the AC joint. The deltotrapezoid fascia and skin was closed in layers, and the arm was put in a sling for 6 weeks with limited range of motion. Active range of motion could be trained after 6 weeks of surgery. Return to contact sports activities was allowed 6 months after the procedure.

Radiology

Unilateral anteroposterior (AP) stress and axillary views were obtained at all previous follow-up time points (6, 12, and 24 months postoperatively) as well as at 58 months postoperatively.[27] The CC distance was measured as the distance between the highest location on the dorsal surface of the coracoid and opposing clavicular undersurface on AP

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TABLE 1
Results of the VAS for Pain, the Unweighted CS, the SST, the SF-36 PCS, the SF-36 MCS, and Patient Satisfaction Preoperatively and at 6, 12, 24, and 58 Months Postoperatively (N = 23)[a]

	Baseline	6 mo	12 mo	24 mo	58 mo[b]
VAS	4.5 ± 1.9	1.4 ± 1.3	0.35 ± 0.7	0.25 ± 0.5	0.32 ± 0.6[c]
CS	34.5 ± 6.9	89.0 ± 5.7	93.9 ± 4.9	94.3 ± 3.2	91.5 ± 4.7[c]
SST	2.8 ± 2.1	11.1 ± 1.6	11.9 ± 0.6	12.0 ± 0	11.8 ± 0.5[c]
SF-36 PCS	46.7 ± 8.3	53.9 ± 3.8	55.9 ± 4.6	56.2 ± 3.2	57.9 ± 2.7[c]
SF-36 MCS	49.3 ± 7.3	50.9 ± 3.9	50.5 ± 8.7	51.1 ± 1.9	49.2 ± 7.9
Satisfaction	NA	1.3 ± 0.5	1.1 ± 0.3	1.0 ± 0	1.2 ± 0.5

[a]Values are presented as mean ± SD. CS, constant score; NA, not available; SF-36 MCS, Short Form–36 Mental Component Scale; SF-36 PCS, Short Form–36 Physical Component Scale; SST, simple shoulder test; VAS, visual analog scale.
[b]No significant difference between the 24- and 58-month follow-up evaluations could be found ($P > .05$).
[c]Difference statistically significant ($P < .05$) between baseline and 58 months.

stress views. The AC displacement was measured as the distance between the anterior edge of the lateral clavicular end and the acromion on axillary views. Posterior displacement was denoted with negative values.

Statistical Analysis

Statistical analysis was done using SPSS for Windows (version 20; SPSS Inc, Chicago, Illinois). For comparison of quantitative data between 2 groups, Mann-Whitney *U* tests were performed; comparisons between more than 2 groups were conducted using the Kruskal-Wallis test or 1-way analysis of variance. For evaluation of changes of quantitative outcomes within the whole study population, Wilcoxon signed-rank tests were used. A P value $< .05$ was considered significant. Data are reported below as mean ± standard deviation (SD).

RESULTS

Clinical Outcome

From the initial 30 patients who were treated at our department, 7 patients already had been excluded (23%).[29] Twenty-three of 30 patients remained for follow-up. All 23 patients who were evaluated at the latest follow-up (24 months) (Table 1) were available for repeat examination. No patients from the 24-month follow-up group were lost to follow-up.

The average postoperative follow-up was 58 ± 5.6 months. The study cohort comprised 21 men and 2 women.[29] There were 3 Rockwood type III, 3 Rockwood type IV, and 17 Rockwood type V separations. Nineteen patients stated that they were very satisfied with the results of the surgery, 3 were satisfied, and 1 patient was partly satisfied. The mean ± SD Constant score for the 58-month follow-up group (91.5 ± 4.7) was significantly different from the Constant score at baseline (34.5 ± 6.9; $P < .05$). The Constant scores of the 58-month (91.5 ± 4.7) and 24-month (94.3 ± 3.2) follow-up time point were not significantly different ($P > .05$) (Table 1). The VAS improved from 4.5 ± 1.9 at baseline significantly to 0.3 ± 0.6 at the 58-month follow-up ($P < .05$). When comparing 58-month data (0.3 ± 0.6) with 24-month data (0.25 ± 0.5), no significant difference could be detected.

All patients retained full range of motion. Clinical examination revealed no tenderness at the location of the clavicular buttons. This was improved when compared with the 24-month follow-up time point when 7 patients reported mild tenderness at the clavicular buttons.

Furthermore, none of the patients complained of any pain at the stabilized AC joint in maximum shoulder abduction (above 120°), and no strength deficits were found. The cross-body adduction test[7] was positive in 2 patients.

Radiographic Outcomes

Three of 23 patients refused radiographic examination. These 3 patients had Constant scores of 89, 92, and 95, respectively. The 20 patients who were available for radiographic evaluation were evaluated radiographically at the 24-month follow-up.

In total, 17 of 20 patients who were evaluated radiologically (85%) had radiographs that were essentially unchanged when compared with the 24-month radiographs. Figure 1 shows unchanged radiographs of 1 patient 24 and 60 months after surgery who had a Rockwood type V injury preoperatively.

On AP stress views, the average CC distance was 10.8 ± 3.2 mm (range, 6-16 mm). Compared with preoperative data (20.5 ± 4.6 mm; range, 13-27 mm), the average CC distance decreased significantly ($P < .05$). The average CC distance did not change between 58-month data (10.8 ± 3.2 mm; range, 6-16 mm) and 24-month data (10.5 ± 3.6 mm; range, 6-16 mm) ($P > .05$). The AC displacement on axillary views (the distance between the anterior edge of the clavicle and the acromion) for all patients was on average –4.8 ± 6.9 mm (range, –20 to 5 mm) 58 months postoperatively. Before surgery, the AC displacement on axillary views was –5.9 ± 6.9 mm (range, –14.5 to 2 mm) and therefore did not change significantly ($P > .05$). The 58-month data (–4.8 ± 6.9 mm; range, –20 to 5 mm) did not significantly change when compared with 24-month follow-up data (–4.9 ± 6.9 mm; range, –17 to 2 mm) ($P > .05$).

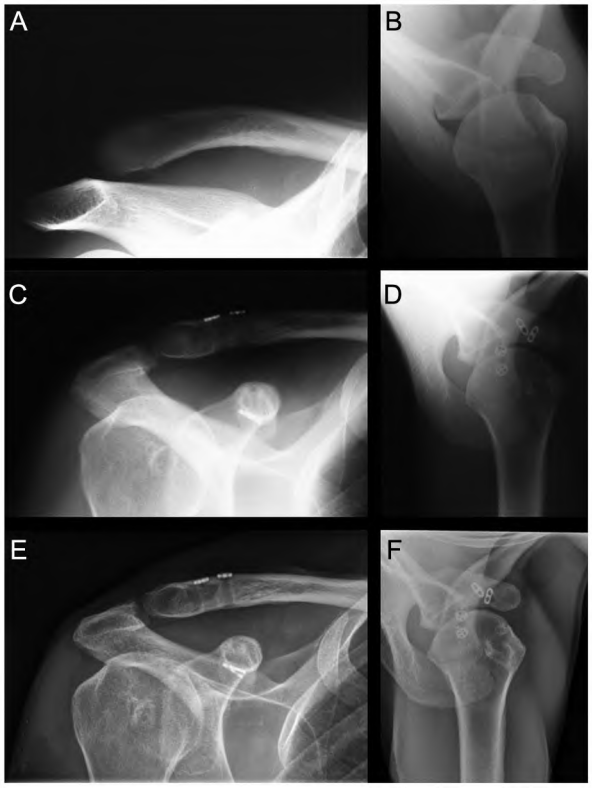

Figure 1. Conventional radiographs of 1 patient with a Rockwood type V injury preoperatively (A, B), 24 months postoperatively (C, D), and 60 months postoperatively (E, F) on anteroposterior stress (A, C, E) view (5-kg load) and axial view (B, D, F). Acromioclavicular articulation and button position remained unchanged when comparing images from 24 months with those from 60 months. No ossifications are visible. The acromioclavicular joint does not show any signs of osteoarthritis.

The clavicular bone tunnels that were operatively drilled were visible in 19 of 20 patients (at the 24-month follow-up, clavicular bone tunnels were visible in 21 of 23 patients). The coracoid bone tunnels were visible in 12 patients at 58 months postoperatively (identical to the 24-month follow-up data). There was no increased radiolucency or tunnel widening when comparing the 58-month follow-up data with the 24-month follow-up data.

Clavicular button position did not change at 58 months postoperatively. There was increased ossification visible surrounding the buttons in 10 patients. This ossification was not clearly visible on the 24-month follow-up radiographs.

Coracoideal button position remained unchanged, and no additional ossification was visible. Postoperative calcification of the CC ligaments was visible in 12 patients (60%) and was increased compared with the 24-month follow-up radiographs in which calcification was visible in 7 patients (30%). Two patients revealed extensive ossification (Figure 2). However, these patients were not clinically different when compared with the patients in whom no ossification was noted on radiographs. These patients did not report

Figure 2. Conventional anteroposterior radiograph (stress view with a 5-kg load) of the right shoulder 56 months postoperatively after acromioclavicular joint reduction using 2 TightRope (Arthrex, Naples, Florida) devices depicting sustained anatomic reduction with extensive ossification in projection of the coracoclavicular ligaments. The patient demonstrated full range of motion of the right shoulder without pain.

any increased AC joint stability compared with those who had no ossification. Both patients reported identical clinical outcomes for the 24- and 58-month follow-up time points. Among the 2 patients who had a positive crossbody adduction test, 1 patient had radiographic signs of osteoarthritis. The other patient had no radiographic signs of osteoarthritis. Before surgery, no radiographic signs of osteoarthritis could be detected in any patient. No implant failure, fracture, or need for revision surgery occurred between 24 months postoperatively and the latest follow-up. In total, radiographs showed 8 radiographic failures (undercorrection, posterior displacement, or both) and 4 additional overcorrections of the CC distance. When compared with 24-month data, 17 of 20 radiographs remained unchanged despite 3 patients who showed radiographic changes. One patient showed a loss of overreduction (CC distance increased from 7-9 mm, and as a consequence, the AC joint was in physiologic position on the 58-month radiograph). This patient was partly satisfied, with a Constant score of 91 (24 months postoperatively, this patient was very satisfied, with a Constant score of 93). The second and third patients with 58-month radiographic changes revealed an increase in posterior clavicle position. The second patient had an increase in posterior displacement from –17 to –20 mm, whereas the Constant score was stable at 87 (previously 91 at 24 months). The third patient had an increase in posterior displacement from –15 mm at 24 months to –20 mm at 58 months, and the Constant score remained identical at 94 (94 at 24 months). Both patients were very satisfied at both 24 and 58 months postoperatively.

DISCUSSION

Various techniques to operatively reduce a separated AC joint have been described. However, most techniques (coracoacromial ligament transfer, hook plate fixation, wire fixation, suture or screw fixation) do not anatomically restore the complex articulation of the AC joint, and

therefore some have been noted to provide inferior biomechanical results in a cadaver study.[22] Consequently, more current techniques have focused on anatomic CC ligament reconstruction.[29,31,41,44] The surgical technique applied here aims to reduce the separated AC joint by anatomic replacement of the CC ligaments using an arthroscopic approach.[30] After reporting our 2-year findings,[29] we present the midterm results of this technique. Fifty-eight months after initial arthroscopic anatomic reduction using 2 suture-button devices, clinical and radiographic data confirm the good clinical outcomes of this technique. The construct has been biomechanically tested and was established as a successful time-zero biomechanical construct.[42] Initial stability in the superoinferior as well as in the anteroposterior plane was significantly higher than in the native CC ligaments. Although the ligaments are not repaired with this technique, they are expected to heal along the suture material and thus provide lasting stability. By restoration of the normal AC joint anatomy, ligament remnants are brought into contact to allow for healing.[19] This technique of arthroscopic AC joint reduction should be performed in the immediate postinjury period when hematoma and ligament remnants are still available. Therefore, this technique should be applied only in the acute setting, within 2 weeks after initial trauma. In chronic AC joint separations beyond that time frame, it is likely that the use of a graft is required.[32,38]

A further advantage of this technique is that an arthroscopic approach allows simultaneous evaluation of the glenohumeral joint. Although open surgical techniques may result in good clinical results,[34,44] we prefer a diagnostic glenohumeral arthroscopic evaluation because it is known that concomitant injuries are common in AC joint dislocations and may occur in up to 20% of patients.[40] If serious glenohumeral joint injury is encountered, it can be corrected during the same surgical procedure. As reported previously, we found a total of 4 of 23 concomitant injuries (17.4%) in our collective, all being addressed within surgery[29]: 1 type I superior labrum anterior-posterior (SLAP) lesion, which was arthroscopically debrided; 2 type II SLAP lesions, in which a biceps tenodesis was performed; and 1 type IV SLAP lesion, which was arthroscopically repaired using suture anchors.

An arthroscopic approach leads to less dissection of tissues, which may lead to better cosmetic results, less chance of implant removal surgery in the future, and less time in the hospital. The use of suture-button devices for AC joint repair was initially performed using a single device.[45] This technique does not allow for an exact anatomic reconstruction and therefore cannot provide 2-plane stability. As a result, horizontal translation may not be addressed. This might lead to recurrent instability or even suture rupture, as described by Motta et al.[25]

Our data demonstrate that AC joint reconstruction using 2 suture-button devices is a promising technique, which retains satisfactory clinical results. Moreover, our data reveal that the technique described—once applied successfully—ensures stable recovery of the AC joint. One patient later had shoulder magnetic resonance imaging (MRI) for an unrelated complaint, but this MRI did reveal notable tissue healing at the anatomic site of the CC ligaments (Figure 3). Extensive scar tissue was generated to replace the former ligaments. Low signal intensity appeared ligament-like on T1- and T2-weighted sequences, most likely representing collagenous tissue. We hypothesize that the CC replacement tissue may be responsible for ongoing AC joint stability in the patients reviewed for this study. Our thought is that the arthroscopic dual-button technique provides enough dual-plane stability in the immediate postinjury period to allow CC ligament healing or scarring.

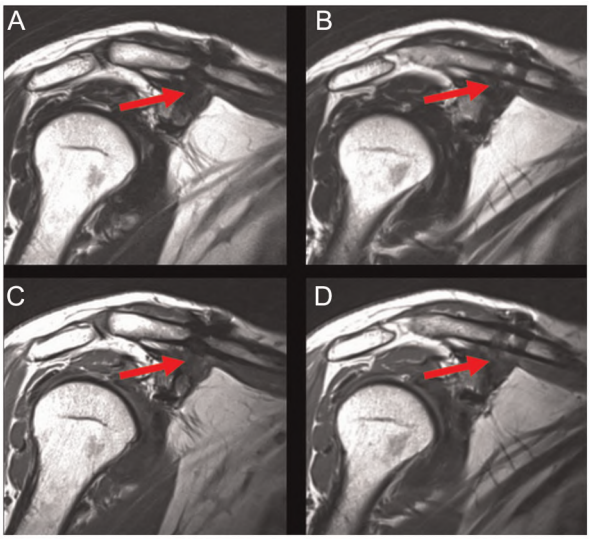

Figure 3. Paracoronal magnetic resonance images (MAGNETOM Verio 3T; Siemens Healthcare, Siemens AG, Erlangen, Germany) of a right shoulder 69 months after acromioclavicular joint reduction using 2 TightRope (Arthrex, Naples, Florida) devices. Magnetic resonance imaging shows tissue with low signal intensity in T1 turbo spin echo (A, B) and T2 spin echo (C, D) in localization of the coracoclavicular ligaments (arrows), most likely collagenous tissue.

In 2 cases, we found extensive ossification in the location of the former CC ligaments (Figure 2). We did not observe progressive radiographic degeneration of the AC joint but detected slightly increased signs of osteoarthritis of the AC joint within patients who already showed degenerative changes of the AC joint preoperatively.[46] It has been noted by prior authors that there is a significant relationship between age and degenerative changes of the AC joint in asymptomatic patients. Therefore, radiological abnormalities should always be interpreted in the context of the patient's symptoms.[3]

Scheibel and colleagues[31] recently reported on their 2-year results of 28 patients with only Rockwood type V dislocations, also arthroscopically reduced using the double TightRope technique. They found similar results to our early data despite the presence of partial recurrent horizontal and vertical AC joint instability; high patient satisfaction rates and good clinical results were reported. The subjects that have been reported on by Scheibel and colleagues[31] had constant scores of 91.5 (2 years

postoperatively) versus 94.3 (24 months) and 91.5 (58 months) within our patient collective. Scheibel and colleagues[31] reported on a CC distance of 13.6 mm (range, 5-27 mm) 2 years postoperatively compared with 10.8 ± 3.2 mm (range, 6-16 mm) at 24 months and 10.5 ± 3.6 mm (range, 6-16 mm) at 58 months postoperatively in our patients, taking into account that Scheibel et al reported on high-grade dislocations only.

Our 24-month radiographic results included cases with over- and undercorrection or posterior clavicular displacement. The 58-month results are essentially the same, with only 3 minor changes in clavicle position, none of which seem to have affected clinical outcomes.[29] Furthermore, there was no significant difference in patient satisfaction or clinical outcomes when comparing anatomically reduced patients with those who were noted on radiographs to be under- or overcorrected.

Limitations of the study include our small patient collective of 30, of whom 23 patients were available for 58-month follow-up. As the double TightRope technique represents a rather new technique to repair the torn AC joint, to our knowledge, no other 5-year follow-up data have been published in the literature so far. Thus, our results give supportive evidence for good clinical midterm results after AC joint stabilization by use of 2 suture-button constructs.

In summary, this study notes the satisfactory clinical and radiographic outcomes of 23 consecutive patients evaluated 58 months after anatomic, arthroscopically assisted suture-button reconstruction of the acutely separated AC joint. Immediate joint stabilization allows for the healing of the ligaments without the use of graft material. Future directions of research could include longer term follow-up in an effort to quantify the development of secondary AC joint osteoarthritis. In addition, if the surgical technique were applied to a larger patient collective, comparison could be made with other AC joint reconstruction techniques.

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