

Clinical and Radiological Outcomes of Acute Acromioclavicular Joint Dislocation: Comparison of Hook Plate Fixation with Single Tight Rope Technique

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Background: This study was conducted to compare the clinical and radiological outcomes of the locking hook plate fixation (HP) technique and the single tight rope (TR) technique applied for acute high-grade acromioclavicular (AC) joint separations.

Methods: Between 2009 and 2014, 135 consecutive patients with acute AC joint separation Rockwood types III, IV, and V were subjected to surgical reconstruction. One hundred fourteen patients (84.4%) were available for retrospective evaluation. Of them, 62 and 52 were treated using the single TR group and clavicular HP group techniques, respectively. The visual analogue scale, Constant, American Shoulder and Elbow Surgeons (ASES), and Taft scores were used for clinical assessment. Postoperative shoulder range of motion was also assessed. An anteroposterior radiograph of the coracoclavicular distance (CCD) was obtained to evaluate the radiographic signs of recurrence.

Results: The TR group patients had better Constant, ASES, and Taft scores than the HP group patients. The loss of reduction in terms of the CCD did not differ between groups. Subacromial osteolysis was observed in 34.6% of the cases in the HP group. However, there were no significant differences in the clinical outcomes between the patients with and without osteolysis in the HP group. Subcoracoid osteolysis, drill tunnel widening, and metal displacement were observed in 3.2%, 22.6%, and 4.8% of the cases in the TR group, respectively.

Conclusions: The single TR technique was relatively more effective at treating acute high-grade AC joint injuries than the HP fixation technique (level of evidence: therapeutic; retrospective comparative study, Level III).

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Key Words: Acromioclavicular joint; Acute separation; Arthroscopic stabilization; Tight rope technique; Clavicular hook plate

Introduction

The optimal treatment of acromioclavicular (AC) dislocations is still a matter of discussion.¹⁾ However, some consensus has been reached regarding low- and high-energy trauma.²⁾ Low-energy trauma injuries, which are classified as type I or type II injuries, are treated conservatively using either a harness or a sling,^{2,3)} while high-energy trauma injuries, such as type IV, V, and VI injuries, are treated surgically⁴⁾ and the treatment for type III injuries is still a matter of debate.^{5,6)} Many operative techniques

have been developed over the years. However, the optimal operative treatments among these options is still unclear. The choice of surgical method is made based on multiple factors, including patient's medical condition and activity level, surgeon's experience, cost effectiveness, and insurance policy.

The use of cerclages for coracoclavicular (CC) augmentation is an alternative to pin fixation or hook plate procedures, which do not require an implant removal.^{4,7,8)} The main problems associated with CC loop augmentations are the highly invasive approach to the coracoid base and the anterior subluxation of

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the clavicle, which leads to a mal-reduction of the AC joint in the postoperative course.⁴⁾ Furthermore, a sawing effect of synthetic material owing to clavicle rotation has been reported.⁴⁾ This highly invasive approach is also associated with increased postoperative morbidity.⁹⁾ To overcome these disadvantages, minimally invasive techniques for CC augmentation using flip buttons have been developed (Fig. 1).¹⁰⁻¹²⁾ These surgeries can be conducted in a minimally invasive or arthroscopically assisted manner. In fact, biomechanical clinical studies report high fixation strength and good to excellent functional results following these types of surgeries.^{3,10,12-14)}

Another well-established method for AC joint reconstruction is hook plate fixation (HP) (Fig. 2).¹⁵⁻¹⁷⁾ Unlike the old Wolter plate, the HP method has been designed to include an extension hook under the acromion to provide more stable fixation.¹⁸⁾ The use of the HP method has increased since advent of the locking plate with locking screws, and good results following its use have been reported.^{19,20)} However, there are known disadvantages associated with this technique, including a mandatory second surgery for removal of the plate. Moreover, transarticular fixation using an HP may induce bony osteolysis, shoulder impingement, and rotator cuff damage, leading to poor functional results.^{15,21)} Considering the advantages and disadvantages of these two surgical methods, there is little radiologic and clinical outcome evidence regarding the management of acute high-grade AC joint injuries using HP vs. the tight rope (TR) method.

Therefore, we compared the clinical and radiologic outcomes of the locking HP fixation technique with those of the single TR

technique for treatment of acute high-grade AC joint separations. Our hypothesis was that the HP fixation would have equal functional and radiographic results to the single TR technique.

Methods

Patient Selection

Between 2009 and 2014, a consecutive series of 135 patients with traumatic AC joint separation were surgically treated in Wonkwang University Hospital Trauma Center. The inclusion criteria of the patients were as follows: (1) radiographically confirmed closed Rockwood type III (with horizontal instability observed in manual/overhead workers or athletes) or higher AC dislocation; (2) surgery within 2 weeks of trauma (it is known that after this period, CC ligaments lack healing potential²²⁾); (3) primary treatment using a clavicular HP (Synthes, Bettlach, Switzerland) or TR (Arthrex, Naples, FL, USA) devices; (4) age of ≥ 18 years; (5) mono trauma; and (6) minimum follow-up of 24 months after surgery. The exclusion criteria were as follows: (1) polytrauma, including associated nerve and/or vessel injury; (2) previous injury to the injured shoulder; and (3) disease processes that would preclude accurate evaluation of the outcomes (e.g., neuromuscular, rheumatic, or significant psychiatric or metabolic disorders).

Between 2009 and 2011, the single TR technique was performed in 61 patients. Between 2012 and 2014, clavicular HPs were implanted in 74 patients. HP surgeries were selected at later dates because of the termination of payments for TR sur-

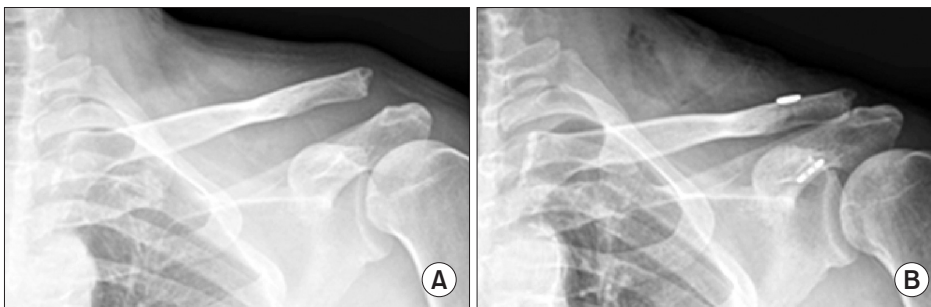


Fig. 1. Serial radiographs from a 39-year-old man treated with reconstruction of an acute acromioclavicular joint separation of Rockwood type V using an arthroscopic single tight rope technique showing good joint reduction and maintenance of joint reduction. (A) Preoperative. (B) Final follow-up.

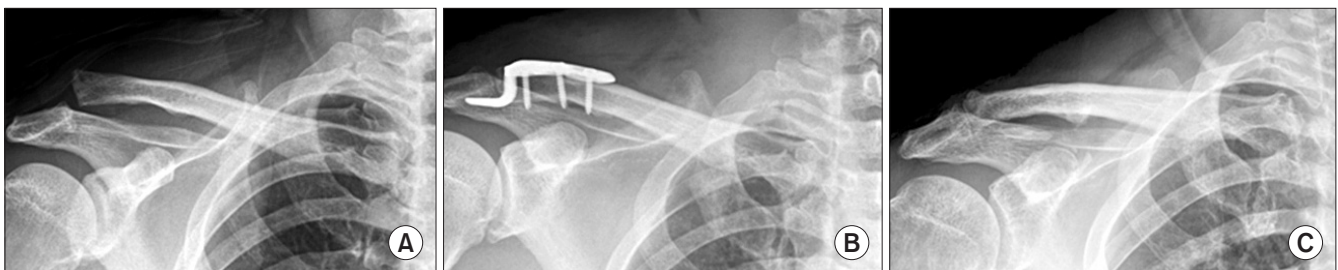


Fig. 2. Serial radiographs from a 35-year-old man treated with a hook plate fixation, showing good maintenance of joint reduction after plate removal. (A) Preoperative. (B) Postoperative. (C) Last follow-up after plate removal.

geries by the national insurance policy of South Korea. Patients were divided into two groups according to the surgical method used (TR group and HP group). In the TR group, 52 of the initial 61 patients were evaluated, five patients were not available for follow-up, and four refused participation. In the HP group, 62 of the initial 74 patients were evaluated (nine patients were unavailable; three patients refused participation). Generally, follow-up was available for 114 (84.4%) of these 135 patients.

Clinical Evaluation

Postoperative clinical evaluations were performed regularly on an outpatient basis (at 4 weeks, 6 weeks, 3 months, 6 months, and 12 months following surgery and at the last follow-up). The results of the evaluations at the last follow-up were analyzed. At the time of follow-up, all patients were evaluated using the visual analogue scale (VAS) to assess subjective pain, and the Constant, ASES, and Taft²³ scores were used for the clinical assessments. Postoperative shoulder ranges of motion (ROMs), including forward flexion, external rotation at the side, internal rotation to the back, and abduction were assessed. ROM of the injured shoulder was compared to that of the contralateral unaffected shoulder to assess ROM limitations.

Radiological Assessment

To evaluate reduction of the AC joint after surgery, we analyzed the anteroposterior radiographs. The CC distance (CCD),²⁴ which was defined as the perpendicular distance between the upper border of the coracoid process and the inferior cortex of the clavicle, was analyzed (Fig. 3). CCD was measured by three orthopedic surgeons who were blinded to the patient information. Interobserver reliability was assessed based on the kappa value, which was found to be 0.91. The CCDs of the contralat-

eral unaffected side and the affected side were compared at the last follow-up to determine if the anatomical reduction was appropriate. We considered increases in the CCD of 0% to 50%, 50% to 100%, and >100% with respect to the contralateral side assessed using the follow-up radiographs as intact, subluxation, and re-dislocation, respectively (Fig. 4).¹⁵ At the final follow-up, subacromial osteolysis, subcoracoid osteolysis, drill tunnel widening, and metal displacement were evaluated using plain radiographs.

Surgical Technique

All patients were placed in the beach-chair position under general anesthesia. All surgeries were performed by one surgeon.

1) HP group

An approximately 5-cm-long skin incision was made in line with the lateral clavicle and the AC joint. The AC joint was exposed, and the articular disc was excised in case of disruption. Following AC joint reduction, the clavicular HP was positioned with the hook placed dorsally under the acromion and fixed onto the clavicle with screws. If possible, the AC joint capsule was reconstructed. The deltoidotrapezoid fascia was then closed using resorbable sutures, and the wound was closed in layers.

2) TR group

Two standard arthroscopic portals were created (posterior and anteroinferior). The posterior portal was the initial viewing portal. After diagnostic glenohumeral arthroscopy and possible therapeutic interventions, the anteroinferior working portal was created. This portal was established in line with the upper subscapularis margin. The coracoid undersurface was prepared using a radio-frequency device. A skin incision approximately 1 cm long was then made in line with the lateral clavicle ~3.5 cm medial to the AC joint, after which the surface of this incision was prepared. An anterior cruciate ligament drill guide with a thrust block (Arthrex) was subsequently introduced via the anteroinferior portal and positioned below the base of the coracoid while the drill sleeve was vertically placed on the clavicular surface ~4 cm medial to the AC joint line. The bone tunnel was then overdrilled using a 4 mm drill bit, and the TR device was inserted via a shuttle-wire under arthroscopic control. The TR was secured using six alternating half hitches. Finally, the wound was closed in layers over the clavicular buttons.

Postoperative Management

Rehabilitation involved wearing a sling for 3 to 4 weeks. The patients were initially allowed to move fully and actively at the elbow, wrist, and hand. Patients in the HP group were allowed to elevate the shoulder passively by no more than 90° in the plane of the scapula after the first week. Patients in the TR group were allowed to perform this movement three weeks after surgery. Pendulum exercises began at the first week after the injury



Fig. 3. Radiological analysis of coracoclavicular distance.



Fig. 4. (A) Serial radiographs from a 20-year-old man treated with a tight rope fixation showing a subluxation of joint reduction at last follow-up. (B) Serial radiographs from a 53-year-old man treated with a hook plate fixation showing a redislocation after plate removal.

in both groups. The active ROM progressively advanced from the sixth week after surgery in both groups. Exercises to regain strength were initiated once the patient had full and pain-free passive and active ROMs. The exercises were primarily directed toward scapular stabilization. In the HP group, patients were advised that the implant should be removed 16 to 20 weeks after surgery. Return to work without restrictions was allowed after 16 to 20 weeks, and contact sports or major efforts were avoided for 4 to 6 months in both groups.

Statistical Analysis

Statistical analyses were performed using SPSS ver. 12.0 (SPSS Inc., Chicago, IL, USA) Data were reported as medians (ranges, minimum–maximum) or means \pm standard deviations. All data were tested for normal distribution using the Kolmogorov-Smirnov test. Subsequently, the data of the two groups were compared using the nonparametric Mann-Whitney U-test for independent samples and the Student's t-test for dependent samples. The level of significance was defined as $p < 0.05$ for all tests.

Ethical Approval

All procedures performed in studies were in accordance with the ethical standards of the institution or practice at which the studies were conducted. This retrospective comparative study was approved by our institutional review board (WKUHIRB 201611-HR-122).

And informed consent was obtained from all individual participants included in the study.

Results

Demographics

Age, sex, follow-up period, and Rockwood classification were evaluated as demographic factors. No significant differences were found in the demographic characteristics between the two groups (Table 1).

Clinical and Radiological Outcomes

The clinical and radiological outcomes are presented in Table 2. The VAS, Constant, ASES, and Taft scores and ROM were evaluated as clinical factors at the last follow-up. The functional scores differed significantly between two groups. Specifically, the mean Constant score was 77.2 ± 8.5 in the HP group and 89.5 ± 7.4 in the TR group ($p = 0.018$), while the ASES score was 80.3 ± 10.2 in the HP group and 92.1 ± 8.7 in the TR group ($p = 0.023$) and the Taft score was 8.3 ± 2.7 in the HP group and 10.5 ± 2.3 in the TR group ($p = 0.015$). No significant differences in the VAS score or ROM were found between groups at the last follow-up.

The radiographic outcomes indicated that the CCDs decreased in both groups from $210.7\% \pm 46.8\%$ preoperatively to $107.2\% \pm 10.5\%$ at the final follow-up in the HP group and from $224.5\% \pm 50.2\%$ preoperatively to $109.1\% \pm 12.1\%$ at

Table 1. Demographics of the Two Groups

Variable	HP group	TR group	p-value
Subject	52	62	NS
Sex (male:female)	47:5	56:6	NS
Age (yr)	38 (20–62)	36 (19–60)	NS
Rockwood classification (III/IV/V)	16 (30.8)/4 (7.7)/32 (61.5)	18 (29.0)/4 (6.5)/40 (64.5)	NS
Follow-up duration (mo)	31.4 ± 5.5	35.8 ± 7.4	NS

Values are presented as number only, median (range), number (%), or mean ± standard deviation.
HP: hook plate, TR: tight rope, NS: not significant.

Table 2. Comparison of Clinical and Radiological Outcomes between Groups

Variable	HP group (n=52)	TR group (n=62)	p-value
VAS*	1.5 ± 1.5	1.8 ± 2.1	NS
Constant score*	77.2 ± 8.5	89.5 ± 7.4	0.018
ASES score*	80.3 ± 10.2	92.1 ± 8.7	0.023
Taft score*	8.3 ± 2.7	10.5 ± 2.3	0.015
Range of motion (°)			NS
Active FE [†]	-8.5 ± 11.2	-7.8 ± 10.8	NS
ER [†]	-4.6 ± 7.4	-4.2 ± 6.7	NS
IR [†]	-3.5 ± 5.1	-2.9 ± 4.5	NS
Abduction [†]	-9.5 ± 13.7	-8.9 ± 14.4	NS
Initial CCD (%)	210.7 ± 46.8	224.5 ± 50.2	NS
Final CCD (%)	107.2 ± 10.5	109.1 ± 12.1	NS
Recurrence (intact/subluxation/re-dislocation)	44/6/2	50/10/2	NS
Postoperative complications (subacromial osteolysis/ subcoracoid osteolysis/drill tunnel widening/metal displacement)	18/52 (18 [34.6]/0 [0]/0 [0]/0 [0])	19/62 (0 [0]/2 [3.2]/14 [22.6]/3 [4.8])	NS

Values are presented as mean ± standard deviation, number only, or number (%).

VAS: visual analogue scale, ASES: American Shoulder and Elbow Surgeons, FE: forward elevation, ER: external rotation, IR: internal rotation, CCD: coracoclavicular distance, HP: hook plate, TR: tight rope, NS: not significant.

*The results at the last follow-up were used for analysis. [†]Difference between affected side and contralateral unaffected side.

the final follow-up in the TR group. No significant differences were found between groups.

Six cases of recurrent subluxation and two cases of re-dislocation were observed in the HP group, while 10 cases of subluxation and two cases of re-dislocation were observed in the TR group at the final follow-up. These differences were also not statistically significant.

Complications and Revisions

Subacromial osteolysis was observed in 34.6% of the cases (18/52) in the HP group (Fig. 5). Of these, 66.7% (12/18) were considered to be mild osteolysis, while 33.3% (6/18) were considered to be severe osteolysis.

There were no significant differences in the VAS, Constant, ASES, or Taft scores at the final follow-up between the patients

with osteolysis (n=18) and those without osteolysis (n=4) in the HP group (Table 3). The radiological findings indicated that there were no differences between the initial and final CCDs (Table 3).

Two patients (3.8% in HP group, 3.2% in TR group) required revision surgery in each group because of recurrent vertical and horizontal instability with pain. In all cases, the AC and CC ligaments were reconstructed.

In 14 patients (22.6%) in the TR group, trapezoid-like tunnel widening in the clavicle bone by a mean of 7.3 ± 0.7 mm was observed when compared with that in the direct postoperative radiographs. Implant migration of the TR buttons was observed in three cases (4.8%) and subcoracoid osteolysis in two cases (3.2%).



Fig. 5. Radiograph obtained 24 months postoperatively showing mild loss of reduction and distal clavicular osteolysis after synthetic ligament reconstruction.

Discussion

The most important finding of this study is that the patients with acute high-grade AC joint injuries managed using the single TR technique showed better clinical outcomes as assessed using the Constant, ASES, and Taft scores than those managed using the HP. In addition, HP fixation induced accompanying complications and required a second surgery for implant removal in all patients. However, the radiographic outcomes indicated that the CCDs decreased in both groups with no significant difference. Accordingly, our hypothesis that the HP fixation would have equal functional and radiographic outcomes with those of the single TR technique was partly rejected.

There are a large number of surgical approaches used to treat acute high-grade AC joint injuries reported in the literature.²⁵⁻²⁸⁾ It has been reported that coracoacromial ligament transfer, HP fixation, AC K-wire fixation, and CC screw fixation are biomechanically insufficient.²⁵⁾ In vivo analysis of AC joint motions after HP fixation indicates that the clavicular motion and AC joint biomechanics change significantly after HP.²⁶⁾ The technique selected to treat an AC joint injury may have a strong influence on the outcomes, especially if open procedures or fixation using metal hardware are performed. Patients in the TR group in this study had better Constant, ASES, and Taft scores at the last follow-up than those in the HP group. The results of our study agree with those published by Andreani et al.,²⁷⁾ who found that patients treated using the TR technique had a mean Constant score of 90, while those managed using an HP had a mean Constant score of 75. In addition, Boström Windhamre et al.²⁸⁾ reported that patients managed using HP fixation have significantly more pain than those managed using a CC non-rigid fixation. They argued that this may be because of the presence of chronic irritation in the subacromial space, which then leads to a persistent pain syndrome.²⁸⁾

We considered the following reasons as contributors to the

Table 3. Comparison according to the Presence of Subacromial Erosions in the HP Group

Variable	Subacromial erosion		p-value
	Patients with osteolysis (n=18)	Patients without osteolysis (n=34)	
Sex (male:female)	16 (88.9):2 (11.1)	31 (91.2):3 (8.8)	NS
Age (yr)	36 (20–58)	38 (21–62)	NS
Initial CCD (%)	215.7 ± 50.3	208.7 ± 46.5	NS
Final CCD (%)	106.2 ± 10.2	108.2 ± 10.18	NS
VAS*	1.6 ± 1.7	1.5 ± 2.2	NS
Constant score*	76.8 ± 8.3	77.5 ± 8.6	NS
ASES score*	79.2 ± 10.4	81.1 ± 10.1	NS
Taft score*	8.2 ± 2.5	8.4 ± 2.2	NS

Values are presented as number (%), median (range), or mean ± standard deviation.

HP: hook plate, CCD: coracoclavicular distance, VAS: visual analogue scale, ASES: American Shoulder and Elbow Surgeons.

*The results at the last follow-up were used for analysis.

inferior functional outcomes. A portion of the hook may enter the posterior aspect of the AC ligaments, which may then compromise the proper healing of these structures. Similarly, HPs must be removed, and the period during which the plate is implanted might be characterized by the development of serious complications, such as the upward cutting of the hook through the acromion,²⁹⁾ subacromial osteolysis,³⁰⁾ fracture,³¹⁾ AC joint osteoarthritis, subacromial impingement, rotator cuff tears,⁵⁾ and plate bending.²⁴⁾ Even when there is timely removal of the plate, the patient may be subjected to an increased risk of fracture of the distal clavicle after low-energy trauma.³²⁾ Further, the HP is a stiff plate that does not allow normal rotation of the clavicle, which may account for some of the late complications and arthritis.²⁶⁾ In this study, 34.6% (18/52) of the patients had mild or severe subacromial osteolysis. Although there were no differences in the clinical and radiologic outcomes based on the presence of subacromial osteolysis, the relatively frequent occurrence of this complication is a considerable disadvantage of the HP fixation. Lin et al.²¹⁾ reported that, among a group of patients with AC joint injuries and distal third clavicle fractures managed using HPs, 37.5% (15/40) developed subacromial impingement syndrome. The functional scores of these patients were lower than those of patients without impingements. Among these patients, 40.0% (6/15) had a rotator cuff tear diagnosed using sonography, while subacromial osteolysis caused by hook pressure was observed in 50.0% (20/40) of the patients.²¹⁾ In the present study, we did not evaluate our patients using sonography. However, we believe that the lower clinical scores may reflect underlying injuries related to the plate.

The arthroscopic technique of CC fixation using an Endobutton device (Smith and Nephew, Memphis, TN, USA) has previ-

ously been reported.^{33,34)} However, the first generation of this device consisted of a smaller round proximal button that had the potential to erode the clavicle and led to loss of reduction.^{35,36)} Since a larger proximal button was developed, no erosion or failure has occurred using this surgery. The titanium buttons, which are positioned centrally on top of the clavicle and under the coracoid, are connected with a continuous loop of No. 5 FiberWire (Arthrex) wire suture. This produces a construct stronger than the native CC ligament and the AC joint complex and leads to strong maintenance of reduction and a homogeneous distribution of load onto the bone surface. These characteristics protect against the sawing effects of sutures, which have been described as a mechanism of failure in other techniques using anchors and sutures.^{37,38)} Accurate positioning of the bony tunnels and buttons centrally on the clavicle and under the coracoid process is essential to solid fixation. Malpositioning of the clavicular (too anteriorly) or the coracoid button (too laterally) may lead to asymmetric loading and cutout of the fixation device.³⁹⁾ Yi and Kim⁴⁰⁾ have suggested that surgeons should strive to place a perpendicular hole from the clavicle to the coracoid process for TR fixation to enable successful reconstruction of acute AC joint injuries.

Another advantage of using arthroscopic procedures is that they enable the diagnosis and treatment of concomitant glenohumeral injuries. In addition, these procedures require no mandatory implant removal.⁹⁾ In fact, potential remaining concomitant intraarticular injuries may be the underlying reasons for failure of some treatments using open surgeries without access to the glenohumeral joint or non-operative management.⁹⁾ We suggest that if orthopedic surgeons decide to manage acute unstable AC joint injuries using open procedures without access to the glenohumeral joint, they should carefully consider performing preoperative magnetic resonance imaging arthrography to avoid 'leaving behind' important simultaneous acute injuries. If these injuries go unnoticed, they may significantly affect the outcome.

Biomechanical studies have shown that HP fixation has a biomechanical disadvantage when compared with CC non-rigid fixations. CC displacement during cyclic loading has been shown to occur more frequently in HP fixations.²²⁾ Despite these biomechanical disadvantages, clinical studies comparing patients managed using HP with those managed using CC non-rigid fixations have shown that there are no differences in the remaining vertical instability.⁹⁾ In the present study, the loss of reduction after HP fixation did not differ significantly from that following the single TR technique with an untouched AC joint and without an implant removal. The fact that a partial recurrent vertical instability may be observed independent of the fixation device indicates that the biological healing potential of the ruptured CC ligaments and the AC joint capsule is limited when appropriate scar tissue formation does not occur. A partial loss of vertical re-

duction has also been shown to have no influence on the overall outcomes.⁴¹⁾ A possible explanation for this finding may be that the healed CC elongated ligaments provide enough stability to relieve symptoms.²⁷⁾

The main limitation of our study was its retrospective design. Additionally, patients were not randomized before undergoing any treatment. Further, this was a single-center study with a small number of enrolled patients. Our patients also had a wide age range. Accordingly, high-quality randomized controlled trials with larger sample sizes are still required to validate our results. This study also contained a relatively large portion of type III dislocations; thus, it was difficult to fully determine whether our results and conclusions can be extrapolated to higher levels of dislocations. We also could not consider horizontal instability, which was not evaluated as CCD. Finally, the wide range of period of plate removal also might influence clinical outcomes.

Conclusion

In this study, patients with acute high-grade AC joint injuries managed using the single TR technique had better clinical outcomes than those managed using an HP as assessed using the Constant, ASES, and Taft scores. The loss of reduction after HP fixation was not significantly different from that prepared following the single TR technique. The single TR technique might be more effective for the treatment of acute high-grade AC joint injuries than HP fixation.

References

1. Babhulkar A, Pawaskar A. Acromioclavicular joint dislocations. *Curr Rev Musculoskelet Med.* 2014;7(1):33-9.
2. Tauber M. Management of acute acromioclavicular joint dislocations: current concepts. *Arch Orthop Trauma Surg.* 2013; 133(7):985-95.
3. Rockwood C, Williams G, Young D. Disorders of the acromioclavicular joint. In: Rockwood CA, ed. *The shoulder.* 3rd ed. Philadelphia: WB Saunders; 2004. 521-95.
4. Greiner S, Braunsdorf J, Perka C, Herrmann S, Scheffler S. Mid to long-term results of open acromioclavicular-joint reconstruction using polydioxansulfate cerclage augmentation. *Arch Orthop Trauma Surg.* 2009;129(6):735-40.
5. Bahk MS, Kuhn JE, Galatz LM, Connor PM, Williams GR Jr. Acromioclavicular and sternoclavicular injuries and clavicular, glenoid, and scapular fractures. *Instr Course Lect.* 2010;59:209-26.
6. Ceccarelli E, Bondi R, Alvitì F, Garofalo R, Miulli F, Padua R. Treatment of acute grade III acromioclavicular dislocation: a lack of evidence. *J Orthop Traumatol.* 2008;9(2):105-8.
7. Dimakopoulos P, Panagopoulos A, Syggelos SA, Panagiotopoulos E, Lambiris E. Double-loop suture repair for acute acromio-

- clavicular joint disruption. *Am J Sports Med.* 2006;34(7):1112-9.
8. Lemos MJ. The evaluation and treatment of the injured acromioclavicular joint in athletes. *Am J Sports Med.* 1998;26(1):137-44.
 9. Jensen G, Katthagen JC, Alvarado LE, Lill H, Voigt C. Has the arthroscopically assisted reduction of acute AC joint separations with the double tight-rope technique advantages over the clavicular hook plate fixation? *Knee Surg Sports Traumatol Arthrosc.* 2014;22(2):422-30.
 10. Petersen W, Wellmann M, Rosslénbroich S, Zantop T. Minimally Invasive Acromioclavicular Joint Reconstruction (MINAR). *Oper Orthop Traumatol.* 2010;22(1):52-61.
 11. Phillips AM, Smart C, Groom AF. Acromioclavicular dislocation. Conservative or surgical therapy. *Clin Orthop Relat Res.* 1998;(353):10-7.
 12. Scheibel M, Dröschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med.* 2011;39(7):1507-16.
 13. Liu X, Huangfu X, Zhao J. Arthroscopic treatment of acute acromioclavicular joint dislocation by coracoclavicular ligament augmentation. *Knee Surg Sports Traumatol Arthrosc.* 2015;23(5):1460-6.
 14. Murena L, Vulcano E, Ratti C, Cecconello L, Rolla PR, Surace MF. Arthroscopic treatment of acute acromioclavicular joint dislocation with double flip button. *Knee Surg Sports Traumatol Arthrosc.* 2009;17(12):1511-5.
 15. Eschler A, Gradl G, Gierer P, Mittlmeier T, Beck M. Hook plate fixation for acromioclavicular joint separations restores coracoclavicular distance more accurately than PDS augmentation, however presents with a high rate of acromial osteolysis. *Arch Orthop Trauma Surg.* 2012;132(1):33-9.
 16. Kienast B, Thietje R, Queitsch C, Gille J, Schulz AP, Meiners J. Mid-term results after operative treatment of rockwood grade III-V acromioclavicular joint dislocations with an AC-hook-plate. *Eur J Med Res.* 2011;16(2):52-6.
 17. Liu HH, Chou YJ, Chen CH, Chia WT, Wong CY. Surgical treatment of acute acromioclavicular joint injuries using a modified Weaver-Dunn procedure and clavicular hook plate. *Orthopedics.* 2010;33(8). doi: 10.3928/01477447-20100625-10.
 18. Koukakis A, Manouras A, Apostolou CD, et al. Results using the AO hook plate for dislocations of the acromioclavicular joint. *Expert Rev Med Devices.* 2008;5(5):567-72.
 19. Modi CS, Beazley J, Zywiell MC, Lawrence TM, Veillette CJ. Controversies relating to the management of acromioclavicular joint dislocations. *Bone Joint J.* 2013;95(12):1595-602.
 20. von Heideken J, Boström Windhamre H, Une-Larsson V, Ekelund A. Acute surgical treatment of acromioclavicular dislocation type V with a hook plate: superiority to late reconstruction. *J Shoulder Elbow Surg.* 2013;22(1):9-17.
 21. Lin HY, Wong PK, Ho WP, Chuang TY, Liao YS, Wong CC. Clavicular hook plate may induce subacromial shoulder impingement and rotator cuff lesion; dynamic sonographic evaluation. *J Orthop Surg Res.* 2014;9:6.
 22. Läderrmann A, Gueorguiev B, Stimec B, Fasel J, Rothstock S, Hoffmeyer P. Acromioclavicular joint reconstruction: a comparative biomechanical study of three techniques. *J Shoulder Elbow Surg.* 2013;22(2):171-8.
 23. Taft TN, Wilson FC, Oglesby JW. Dislocation of the acromioclavicular joint. An end-result study. *J Bone Joint Surg Am.* 1987;69(7):1045-51.
 24. Sim E, Schwarz N, Höcker K, Berzlanovich A. Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. *Clin Orthop Relat Res.* 1995;(314):134-42.
 25. Jari R, Costic RS, Rodosky MW, Debski RE. Biomechanical function of surgical procedures for acromioclavicular joint dislocations. *Arthroscopy.* 2004;20(3):237-45.
 26. Kim YS, Yoo YS, Jang SW, Nair AV, Jin H, Song HS. In vivo analysis of acromioclavicular joint motion after hook plate fixation using three-dimensional computed tomography. *J Shoulder Elbow Surg.* 2015;24(7):1106-11.
 27. Andreani L, Bonicoli E, Parchi P, Piolanti N, Michele L. Acromioclavicular repair using two different techniques. *Eur J Orthop Surg Traumatol.* 2014;24(2):237-42.
 28. Boström Windhamre HA, von Heideken JP, Une-Larsson VE, Ekelund AL. Surgical treatment of chronic acromioclavicular dislocations: a comparative study of Weaver-Dunn augmented with PDS-braid or hook plate. *J Shoulder Elbow Surg.* 2010;19(7):1040-8.
 29. Gstettner C, Tauber M, Hitzl W, Resch H. Rockwood type III acromioclavicular dislocation: surgical versus conservative treatment. *J Shoulder Elbow Surg.* 2008;17(2):220-5.
 30. Chiang CL, Yang SW, Tsai MY, Kuen-Huang Chen C. Acromion osteolysis and fracture after hook plate fixation for acromioclavicular joint dislocation: a case report. *J Shoulder Elbow Surg.* 2010;19(4):e13-5.
 31. Hoffer CE, Karas SG. Transacromial erosion of a locked subacromial hook plate: case report and review of literature. *J Shoulder Elbow Surg.* 2010;19(3):e12-5.
 32. Nadarajah R, Mahalaxmivala J, Amin A, Goodier DW. Clavicular hook-plate: complications of retaining the implant. *Injury.* 2005;36(5):681-3.
 33. Boileau P, Old J, Gstaad O, Brassart N, Roussanne Y. All-arthroscopic Weaver-Dunn-Chuinard procedure with double-button fixation for chronic acromioclavicular joint dislocation. *Arthroscopy.* 2010;26(2):149-60.
 34. Wellmann M, Zantop T, Petersen W. Minimally invasive coracoclavicular ligament augmentation with a flip button/polydioxanone repair for treatment of total acromioclavicular joint dislocation. *Arthroscopy.* 2007;23(10):1132.e1-5.
 35. Bishop JY, Kaeding C. Treatment of the acute traumatic acromioclavicular separation. *Sports Med Arthrosc.* 2006;14(4):

- 237-45.
36. Hosseini H, Friedmann S, Tröger M, Lobenhoffer P, Agneskirchner JD. Arthroscopic reconstruction of chronic AC joint dislocations by transposition of the coracoacromial ligament augmented by the Tight Rope device: a technical note. *Knee Surg Sports Traumatol Arthrosc.* 2009;17(1):92-7.
 37. Somers JF, Van der Linden D. Arthroscopic fixation of type III acromioclavicular dislocations. *Acta Orthop Belg.* 2007;73(5):566-70.
 38. Wellmann M, Zantop T, Weimann A, Raschke MJ, Petersen W. Biomechanical evaluation of minimally invasive repairs for complete acromioclavicular joint dislocation. *Am J Sports Med.* 2007;35(6):955-61.
 39. Defoort S, Verborgt O. Functional and radiological outcome after arthroscopic and open acromioclavicular stabilization using a double-button fixation system. *Acta Orthop Belg.* 2010;76(5):585-91.
 40. Yi Y, Kim JW. Coronal plane radiographic evaluation of the single Tight Rope technique in the treatment of acute acromioclavicular joint injury. *J Shoulder Elbow Surg.* 2015;24(10):1582-7.
 41. Weinstein DM, McCann PD, McIlveen SJ, Flatow EL, Bigliani LU. Surgical treatment of complete acromioclavicular dislocations. *Am J Sports Med.* 1995;23(3):324-31.