ORIGINAL ARTICLE

CiSE
Clinics in Shoulder and Elbow

Clinics in Shoulder and Elbow Vol. 20, No. 2, June, 2017
https://doi.org/10.5397/cise.2017.20.2.59

All-arthroscopic, Guideless Single Suture-button Fixation of Acute Acromioclavicular Joint Dislocation: A Description of the Technique and Early Treatment Results

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Background: The purpose of this study was to examine the clinical and radiological results of the all-arthroscopic, suture-button fixation technique to treat acute acromioclavicular (AC) joint separations.
Methods: All patients with acute AC joint separations received all-arthroscopic, single suture-button (TightRope) procedure without a special guide. Postoperative Constant score (CS), pain level according to visual analogue scale, and range of motion (ROM) were evaluated. For radiological evaluation, coracoclavicular distances were measured bilaterally.
Results: Between December 2010 and June 2012, 18 consecutive patients (4 women and 14 men; mean age, 29.3 years) with acute AC joint separations underwent surgical treatment after 6.4 days (range, 2–20 days) following the initial trauma. The average postoperative follow-up was 16.9 months. The mean CS was 92.4 (range, 84–96). The mean external rotation, forward flexion, and abduction were 75.8° (range, 50°–90°), 170° (range, 150°–180°), and 163.8° (range, 140°–180°), respectively. Five patients exhibited coracoclavicular ossifications. In two patients, superficial wound infections were successfully treated with antibiotic therapy. In one patient, a coracoid fracture was observed. No significant differences were found regarding pain, ROM, or strength parameters between both sides. The coracoclavicular distance was discovered to be approximately 2.8 mm greater on the affected side; however, this minimal reduction loss did not affect the functional results.
Conclusions: The findings of this study suggests that all-arthroscopic treatment of AC joint separations using the single suture-button technique without a drill guide is safe, yielding good to excellent clinical results.
(Clin Shoulder Elbow 2017;20(2):59-67)

Key Words: Acromioclavicular joint dislocation; Arthroscopic fixation; Suture-button fixation

Introduction

Acromioclavicular (AC) joint dislocation is a common shoulder injury, particularly among young and active patients. This injury may be classified into six types, according to Rockwood.[1)] Typically, types I and II are treated conservatively.[2)] Although there is a consensus regarding surgical treatment for types IV through VI, the management of type III injuries remains controversial, particularly in physically active patients.[3)] The International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) Upper Extremity Committee recommended that types IIIA and IIIB injuries need to modified on the Rockwood classification to distinguish between stable and unstable type III injuries; the latter with therapy-resistant scapular dysfunction and overriding of the clavicle on the Alexander view. According to their algorithm, type III injuries should mainly be treated conservatively with a reevaluation in 3 to 6 weeks, with consideration to surgical therapy in case of persistent instability.[4)]

Beitzel et al.[5)] showed a lack of evidence to support early versus delayed surgical interventions as well as anatomic versus

Received February 13, 2017. **Revised** April 19, 2017. **Accepted** April 23, 2017.

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IRB approval (No. 23.07.2015-10).

Financial support: None. **Conflict of interests:** None.

pISSN 2383-8337
eISSN 2288-8721

non-anatomic surgical techniques in the treatment of patients with AC joint dislocations, despite the previously described 151 techniques for operative reconstruction of the AC in the literature.

Recently, arthroscopically-assisted stabilization techniques have gained much popularity. In these procedures, tunnel and button placements are critically important to avoid early loss of reduction.[6] The suture-button device (TightRope; Arthrex, Naples, FL, USA) was developed to anatomically reconstruct the coracoclavicular (CC) ligaments.[7] Until now, all relevant studies have been performed using the arthroscopically-assisted technique with the aid of a drill guide and an image intensifier during the placements of clavicular and coracoid holes. Three-dimensional C-arm flat detector navigation has even been suggested.[8]

The purposes of this study were to describe an all-arthroscopic anatomic reconstruction of the AC joint using the single suture-button technique without the use of a drill guide and to document the clinical and radiological outcomes of patients following acute AC joint dislocations of type III through V. Our hypothesis was that all-arthroscopic AC reconstructions with the single suture-button technique would provide satisfactory functional and radiological outcomes with minimal complications.

Methods

All patients with acute AC joint separations were treated using the entirely arthroscopic, single suture-button procedure without the use of a special guide, which is described below. The institutional review board approved the study protocol, and all patients read and signed the detailed informed consent form regarding treatment. In all cases, the first-generation TightRope system, which consists of two titanium buttons, a round clavicular (6.5 mm in diameter), and an oblong coracoid button (3.5 mm) connected by a nonabsorbable No. 5 FiberWire suture (Arthrex), was used. A total of 18 patients were included in this study: 10 patients with sustained acute type III separations, 2 with acute type IV injuries, and 6 with acute type V injuries, in accordance with the Rockwood classification. Indications for surgical treatment included type III instability in manual/overhead workers and with type IV and V injuries in athletes. The time to operative treatment was 6.4 days (range, 2–20 days). Other patients with acute type I–II and type III AC joint injuries without high daily demands and those who refused surgical intervention were treated non-operatively. Patients with chronic AC joint instabilities were also excluded. Among these 18 patients, 4 were female and 14 were male. The mean patient age was 29.3 years (range, 22–40 years). The dominant arm was injured in 12 patients.

Table 1. Patient Demographics and Constant Scores

Patient No.	Gender	Age (yr)	Injured side	Trauma mechanism	Rockwood type	Return to daily activity (wk)	Surgical timing (d)	Constant score
1	Male	32	Dominant	Fall from bike	III	6	5	93
2	Male	27	Non-dominant	Fall during sports	III	5	7	94
3	Male	36	Non-dominant	Fall from standing	III	6	2	93
4	Male	22	Non-dominant	Traffic accident	V	10	20	84
5	Male	22	Dominant	Fall from bike	IV	6	4	96
6	Male	40	Dominant	Traffic accident	III	8	5	90
7	Male	30	Non-dominant	Traffic accident	V	5	5	93
8	Female	25	Dominant	Fall from bike	III	4	2	96
9	Male	27	Dominant	Fall during sports	V	6	4	96
10	Male	23	Dominant	Fall during sports	III	6	5	96
11	Male	36	Non-dominant	Traffic accident	IV	5	10	90
12	Male	23	Dominant	Fall from bike	III	6	6	90
13	Female	25	Dominant	Traffic accident	III	6	5	94
14	Male	30	Dominant	Fall during sports	V	7	10	84
15	Female	35	Dominant	Traffic accident	V	4	7	93
16	Male	29	Non-dominant	Traffic accident	V	4	7	90
17	Male	33	Dominant	Fall during sports	III	3	4	96
18	Female	32	Dominant	Fall during sports	III	5	7	96

Eleven AC joint separations were caused by direct trauma to the shoulder, and 7 patients were caused by indirect trauma following car accidents. Four patients injured their shoulders while falling from their bicycles, 6 patients while playing sports, and one patient while falling from a standing position (Table 1).

The radiographic diagnoses of AC joint separations were established using true anteroposterior view of the affected shoulder, and bilateral anteroposterior stress views with 10-kg loads on both sides. The CC distance was measured between the coracoid process and the inferior cortex of the clavicle on the anteroposterior stress views.

Surgical Technique

All patients were informed about the risks and benefits of the surgical technique, with respect to and those of other operative and conservative therapies. All patients provided written informed consent that their data could be used for research prior to undergoing the operation. The same surgeon performed all operations using the standardized procedure, as described below. Under general anesthesia and perioperative intravenous antibiotics (2 g, cefazolin), patients were placed in a beach-chair position with the injured arm and shoulder prepared and draped in sterile fashion. The following five portals were used for this all-arthroscopic technique: one posterior standard initial portal, one anterior rotator interval portal, one lateral viewing portal, and 2 working coracoid and clavicular portals (Fig. 1).

First, the diagnostic arthroscopy of the shoulder was performed through the standard posterior portal. Subsequently, the anterior rotator interval portal was used to open the anterior rotator interval to expose the coracoid insertion of the coracoacromial ligament, the conjoint tendon, and the superoinferior borders of the coracoid process. Next, the subcoracoid space and the base of the coracoid process were prepared with the aid of a radiofrequency ablation device or a shaver that was introduced through the anterior portal (Fig. 2).

The aim was to obtain a clear visualization of the undersurface and the superior border of the coracoid process, through which the drill holes could be made. Subsequently, a lateral viewing portal was established using the outside-in technique on the same plane as the coracoid process to gain a good visualization to ensure a safe fixation.

A 2.0-mm Kirschner (K) wire was inserted, using another anterior coracoid portal, and passed through the medial aspect of the coracoid process under visual control of the superoinferior borders through the lateral viewing portal. The K-wire was overdrilled using a cannulated 4.0-mm drill bit, and then a nitinol suture passer was inserted into the subcoracoid space through the drill. The cannulated drill bit was then removed, and both ends of the nitinol suture passing the wire were held with a clamp. The nitinol wire was retrieved via the posterior portal. Another K-wire was introduced through the clavicular portal over the desired centered entry point approximately 4 cm from the lateral end of the clavicle toward the direction of the coracoid base. After identifying the K-wire in the supracoracoid area, it was overdrilled. Then, an additional suture shuttle was passed through the clavicular drill hole. These coracoid and clavicular shuttles were linked together using the anterior and posterior portals. The TightRope device was attached to the nitinol suture shuttle and pulled from the posterior portal under arthroscopic lateral visual control until the oval-shaped button was flipped beneath the coracoid arch (Fig. 3).

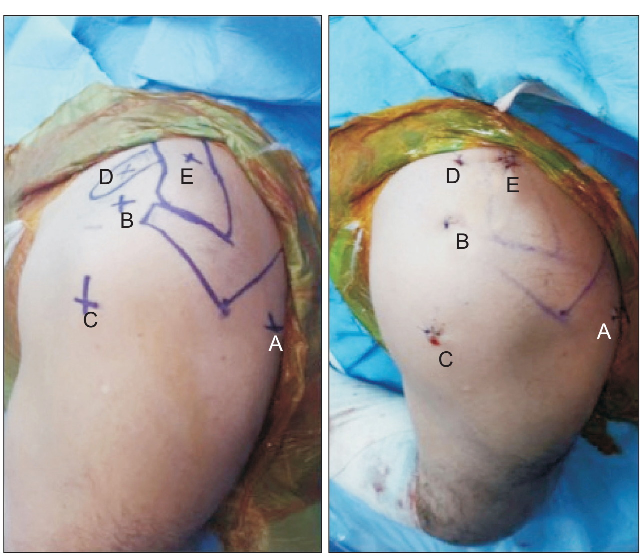

Fig. 1. Posterior standard viewing portal (A), anterior interval portal (B), lateral viewing portal (C), 2 working coracoid (D), and clavicular (E) portals were used.

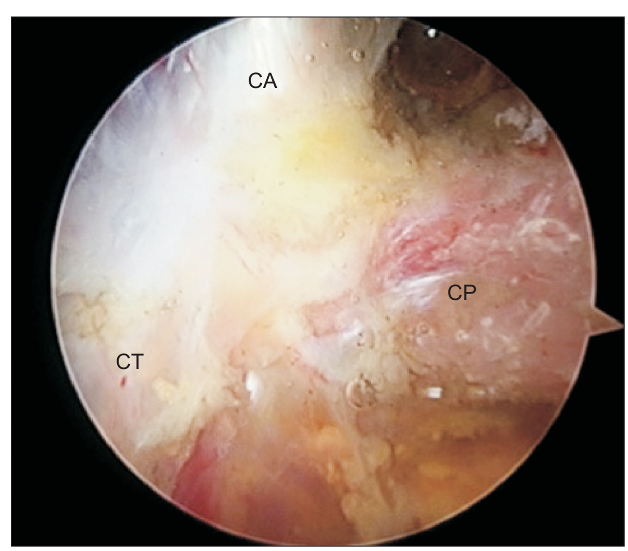

Fig. 2. The coracoid process (CP), the coracoacromial (CA) ligament, and the conjoint tendon (CT) are visualized.

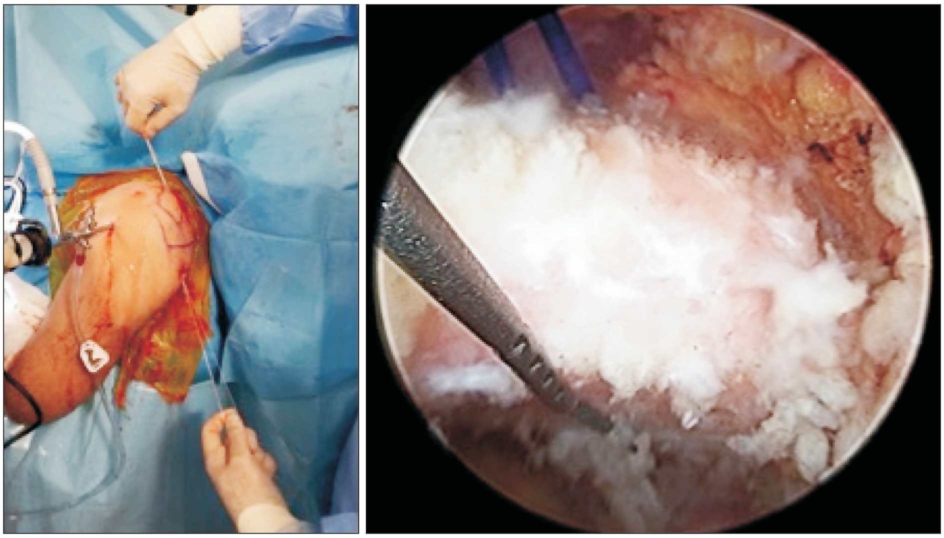

Fig. 3. The TightRope devices were attached to the nitinol suture shuttle and pulled from the posterior portal under arthroscopic lateral viewing control until the oval-shaped button was flipped beneath the coracoid arch.

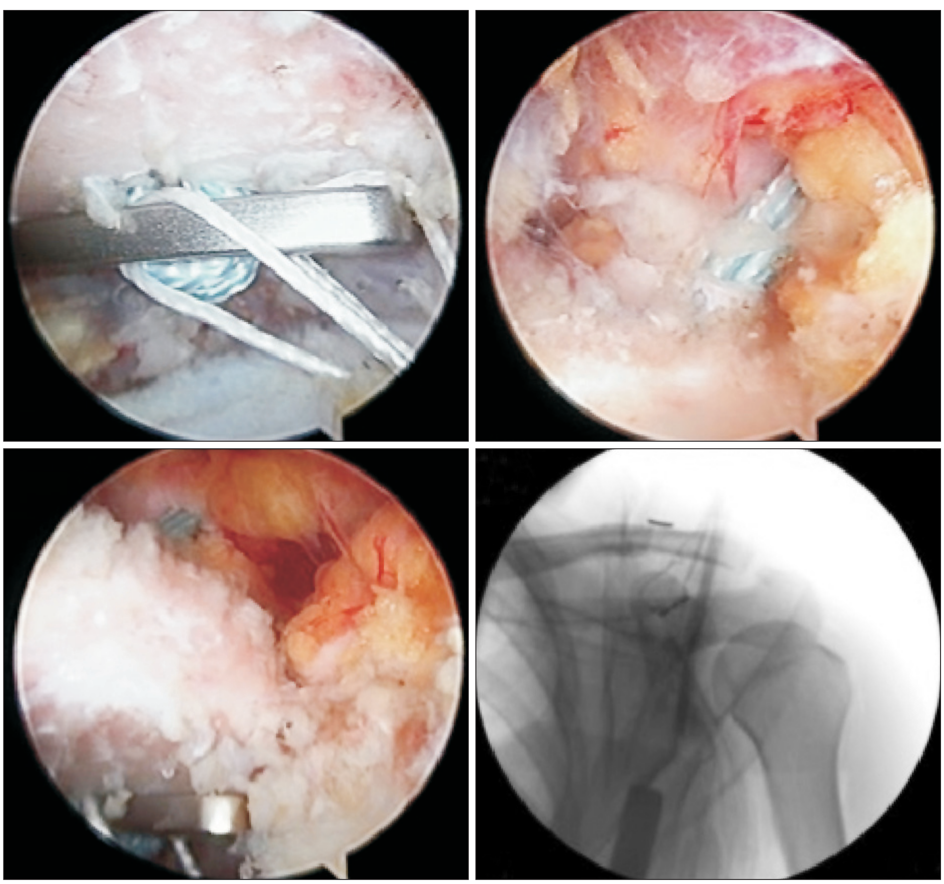

Fig. 4. Anatomical reduction of the acromioclavicular joint under direct visualization and radiographic control.

A grasper was used to place the inferior button perpendicular to the coracoid base. Subsequently, as the weight of the arm was supported from below, the surgeon pulled on the No. 5 FiberWire sutures of the TightRope device, reducing the AC joint anatomically under radiographic control (Fig. 4). Once reduction was achieved, the sutures on the clavicular button were knotted. The arthroscopic portals were closed in a standard fashion. Then, the postoperative radiographs were obtained.

Postoperatively, the shoulder was protected in a sling (shoulder immobilizer; DJO, Carlsbad, CA, USA) for 2 weeks. Subsequently, the shoulder was passively mobilized with maximum flexion and abduction of 45° in the first 3 weeks and 90° in the follow-

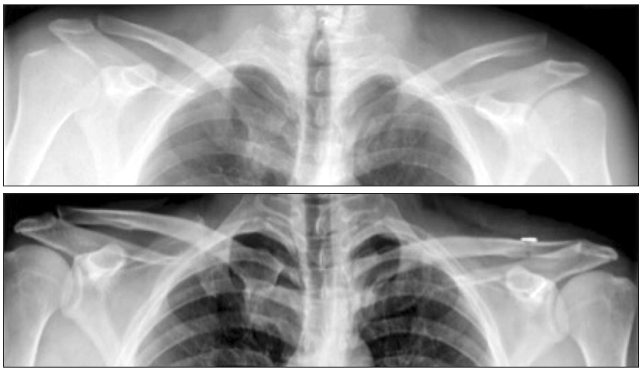

Fig. 5. Anteroposterior stress views before and after the operation. The acromioclavicular joint is anatomically reduced.

ing 3 weeks. Beginning in the 7th postoperative week, the free passive range of motion was allowed. Moreover, patients began active range of motion exercises. Patients were prohibited from performing activities that stressed the AC joint, such as reaching, pushing, and pulling. Muscle strengthening exercises were postponed for up to 12 weeks.

The final evaluation consisted of a complete physical examination of both shoulders, including the clinical tests for AC joint disorders (i.e., the AC joint tenderness, cross-body and resisted AC joint compression tests). Additionally, the Constant score (CS)[9] was used to clinically evaluate the AC joint.

The abduction strength was measured at 90° of abduction in the scapular plane bilaterally, using a handheld Nicholas Manual Muscle Tester dynamometer (Model 01160; Lafayette Instrument Company, Lafayette, IN, USA). This dynamometer allows for muscle strength measurements to increase, from 0.0 to 199.9 kg, with a precision of 0.1 kg. The mean values were calculated following 3 assessments on each side.

Vertical stability was evaluated on the anteroposterior stress views. For all measurements, the unaffected contralateral side served as the control (Fig. 5).

Heterotopic ossifications were graded into three categories: None, mild, and severe. Bone formation around the CC ligament without bridging was graded as mild, and bridging was graded as severe.

Statistical analysis was performed using IBM SPSS ver. 20.0 (IBM Co., Armonk, NY, USA). Descriptive statistics were used to calculate the means and standard deviations. The distribution ratios of the qualitative variables were analyzed using Fisher's exact test. The metric data were compared using independent-samples t-tests. Paired t-tests were used to examine the differences within the groups. CS results were correlated using the Spearman correlation coefficient. Ordinal data were compared using the Mann-Whitney U-test. Wilcoxon signed rank tests were utilized to examine the differences within groups. The level of significance was defined as $p=0.05$.

Results

Clinical Outcomes

Between December 2010 and June 2012, a total of 18 consecutive patients (4 women and 14 men; mean age, 29.3 years) with acute AC joint separations were treated. All of these 18 patients were followed-up until final evaluation. The average postoperative follow-up was 16.9 months (range, 12–26 months). The study cohort was comprised of 14 men and 4 women, who altogether sustained 10 Rockwood type III, 2 Rockwood type IV, and 6 Rockwood type V separations. The average day for surgical treatment was 6.4 days (range, 2–20 days) after the initial trauma. In 12 patients, the dominant arm was injured. Pain was recorded using a visual analogue scale, which decreased from 7 (range, 6–9) preoperatively to 1 (range, 0–4) at the last follow-up.

The mean time to return to daily activities was 5.6 weeks (range, 3–10 weeks). No difference was observed in the time required to return to daily activities between subjects who sustained injuries on the dominant side and those who sustained injuries on the non-dominant side.

All patients retained full range of motion. The clinical examinations revealed no tenderness at the location of the clavicular button. Furthermore, no patients complained of any pain in the stabilized AC joint at the maximum shoulder abduction (above 120°). The cross-body adduction test was negative in all patients.

The mean CS was 92.4 (range, 84–96). The mean external rotation was 75.8° (range, 50°–90°), whereas the mean forward flexion was 170° (range, 150°–180°) and the mean abduction was 163.8° (140°–180°). The Spearman correlations revealed significant inverse correlations of the time to surgery with postoperative external rotation, forward flexion, and abduction ($p<0.05$).

Five patients (27.8%) exhibited ossification between the clavicle and the coracoid. Three of these patients showed a severe ossification and 2 patients showed mild ossification. Due to the low number of patients with ossification, statistics were obtained disregarding the ossification severity. No association of ossification with patient gender or hand dominance was observed.

Patients without ossification had an average difference in CC distance of 2.3 mm (range, 0–10 mm), and those with ossification had an average difference in CC distance of 2.6 mm (range, 0–8 mm). The patients with ossification scored on average 92.4 (range, 83–96) in the CS.

Post-traumatic osteoarthritis of the AC joint was not detected in any of the radiographic follow-ups.

The postoperative strength was significantly lower in patients with type V injuries than in those with type III and IV ($p=0.049$); however, there was no difference regarding reduction loss.

Fig. 6. In one patient, a coracoid fracture was observed in the second postoperative week.

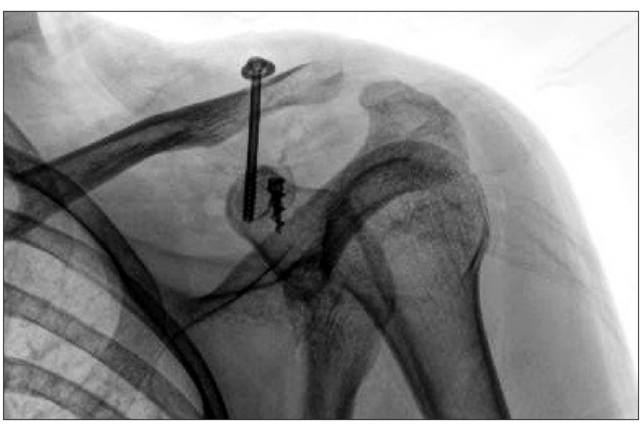

Fig. 7. This fracture was treated with reoperation and the insertion of a Bosworth screw.

Fig. 8. The fracture healed without complications, and the Bosworth screw was removed at 10 weeks after surgery.

Complications

In two patients, there was an occurrence of superficial wound infections, which were successfully treated via antibiotic therapy.

In one patient, a coracoid fracture was observed in the second postoperative week (Fig. 6). This fracture resulted from a technical failure, in which the coracoid drill hole was placed too far medially. This fracture was treated with a reoperation and an insertion of the Bosworth screw (Fig. 7). The fracture healed without complications, and the Bosworth screw was removed at 10 weeks after surgery (Fig. 8).

Due to the low prevalence of complications, no correlation analysis was performed.

Radiographic Outcomes

Preoperatively, the mean CC distance was 55.8 mm (range, 30–85 mm) on the affected side. The postoperative CC distance on the affected side was significantly reduced to 26 mm (range, 18–31 mm; $p<0.001$).

At the follow-up, the CC distance of the affected side averaged 26 mm (range, 18–31 mm), which differed significantly from the non-affected side (23.7 mm; range, 17–31 mm) in all cases ($p=0.003$) and in the cases without complications ($p=0.005$).

Postoperative CC ossifications were more frequently observed in cases with trauma on the dominant side (4/12) than in those on the non-dominant side (1/6); however, this difference did not reach statistical significance.

The clavicular bone tunnels that were operatively drilled were visible in all patients. The coracoid bone tunnels were not visible at the final follow-up. There was no increased radiolucency or tunnel widening. The clavicular and coracoid button positions did not change.

Discussion

Treatments for AC joint separations range from closed reduction to surgeries, including ligament reconstruction, open reduction with K-wires or plate fixation, and suture-button reconstruction using TightRope.[10-12] The suture-button technique with TightRope has an advantage of combining closed reduction with arthroscopically assisted fixation using a drill guide. Although some surgeons prefer to use the double-implant technique,[6] our preference is to use the single-implant technique,[13] and it was the technique of choice in this study. Using this method, we were able to produce comparable results without encountering problems, such as suture rupture or recurrent instability.[14] Although the ligaments are not reconstructed directly using this technique, healing occurs along the suture material with the expectation of stability.[15] This is the reason that we performed these operations in the acute period of injury (within 3 weeks). Another advantage of this technique is the possibility to arthroscopically evaluate the glenohumeral joint for concomitant pathologies. While concomitant injuries have been reported to occur with rates as high as 20% in AC joint separations, we did not encounter such pathologies in our study group.[16] Due to the acute nature of the AC separations, no graft augmentations were performed. We believe that the support function of a single TightRope is sufficient for healing the AC ligaments after acute injury. Further follow-up will determine the results of the single-implant technique described in this article; however, because the ligament healing will be completed within the first year after surgery, we do not expect any future complications regarding implant failure. Recently, De Carli et al.[17] reported similar results following single suture-button procedures with TightRope for Rockwood type III AC joint dislocations after a minimum follow-up of 24 months.

In contrast to Arrigoni et al.,[18] who showed an overall rate of 29.5% associated pathologic lesions requiring additional surgical treatment in patients with type III AC joint dislocation, we did not find any concomitant pathology.

Many studies evaluating the treatment of AC joint injuries have focused on different treatment modalities in acute and chronic cases; however, no studies have addressed the effects of surgical timing on clinical outcomes. Our data suggest that patients with acute injuries to the AC joint profit from early surgical therapy, with respect to postoperative range of motion. This benefit might be attributable to faster healing, following the early repositioning of the AC joint, which could minimize further soft tissue damage, particularly in higher grade dislocations.

Ossification around the CC ligaments is a phenomenon that has already been described in several articles,[15,19] which still to date, has not been fully elucidated. We were unable to correlate the degree of ossification or the existence of ossification with any of the clinical parameters. Further studies are needed to determine whether CC ossification merely results from the clavicular drilling dust or whether it is a relevant clinical feature of AC joint stability following reconstruction.

Correct bone tunnel placement and bone quality play an important role in the success of this procedure. In a cadaver study, the optimal bone density of the lateral clavicle was found in the anatomic insertion area of the CC ligaments between 20 mm and 50 mm from the lateral end of the clavicle. Moreover, low bone mineral density correlated with decreased load to failure after AC reconstruction.[20] Recently, Yi and Kim[21] introduced the concept of the clavicle tunnel anteroposterior angle (i.e., the angle between the perpendicular line of the clavicular upper border and the midline of the passing tunnel) as a predictor for CC augmentation surgery outcome. These authors emphasized that the surgeon should strive to place a perpendicular hole from the clavicle to the coracoid process for suture-button fixation with TightRope to enable the successful reconstruction of acute AC-CC injury. Scheibel et al.[19] utilized an image intensifier control during tunnel placement to prevent overdrilling as well as to control the location and entry points of the K-wires, thereby, minimizing the risk of K-wire and tunnel malpositioning. In a cadaver study, Hoffmann et al.[22] utilized the electromagnetic navigation system for transclavicular-transcoracoid tunnel placement in minimally invasive arthroscopically assisted anatomic AC joint reconstruction. We performed a cadaver study (unpublished data) prior to this study and found that the anatomical relationship of the clavicle and the coracoid process is too complex to be precisely addressed by only using a drill guide, which is a rigid tool and not sufficiently flexible to adjust for any variations in the CC anatomy.

Ferreira et al.[23] showed a higher peak load to failure with a center-center or medial-center coracoid tunnel orientation, which may have lessened the risk of coracoid fracture during drilling with a 6 mm cannulated drill bit. In another cadaver study, a 4.5 mm coracoid tunnel provided greater fixation strength than a 6 mm tunnel in CC ligament reconstruction, and the base of the coracoid was more forgiving than the distal coracoid regarding location.[24] This suggests the importance of direct coracoid process visualization for tunnel placement, which was performed in this study. The utilization of a rigid drill guide predisposes the risk for center-lateral coracoid tunnel orientation with increased risk for coracoid fracture. With this method, we were able to directly visualize the clavicular and coracoid entry points and to perform the procedure with direct arthroscopic visualization without requiring any further x-ray imaging. As a result, we were able to protect our young patient population from additional x-ray exposure. Moreover, using the lateral portal as the secondary viewing portal facilitated the manipulation of the TightRope buttons from the anterior and posterior portals.

A recent study of Shin and Kim[25] showed a complication rate of 44% in a case series with 18 patients after a single adjustable loop-length suspensory fixation for acute AC dislocation. They described one case of delayed distal clavicular fracture at the clavicular hole of the device, in addition to 3 cases of clavicular or coracoid button failures and 3 cases of clavicular bony erosion after a mean follow-up of 25.6 months. During the early phase of investigation, we observed a coracoid fracture due to drilling too medially on the coracoid process. This was the only technical deficiency in this study population. No other serious complications, such as nerve or vessel injuries, were observed.

Although there was no difference regarding the reduction loss, the postoperative strength was significantly lower in patients with type V injuries than in those with types III and IV. This finding is interesting because no concomitant pathologies were observed during the diagnostic arthroscopies of the shoulder joint. This finding might be attributable to greater soft tissue damage that occurs in higher-grade AC injuries.

Limitations

The main limitation of this study is its retrospective nature in the evaluation of patients. We did not perform any assessments regarding horizontal stability following the procedure; however, despite the presence of partial recurrent horizontal and vertical AC joint instabilities, high patient satisfaction rates and good clinical results were obtained.[19)]

The clinical outcome of this study was comparable to previous studies with good-to-excellent results. Regarding the implant-related problems, TightRope buttons were tolerated very well in our study group, and no patients requested implant removal. We did not observe any migration of the superior buttons. In addition, the postoperative pain levels were significantly reduced.

Conclusion

The all-arthroscopic treatment of AC joint separations using the single suture-button technique without a drill guide is a safe technique, yielding good-to-excellent clinical results. The horizontal stability following this grade of reconstruction requires further evaluation in the future.

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