Early clinical and radiographic results of fixation with the TightRope device for Rockwood type V acromioclavicular joint dislocation: A retrospective review of 15 patients

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Introduction

Acromioclavicular joint dislocations (ACJDs) are some of the most frequent injuries of the shoulder girdle in active people (1). ACJDs are divided into subgroups according to the severity of the injury at the acromioclavicular (AC) and coracoclavicular (CC) ligaments (2). The clinical findings vary from an asymptomatic shoulder to a painful shoulder, with a significant loss of strength in the affected upper limb. Rockwood and Green have classified ACJ injuries into 6 types according to the severity and direction of the ACJD (3).

Rockwood type V ACJD is defined as superior displacement of the lateral end of the clavicle, with a CC distance that is increased from 100% to 300% subluxation at the final follow-up examination. The mean CC distance was 19.95 (range=13.1-28.3) mm before surgery. The mean CC distance was 7.47 (range=4.2-11.5) mm in the early postoperative radiographic measurements. This difference was statistically significant (p=0.001). The mean CC distance at the final follow-up examination was 7.70 (range=4.5-11.7) mm. At the final follow-up visit, the shoulders of all the patients were still completely reduced, with a mean difference in the CC distance of 0.23 (range=0-1.3) mm compared with that in the early postoperative period. The difference in the CC between the early postoperative and final follow-up intervals was not statistically significant (p=0.055). No patient experienced recurrence or required an operation for hardware removal.

Conclusion: It seems that the TightRope device can provide anatomical restoration in patients with acute type V ACJD without subluxation at the final follow-up examination.

Level of Evidence: Level IV, Therapeutic study

OBJECTIVE: The aims of this study were, first, to assess the loss of reduction after fixation of Rockwood type V acromioclavicular joint dislocation (ACJD) with the TightRope device (Arthrex, Naples, FL, USA) and, second, to present the functional and radiological outcomes of this treatment.

RESULTS: The mean CMS at the final follow-up was 93.2 (range=82-100) points. All the patients experienced full recovery of the shoulder’s range of motion, were able to return to the activities of daily living, and were satisfied with the treatment. ACJD reduction was successfully achieved in all the patients using the TightRope technique. Postoperative radiographs revealed no reduction loss in the ACJ, and the CC distance was well maintained. The mean CC distance was 19.95 (range=13.1-28.3) mm before surgery. The mean CC distance was 7.47 (range=4.2-11.5) mm in the early postoperative radiographic measurements. This difference was statistically significant (p=0.001). The mean CC distance at the final follow-up examination was 7.70 (range=4.5-11.7) mm. At the final follow-up visit, the shoulders of all the patients were still completely reduced, with a mean difference in the CC of 0.23 (range=0-1.3) mm compared with that in the early postoperative period. The difference in the CC between the early postoperative and final follow-up intervals was not statistically significant (p=0.055). No patient experienced recurrence or required an operation for hardware removal.

Conclusion: It seems that the TightRope device can provide anatomical restoration in patients with acute type V ACJD without subluxation at the final follow-up examination.

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Materials and Methods

This retrospective study was approved by our institutional review board (no: 56-14.06.2016), and all the patients provided informed consent prior to being included in the study. We reviewed the medical records of 19 patients who underwent fixation at our institution using the TightRope device for acute (<3 weeks) ACJD Rockwood type III (n=3), IV (n=1), or V (n=15). One study stated that this method was associated with complications such as partial loss of reduction, recurrence, and degenerative changes at the follow-up evaluation (15, 16).

The aim of this retrospective study was to assess the reduction loss after fixation of the type V ACJD with the TightRope device. In addition, the postoperative functional and radiological outcomes were evaluated. We hypothesized that the Tightrope device would achieve stability and provide satisfactory clinical outcomes in patients with type V ACJD.
injuries from 2015 to 2016. We selected the medical records of 15 patients (12 males and 3 females) with a mean age of 39.2 (range: 23-61) years who underwent fixation for acute ACJD Rockwood type V injuries. All the fixation procedures were performed using the same technique.

Surgical technique
Under general anesthesia, the patient was placed in the beach chair position, and the shoulder was prepared and draped in a sterile fashion. A 5-cm incision was made over the lateral clavicle, perpendicular to the coracoid process. The deltotrapezial fascia was incised, and the center of the clavicle was identified. To optimize tunnel placement, the medial and lateral borders as well as the complete base of the coracoid process was visualized. A guide pin sleeve was positioned over the superior clavicle at its midline, approximately 25 mm from the distal clavicle. A guide pin (2.4 mm) was inserted into the clavicle and the base of the coracoid process. The guide pin was overdrilled using a cannulated drill bit (4.0 mm) through the clavicle and coracoid process. The drill was then removed, and the button was pushed so that it could pass through the drill holes. Once the oblong button was seen under the coracoid process, a trailing suture was used to lock the button under the bone. The clavicle was then reduced until the position was considered satisfactory under direct visualization. The intended position was checked and confirmed with palpation. The sutures were tied over the top of the superior button. We could not perform primary repair of the CC ligaments because serious injury might have disrupted the integrity of the CC ligaments. The wounds were then closed in layers. The fixation procedures were performed without fluoroscopy.

Postoperative care
Postoperatively, the patient wore a shoulder immobilizer sling for 3 weeks. The patient was allowed to remove the sling to perform elbow flexion and extension exercises. Passive and below-shoulder range of motion exercises started at 3 weeks postoperatively. Full active movement was allowed at 6 weeks. Heavy resistance work was avoided until 3 months postoperatively.

Clinical and radiological evaluation
The functional outcome was evaluated using the Constant-Murley score (CMS) at the final follow-up examination. CMS is one of the most widely used scoring systems and consists of sub-items such as pain, activities of daily living and function, range of motion, and strength (17). To evaluate reduced ACJ stability postoperatively, we analyzed a radiograph with a Zanca view, which is one of the most important radiological views for good visualization of the ACJ (18, 19). The Zanca view is an anteroposterior view that is centered on the ACJ with a 10°-15° cephalic tilt. We compared the CC distances measured in the early postoperative period and at the final follow-up examination (Figure 1. a-c). The CC distance was measured as the distance between the superior border of the coracoid and inferior cortex of the clavicle on the Zanca view, using a digital caliper in the Picture Archiving and Communication System (INFINITT PACS Healthcare Co., Seoul, Korea).

The functional and radiological outcomes were assessed during routine follow-up examinations preoperatively and postoperatively (1, 3, and 6 months and 1 year postoperatively). Two independent observers (R.O. and K.A.) performed the functional and radiological assessments. The intraobserver reliability of the CC measurement was assessed using the interclass correlation coefficient, which was 0.999 (95% confidence interval: 0.998-1.000). The interobserver reliability was also assessed using the interclass correlation coefficient and was 0.984 (95% confidence interval: 0.953-0.985). We also recorded osteolysis around the clavicle, suture breakage through the bony cutout, button failure, post-traumatic degenerative change around the ACJ, and calcification along the CC ligaments.

Statistical analysis
The Kolmogorov-Smirnov test was used to test for normal distribution, and parametric tests were performed. The difference in the CC distance among the preoperative, early postoperative, and final follow-up periods was tested with a paired sample test. The intraobserver and interobserver reliabilities of the CC measurement were assessed with an interclass correlation coefficient test. The level of significance was set at p<0.05. The statistical analysis was performed using the Statistical Package for Social Sciences software version 20.0 (IBM SPSS Corp.; Armonk, NY, USA).

HIGHLIGHTS

- We hypothesized that the Tightrope device would achieve stability and provide satisfactory clinical outcomes in patients with type V ACJD.
- AC joint stabilization with TightRope technique is a valid option to with satisfactory results when performed without fluoroscopy.
- Hardware migration or loss of reduction do not cause clinically inferior results, if early soft tissue healing is achieved.
Results
The mean follow-up period was 19.3 (range: 12-30) months. The mean CMS at the final follow-up examination was 93.2 (range: 82-100) points. All the patients experienced full recovery of the shoulder’s range of motion, were able to return to activities of daily living, and were satisfied with the treatment.

The mean CC distance was 19.95 (range: 13.1-28.3) mm before the surgery. Radiographs taken during the early postoperative period showed that the mean CC distance was 7.47 (range: 4.2-11.5) mm. This difference was statistically significant (p<0.001). The mean CC distance at the final follow-up examination was 7.70 (range: 4.5-11.7) mm. At the final follow-up visit, the shoulders of all the patients were still completely reduced, with a mean difference in the CC of 0.23 (range: 0-1.3) mm CC compared with that in the early postoperative period. The difference in the CC between the early postoperative and final follow-up intervals was not statistically significant (p=0.055).

Early postoperative radiographic imaging showed that ACJ reduction was successful in all the patients. None of the patients experienced failure, as seen on Zanca views in the early postoperative period. We detected osteolysis around the clavicular button in 4 (26.66%) patients. No patient required reoperation owing to the loss of articular reduction. Observed complications included 2 patients with implant failure that was because of the failure of the coracoid button. Nevertheless, the functional outcomes of these 2 patients were good; they had CMSs of 82 and 86 and complete range of motion. Moreover, 2 patients had no pain or clinical complaints at the final follow-up examination. On radiographs, these 2 shoulders were still completely reduced at the final follow-up examination. A total of 5 (33.33%) patients presented with ACJD changes at the last radiographic evaluation; 4 (26.66%) patients presented with calcification along the CC ligaments.

Discussion
The most important finding of our study was that anatomical fixation with the TightRope device led to stable radiological results with a good functional outcome in 15 patients with acute Rockwood type V ACJD. In the treatment of acute ACJD, the primary intention is to restore the joint consistency and stabilize the physiological conditions until the soft tissue around the CC ligaments heals biologically.

The TightRope device is an adjustable loop fixation device that includes 2 titanium buttons (clavicle and coracoid buttons) with a no. 5 FiberWire loop suture (Arthrex, Naples, FL, USA). The coracoid button remains under the coracoid process, and the clavicular button remains over the clavicle between the insertion sites of 2 CC ligaments. The CC interval is then maintained with tension of nonabsorbable suturing material. However, increases in the CC distance over time, failure of the clavicular or coracoid buttons at the attachment sites, and clavicle fracture were reported as complications of this fixation device (20).

The AC and CC ligaments contribute to the stability and structure of the ACJ. Direct trauma to the acromion while a person falls on the shoulder is the most frequent mechanism of injury. This force causes displacement of the acromion, resulting in failure of the AC ligaments, joint capsule, CC ligaments, and deltotrapezial fascia (3). The conoid ligament is the most important ligament for superoinferior stability of the ACJ. The trapezoidal ligament has been shown to provide additional stability under axial loading of the ACJ (21). Fixation methods should provide adequate strength to maintain the CC distance until the soft tissues around the CC ligaments have healed biologically. We could not perform primary repair of the CC ligaments because serious injury may have disrupted the integrity of the CC ligaments and their vascular structures. Because of trauma, damaged and insufficient vascular supply decreases the healing potential of the CC ligaments (22). Consistent with our opinion, magnetic resonance imaging studies of surgically treated acute ACJD have shown that more than 50% of CC ligaments are insufficient (23). Weiser et al. studied 24 human cadaveric shoulders and found that AC repair did not provide increased stability compared with treatment without AC repair (24). We discovered that the TightRope device effectively maintained the anatomy of the ACJ and CC complex in patients with acute ACJD until healing occurred. Using the TightRope device, we successfully performed anatomical reduction in all the patients. In our study, the increase in the CC measurement from the early postoperative period to the final follow-up was not statistically significant. Vulliet et al. defined failure of reduction as a reduction loss of 5 mm or greater on radiographs (25). Postoperative radiographs showed there was no reduction loss of 5 mm or greater in the ACJ, and the CC distance was well maintained.

Numerous surgical methods have been described, including Kirschner wire fixation, screw fixation, hook plate fixation, a Weaver-Dunn procedure, anatomical CC joint reconstruction (with a SurgiLig ligament, TightRope, GraftRope, semitendinosus graft, or prothetic ligament), and distal clavicular resection (4-12), but none of these methods can be considered to be the gold standard for stabilizing the ACJ. Removing temporary fixation materials such as plates and screws is not recommended before complete soft tissue healing. The ideal time to remove these materials is from the 6th to the 12th week (26). Since the TightRope method was first described as a technique to treat ACJ dislocation, remarkable postoperative results have been published (27). The biggest feature that separates the TightRope device from others is that there is no need for a second surgical operation to remove the hardware. In addition, this technique does not require any autograft or allograft procedures.

We used the TightRope system to maintain the original anatomy of the ACJ complex. The strength of fixation achieved was superior to the original strength of the CC ligaments. Biomechanical studies have shown that TightRope systems are stronger than native CC ligaments (28). Cadaveric studies showed that the ultimate load-to-failure of the ACJ was about 500-700 N (29), whereas the load-to-failure of the CC ligaments (22). Consistent with our opinion, magnetic resonance imaging studies of surgically treated acute ACJD have shown that more than 50% of CC ligaments are insufficient (23). Weiser et al. studied 24 human cadaveric shoulders and found that AC repair did not provide increased stability compared with treatment without AC repair (24). We discovered that the TightRope device effectively maintained the anatomy of the ACJ and CC complex in patients with acute ACJD until healing occurred. Using the TightRope device, we successfully performed anatomical reduction in all the patients. In our study, the increase in the CC measurement from the early postoperative period to the final follow-up was not statistically significant. Vulliet et al. defined failure of reduction as a reduction loss of 5 mm or greater on radiographs (25). Postoperative radiographs showed there was no reduction loss of 5 mm or greater in the ACJ, and the CC distance was well maintained.

Overhead shoulder movements cause restricted movement of the ACJ. Studies using rigid fixation methods have had unsuccessful results because the ACJ is not a rigid joint and needs limited motion (31). The TightRope system allows for non-rigid fixation and stabilizing the ACJ with anatomical reduction. We started full passive range of motion exercises at 3 weeks postoperatively. It is important for the patient to start moving early so that their activities of daily life can continue and they can return to their pre-injury activities as soon as possible, which is the main goal in the treatment of ACJD. Exercises that help regain muscle power should begin as soon as possible. The non-rigid fixation feature of the TightRope device allows the patients to start moving early.

Studies have reported that the main complication with the TightRope system is the partial loss of reduction during follow-up owing
to osteolysis around the clavicular button [32, 33]. Osteolysis around the clavicular button may result in subluxation while the soft tissues around the CC ligaments heal and may impair the functional outcome. Jensen et al. reported an 18% loss of reduction in patients who underwent fixation with the TightRope device [34]. Considering this possible complication, we did not observe early or late loss of reduction in 4 patients with clavicle osteolysis.

When the TightRope device is used, sutures can break through the bony cutout in both those patients with and without early failure (15, 35). In our study, 2 patients experienced implant failure due to coracoid button failure. We think that this failure was caused by 2 reasons. The first reason was that the bony cutout of the coracoid button because of superoinferior stiffness. Motion in the superior direction was decreased with the use of the TightRope device. Lädermann et al. performed a cadaver study and found that increased superoinferior stiffness was obtained with the TightRope technique [36]. The second reason is that tunnel malposition led to lateral mobilization of the coracoid button to the bone tunnel. Schliemann et al. found that malposition will break the sutures or fracture bone, with failure of fixation [37]. In the 2 patients in whom the soft tissues around the CC ligaments were thought to have healed, the shoulders remained completely reduced, and satisfactory functional scores were obtained at the final follow-up examination. Similar to our outcome, some authors found that there was no correlation between implant migration and the CC distance, nor were there differences between the affected and contralateral sides. Venjakob et al. compared final radiographs at the 58-month follow-up interval with those taken at the 24-month follow-up interval and found that the clavicle had not migrated further [38]. This shows that even if hardware migration was observed on follow-up radiographs, migration would not cause clinically poor results or loss of reduction if early soft tissue healing can be achieved. If failure occurred before soft tissue forms, the reduction could be lost. Regardless of the soft tissue healing around the ligaments, our study indicated that reduction was lost, as seen on radiographs.

A total of 5 patients presented with ACJD changes at the last radiographic evaluation. These changes did not have a negative impact on our clinical results, similar to previous results [39]. Many authors recommend resection of the distal clavicle when arthritic findings are present [12], but we did not consider any other surgical intervention because the patients did not have clinical complaints and the functional outcomes were successful.

Furthermore, 4 patients presented with calcification around the CC ligaments. There were distinct differences among different studies, and the rates of calcification ranged from 0% to 85% (40). Calcification did not have a negative effect on the loss of reduction of the CC distance or functional outcome. Calcification may be created by biological healing of the soft tissue around the CC ligaments, leading to heterotopic ossification or calcium deposition of bone fragments in the soft tissues.

This study has several limitations. First, it was a retrospective study, and there was a lack of prospective planning, which limited our ability to extrapolate the data. Other limitations included the small sample size and short follow-up period. The value of the statistical analysis may have been limited by the small number of patients. Another limitation was that healing of the CC ligaments was not evaluated with a radiological examination. We think that the radiological evaluation system used in this study is not used frequently in studies on the TightRope system, and we think that we can contribute to the literature in this regard.

In conclusion, using the TightRope technique in patients with acute ACJD allows for anatomical restoration of the joint. According to the results of our study, the TightRope technique is a safe and effective procedure and is a valid option to stabilize the AC joint with satisfactory results. Fixation is performed without fluoroscopy. Furthermore, this technique does not require any autograft or allograft procedures or an additional operation to remove hardware because of its very low profile.

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