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Comparison of trans-articular Kirschner wire fixation and TightRope System for the treatment of acromioclavicular joint injuries

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ABSTRACT

Aim: Acromioclavicular joint (ACJ) injuries are common among the young and middle-aged population. The management of Grade 3 to 6 ACJ injuries is still controversial. The purpose of the present study was to compare the clinical results and complication rates of trans-articular Kirschner (K) wire fixation and the TightRope System for surgically treated ACJ injuries.

Material and Method: Patients with Grade 3 to 6 ACJ injuries surgically treated for acute ACJ injuries were included in this retrospective study. The patients were grouped according to the fixation method; the patients treated with the TightRope System were called Group 1 (n=17). The patients treated with trans-articular K-wire fixation were called Group 2 (n=21). The American Shoulder and Elbow Surgeons (ASES), Constant-Murley (CS), Visual Analog Scale (VAS) scores, and shoulder range of motion (ROM) values were evaluated, and the complications were recorded and compared between the two groups.

Results: Thirty-eight patients (7 females, 31 males) were included in the study with a mean age of 33±9.04. There was no significant difference between the two groups in terms of demographic and preoperative variables. ASES (P=0.400), CS (P=0.172), VAS (P=0.234), and ROM values were similar between the two groups. The rate of complications was significantly higher in Group 2 (P=0.025).

Conclusion: Trans-articular K-wire fixation and the TightRope System have similar clinical scores and ROM values; on the other hand, trans-articular K-wire fixation has significantly higher complication rates.

Keywords: Acromioclavicular joint, injury, surgical treatment, Kirschner wire, TightRope

INTRODUCTION

The acromioclavicular joint (ACJ) is a synovial joint that connects the clavicle to the shoulder blade; its injury accounts for approximately 9% of shoulder girdle injuries and is about five times more common in men than in women (1). Acromioclavicular joint dislocation (ACJD) occurs mainly during sports activities, while direct trauma to the adducted arm, falling on the shoulder directly forcefully. The treatment of these injuries depends on the degree of dislocation, patient complaints, and the period after the injury (2). The joint stability is assessed by clinical evaluation and conventional radiography. Classification is according to the Rockwood system, which defines six degrees of injury (3). This classification is based on the degree of disruption of the acromioclavicular and coracoclavicular

ligaments and surrounding facial tissues and the degree of radiological displacement of the clavicle in relation to the acromion. Higher degrees are associated with more displacement and more severe ligament injury. Recently, the literature supports the nonsurgical management of Grade I and II injuries, and it is generally accepted that patients with Grade IV, V, and VI injuries benefit from operative treatment. However, optimal treatment for Grade III injuries remains controversial (4). There are numerous procedures and protocols designed to treat the AC joint, and the literature on treatment options is full of descriptions of surgical techniques (1,5). Therefore, there is no consensus on the treatment of AC joint dislocation, which continues to be controversial.

Our study aimed to contribute to the literature by evaluating and comparing the clinical and radiological results of patients who underwent the trans-articular K-Wire fixation and the TightRope System technique in ACJD.

MATERIAL AND METHOD

After obtaining approval by Gaziosmanpaşa Training and Research Hospital Clinical Research Ethics Committee (Date: 05.05.2021, Decision No: 278) and All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Patients who received surgical treatment for ACJD between January 2017 and January 2020 were evaluated using a retrospective database. Inclusion criteria included patients over 18 years of age, Grade III, IV, V, and VI acromioclavicular joint dislocations, acute dislocations (less than three weeks), and at least 1-year follow-up. Exclusion criteria were patients under 18 years of age, previous shoulder surgery on the ipsilateral side, systemic diseases affecting joint movement, grade 3 and 4 shoulder joint osteoarthritis, Grade I and II acromioclavicular joint dislocations of the same side, chronic dislocation independent from the grade (longer than 3 weeks), presence of ipsilateral neurologic disorder and follow-up period less than 1 year.

A total of 69 patients were identified for the study; 31 patients were excluded because they did not meet the criteria, and baseline data were lacking. Ultimately, 38 patients undergoing surgical treatment for ACJD met the inclusion criteria and had their data available for research.

Demographic and medical variables such as age, gender, operated side, dominant side, injury mechanism, type of dislocation, the time between injury and surgery, follow-up time, complications, and clinical and radiologic outcomes were all assessed.

Clinical and Radiological Evaluation

The anteroposterior and axillary radiographs of the shoulder were evaluated by an independent clinician to classify the types of dislocations and radiological evaluation at the last follow-up examination. Classification of dislocations was made according to the Rockwood classification (6). Weighted stress radiographs were used to differentiate type II ACJD from occult type III injury (7). While evaluating the radiological results, the vertical distance between the lower border of the acromion and the clavicle was compared with the contralateral side. The differences were measured in millimeters. Less than 2 mm, anatomical repositioning; 2-4 mm, slight loss reduction; 4-8 mm, partial reduction loss; more than 8 mm was considered complete reduction loss (8). At the last follow-up, the American Shoulder and Elbow Surgeons (ASES) (9), Constant-Murley (9), Visual Analog Scale (VAS) scores, and shoulder range of motion degrees were all assessed for clinical evaluation.

Surgical treatment of Grade III ACJD was applied to patients younger than 60 years of age, active, and with a higher activity level, depending on the experience and preferences of the surgeons. Two different surgeon were performed the operations. According to their own experience, one of the operating surgeons chose to use the trans-articular K-wire fixation for ACJD and the other to use the TightRope system. Therefore, in our study, the patients operated with the TightRope system were classified as Group 1, and the patients operated with the transarticular K-wire as Group 2.

Surgical Technique

All patients were given a single dose of 1 g cefazolin antibiotic intravenously 30 minutes before surgery, and they were operated on in the beach-chair position.

TightRope System

An invasive application was performed from the craniodorsal of the clavicle to the ventral border of the coracoid. The clavicle was pierced with a K-wire targeting the coracoid base. The clavicle and coracoid were drilled with a 4 mm diameter drill guided with a K-wire. The TightRope® system (Arthrex, Napoli, USA) was pulled using guide sutures. The endobutton was inverted under the caudal direction of the coracoid, and the fixing button was placed in the clavicle after reduction. The procedures performed were checked by fluoroscopy. Distal clavicle resection was not performed.

Trans-articular K-Wire Fixation

Using a frontolateral approach parallel to the clavicle, the insertion point for the K-wires was set, and the clavicle was repositioned. Two K-wires with a diameter of 2 mm were drilled lateral to the acromion and placed in parallel under fluoroscopic control targeting the cranial cortical of the clavicle. Metal cerclage was used in addition to the K-wires, and fixation was achieved. Removal of the implant was routinely performed 12 months after surgery, but earlier implant removal was performed in patients with implant failure earlier than 12 months during follow-up. Reoperations for implant failure or any revisions were analyzed as 'reoperations.' Routine implant removal procedures were not analyzed as 'reoperation.'

Rehabilitation

Patients have been used a sling for the postoperative six weeks. Passive mobilization and pendulum exercises were applied at first two weeks. Active abduction and flexion were allowed up to 30 degrees after two weeks and gradually increased to 90 degrees within six weeks. The full active movement was allowed at postoperative 8th week. After 3rd month muscle strengthening exercises were started.

Statistics

The mean, standard deviation, and percent values were used, as appropriate, to describe the data. The distribution for each measured variable was evaluated for normality using the Kolmogorov–Smirnov test. Categorical variables are summarized as frequency (n) and a percentage of the total. Statistical analyses were conducted with the χ^2 test to compare categorical variables and the Student t-test or Mann Whitney U test to analyze group differences in clinical scores and the shoulder range of motion values. All statistical analyses were performed using the SPSS v24 (SPSS Inc., Armonk, NY) software. P values <0.05 were considered to be statistically significant.

RESULTS

The mean follow-up period was 35.28 ± 13.92 months (range 12-60) for all patients. Mean 34.56 ± 15.72 (range, 12-60) months in Group 1 and 36 ± 12.48 (range, 24-60) months in Group 2 without a statistical difference ($p=0.204$). Patient characteristics and distribution of demographic values between groups are presented in **Table 1**. When the preoperative dislocation degree was evaluated, 20 (52.6%) patients had grade III, 5 (13.2%)

patients had grade IV, and 13 (34.2%) patients had grade V ACJD. The distribution between the two groups was not statistically significant in terms of the degree of dislocation ($p=0.972$).

Table 2 shows the comparison of ASES, CM, VAS scores, and shoulder range of motion degrees between both groups. Although mean ASES, CM, VAS scores were higher in Group 1 than Group 2 at the last examination, differences were not statistically significant ($p=0.400$, $p=0.172$, $p=0.234$, respectively). Both ROM measurements were also better in Group 1 without statistical significance ($p=0.204$, $p=0.439$, respectively). Complications were as follows, 3 (17.6%) patients had implant failure in Group 1, and 7 (33.3%) patients had implant failure in Group 2. (4 (19%) implant failure, 1 (4.8%) superficial infection, 1 (4.8%) osteolysis, 1 (4.8%) arthrosis). Complication rates were significantly higher in Group 2 ($p=0.025$).

Reoperation was performed in 1 (5.9%) patient in Group 1, and 4 (19.0%) patients in Group 2 ($p=0.043$). The reduction quality of the last follow-up examination was similar between Groups 1 and 2 (**Table 2**) ($p=0.323$).

Table 1. Demographic and disease-specific characteristics of the patients

| Variable | Entire study population | Group 1 | Group 2 | p |
|--|-------------------------|--------------------------|--------------------------|-------|
| Patient number, n (%) | 38 (100) | 17 (44.7) | 21 (55.3) | |
| Age, year, (mean \pm SD [min-max]) | 33 \pm 9.04 (19-57) | 32.23 \pm 8.74 (19-53) | 33.61 \pm 9.45 (20-57) | 0.966 |
| Gender, n (%) | | | | 0.912 |
| Female | 7 (18.5) | 3 (17.6) | 4 (19.1) | |
| Male | 31 (81.5) | 14 (82.4) | 17 (80.9) | |
| Side, n (%) | | | | 0.618 |
| Right | 24 (63.1) | 10 (58.8) | 14 (66.7) | |
| Left | 14 (36.9) | 7 (41.2) | 7 (33.3) | |
| Dominant side, n (%) | | | | 0.796 |
| Yes | 21 (55.3) | 9 (52.9) | 12 (57.1) | |
| No | 17 (44.7) | 8 (47.1) | 9 (42.9) | |
| Time from injury to surgery, days, (mean SD) | 4.10 \pm 2.26 (1-11) | 4.05 \pm 1.95 (2-9) | 4.14 \pm 2.53 (1-11) | 0.835 |
| Injury mechanism, n (%) | | | | 0.875 |
| Simple fall | 10 (26.4) | 4 (23.5) | 6 (28.6) | |
| Traffic accident | 14 (36.8) | 7 (41.2) | 7 (33.3) | |
| Sport trauma | 14 (36.8) | 6 (35.3) | 8 (38.1) | |

Abbreviations: SD: standard deviation, n: number, $p<0.05$ was defined as significant and defined in bold

Table 2. Clinical Scores, shoulder range of motion degrees, and radiologic reduction status of both groups

| Variable | Entire Study Population | Group 1 | Group 2 | p |
|---------------------------------|-------------------------|--------------------|--------------------|-------|
| ASES, (mean \pm SD) | 81.71 \pm 8.81 | 85.17 \pm 6.52 | 78.90 \pm 9.56 | 0.400 |
| CM, (mean \pm SD) | 80.47 \pm 8.36 | 83.58 \pm 6.53 | 79.95 \pm 8.96 | 0.172 |
| VAS (mean \pm SD) | 2.42 \pm 1.91 | 1.70 \pm 1.26 | 3.0 \pm 2.16 | 0.234 |
| ROM, (mean \pm SD) | | | | |
| Forward flexion | 159.94 \pm 18.80 | 165.23 \pm 13.54 | 155.66 \pm 21.54 | 0.204 |
| Abduction | 153.28 \pm 27.16 | 160.11 \pm 19.77 | 147.76 \pm 31.31 | 0.439 |
| Radiologic reduction assessment | | | | |
| Anatomic reduction | 22 (57.9) | 12 (70.6) | 10 (47.6) | 0.323 |
| Mild reduction loss | 5 (13.2) | 2 (11.8) | 3 (14.3) | |
| Partial reduction loss | 8 (21.1) | 2 (11.8) | 6 (28.6) | |
| Total reduction loss | 3 (7.9) | 1 (5.9) | 2 (9.5) | |

Abbreviations: SD: standard deviation, n: number, $p<0.05$ was defined as significant and defined in bold

DISCUSSION

The most important finding in our study was that there was no significant difference in the clinical, functional, and radiological results of patients with ACJD treated using K-wire fixation with tension band cerclage and the TightRope system.

One of the most common surgical techniques used to treat ACJD is K-wire fixation (10). In studies conducted on this subject, Sirveaux et al. (11) published long-term functional results of surgical treatment with K-wire fixation with tension band cerclage in 29 patients and obtained good and excellent results. Leidel et al. (10) achieved satisfactory functional results in short, midterm, and long-term follow-up with joint transfixation using K-wire fixation with tension band cerclage of Grade III ACJD. Murphy et al. (12) reported good and excellent clinical results in fixation results with K-wire fixation with tension band cerclage in the short-term follow-up of 23 patients with ACJD. Vrgoč et al. (13) compared K-wire fixation with tension band cerclage and TightRope System methods for surgical treatment of Grades III and V ACJD. They reported good clinical results in terms of surgical outcomes between patients and found no statistically significant difference. In a retrospective analysis of the results of Grade V ACJDs treated with K-wire fixation with tension band cerclage and screw stabilization for at least 15 years, successful functional results were obtained, and minor differences between the two groups were found (14). A recent study found no significant difference in ACJD surgical treatment between patients treated with K-wire fixation with tension band cerclage, the Weaver-Dunn procedure, single TightRope®, or double TightRope® (15). A biomechanical study showed that ACJ trans-articular K-wire fixation with tension band cerclage provided good mechanical resistance to secondary joint dislocation during passive motion (16). Studies have stated that satisfactory results can be obtained using K-wire fixation with tension band cerclage in ACJD repair. Still, the displacement of the wires poses the most critical risk in this method (4).

Our study observed loosening of the K-wire, displacement, and associated implant failure in 4 (19%) patients. Patients with implant failure were reoperated, and their K-wires and cerclage were removed. We obtained satisfactory clinical, functional, and radiological results in this method, but implant failure posed a serious risk for migration.

The TightRope technique is a stable and functional anatomical reconstruction procedure, and studies are showing that it results in forces equal to or even higher than the natural ligaments (17). Biomechanical studies have shown that the Tightrope system is superior to established surgical methods in treating ACJD and is

stronger than natural coracoacromial ligaments. However, they have also been found to fail easily with cyclic loading, although clinical trials on this topic are infrequent (18-21).

Using the TightRope system for ACJD, Thiel et al. (22) obtained satisfactory functional results in the vast majority of patients. Still, in the same study, they found a fixation failure rate of 16.6%. Beris et al. (23) obtained satisfactory functional and radiographic results in treating Grade III and IV ACJD with the TightRope system in an average 18-month follow-up of 12 patients. In recent studies, the TightRope® system technique is an effective method to stabilize acute ACJD. In the results, encouraging data were obtained in high-grade ACJD (Grades IV - V) and Grade III dislocations (15). When the literature was reviewed, it was observed that ACJD surgical treatment had changed significantly in the last decade, the use of the previously popular K-wire techniques has decreased (from 37% in 2001 to 6% in 2014), while the TightRope® system is now used more frequently (27% in 2014) (15). As mentioned in the literature, satisfactory results have been achieved in both methods. Our study's data also reached higher shoulder scores and fewer pain scores in the surgical treatment performed with the TightRope technique. Still, there was no statistically significant difference in both determinations. In this respect, the data of our study is consistent with the literature.

Most of the complications after using Kirschner wires have been reported in the literature due to loss of reduction, posttraumaticosteoarthritis, clavicular osteolysis, superficial wound infections, and displacement of the wire to the lung, spinal cord, or longitudinal cord (7,24,). However, the TightRope technique has some disadvantages. It requires bicortical holes that can cause fractures in the clavicle and coracoid (17). Walz et al. (18) reported three coracoid fractures and one clavicle fracture in their study. Motta et al. (26) reported a loss of reduction in four cases (20%) of TightRope fixation due to the rupture of the sutures during the follow-up. Scheibel et al. (27) examined 27 patients who underwent TightRope fixation and reported mild reduction losses up to six months postoperatively. In other studies, fixation failure was reported in one-third of Grade III and V ACJD patients using the TightRope system (22,28). When the complications were evaluated in our study, we did not encounter wire displacement in any of the patients who underwent K-wire fixation with tension band cerclage. We attribute this result to regular patient follow-up and our routine removal of implants in the early period. Implant failure rates were similar in both groups, but the complication rates were significantly higher in the K-wire fixation group when evaluated together with other complications. We can attribute this result to the K-wires piercing and partially destroying the ACJ during application.

There are some limitations to our study. The first of these was the retrospective evaluation of the patients; the second was evaluating the results of relatively few patients; our third and last limitation was the evaluation of the results of two different surgeons. Examining the results of a single experienced surgeon can provide more precise data on the results. Beside that short follow-up time may lead to more subjective outcomes.

CONCLUSION

We achieved similar clinical, functional, and radiological results in both techniques, but we found more frequent complication rates in fixations made with K-wires. For this reason, we can say that the fixation method with TightRope is a safer technique in terms of complications.

ETHICAL DECLARATIONS

Ethics Committee Approval: Gaziosmanpaşa Training and Research Hospital Clinical Research Ethics Committee (Date: 05.05.2021, Decision No: 278).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

- Mazzocca AD, Arciero RA, Bicos J. Evaluation and treatment of acromioclavicular joint injuries. *Am J Sports Med.* 2007; 35: 316-29.
- Lafosse L, Baier GP, Leuzinger J. Arthroscopic treatment of acute and chronic acromioclavicular joint dislocation. *Arthroscopy.* 2005; 21: 1017.
- Alyas F, Curtis M, Speed C, Saifuddin A, Connell D. MR imaging appearances of acromioclavicular joint dislocation. *Radiographics.* 2008; 28: 463-79.
- Modi CS, Beazley J, Zywiell MG, Lawrence TM, Veillette CJ. Controversies relating to the management of acromioclavicular joint dislocations. *Bone Joint J.* 2013; 95: 1595-602.
- Beitzel K, Cote MP, Apostolakis J, et al. Current concepts in the treatment of acromioclavicular joint dislocations. *Arthroscopy.* 2013; 29: 387-97.
- Gorbaty JD, Hsu JE, Gee AO. Classifications in Brief: Rockwood Classification of Acromioclavicular Joint Separations. *Clin Orthop Relat Res.* 2017; 475: 283-7.
- Johansen JA, Grutter PW, McFarland EG, Petersen SA. Acromioclavicular joint injuries: indications for treatment and treatment options. *J Shoulder Elbow Surg.* 2011; 20: 70-82.
- Pavlik A, Csépai D, Hidas P. Surgical treatment of chronic acromioclavicular joint dislocation by modified Weaver-Dunn procedure. *Knee Surg Sports Traumatol Art.* 2001; 9: 307-12.
- Wylie JD, Beckmann JT, Granger E, Tashjian RZ. Functional outcomes assessment in shoulder surgery. *World J Orthop.* 2014; 5: 623-33.
- Leidel BA, Braunstein V, Kirchhoff C, Pilotto S, Mutschler W, Biberthaler P. Consistency of long-term outcome of acute Rockwood grade III acromioclavicular joint separations after K-wire transfixation. *J Trauma.* 2009; 66: 1666-71.
- Sirveaux F, Traversari R, Roche O, Mole D. Outcome more than ten years after surgical treatment of acromioclavicular disjunction. *J Bone Joint Surg Br.* 2001; 83: 36.
- Murphy M, Connolly P, Murphy P, McElwain JP. Retrospective review of outcome post open reduction and K-wire fixation for grade III acromioclavicular joint subluxations. *Eur J Orthop Surg Traumatol.* 2004; 14: 147-50.
- Vrgoč G, Japjec M, Jurina P, et al. Operative treatment of acute acromioclavicular dislocations Rockwood III and V-Comparative study between K-wires combined with FiberTape(®) vs. TightRope System(®). *Injury.* 2015; 46: 107-12.
- Virtanen KJ, Remes VM, Tulikoura IT, et al. Surgical treatment of Rockwood grade-V acromioclavicular joint dislocations: 50 patients followed for 15-22 years. *Acta Orthop.* 2013; 84:191-5.
- Horst K, Garving C, Thometzki T, et al. Comparative study on the treatment of Rockwood type III acute acromioclavicular dislocation: Clinical results from the TightRope® technique vs. K-wire fixation. *Orthop Traumatol Surg Res.* 2017; 103: 171-6.
- Fialka C, Michlits W, Stampfl P, et al. Biomechanical analysis of different operative techniques for complete acromioclavicular joint disruptions. *Osteosynthesis and Trauma Care.* 2005; 13: 154-9.
- Cai L, Wang T, Lu D, Hu W, Hong J, Chen H. Comparison of the Tight Rope Technique and Clavicular Hook Plate for the Treatment of Rockwood Type III Acromioclavicular Joint Dislocation. *J Invest Surg.* 2018; 31: 226-33.
- Walz L, Salzmann GM, -Fabbro T, Eichhorn S, Imhoff AB. The anatomic reconstruction of acromioclavicular joint dislocations using 2 TightRope devices: a biomechanical study. *Am J Sports Med.* 2008; 36: 2398-406.
- Nuchtern JV, Sellenschloh K, Bishop N, et al. Biomechanical evaluation of 3 stabilization methods on acromioclavicular joint dislocations. *Am J Sports Med.* 2013; 41: 1387-94.
- Zooker CC, Parks BG, White KL, Hinton RY. TightRope versus fiber mesh tape augmentation of acromioclavicular joint reconstruction: a biomechanical study. *Am J Sports Med.* 2010; 38: 1204-8.
- Ladermann 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: 171-8.
- Thiel E, Mutnal A, Gilot GJ. Surgical outcome following arthroscopic fixation of acromioclavicular joint disruption with the tightrope device. *Orthopedics.* 2011; 34: 267-74.
- Beris A, Lykissas M, Kostas-Agnantis I, Vekris M, Mitsionis G, Korompilias A. Management of acute acromioclavicular joint dislocation with a double-button fixation system. *Injury.* 2013; 44: 288-92.
- Fraser-Moodie JA, Shortt NL, Robinson CM. Injuries to the acromioclavicular joint. *J Bone Joint Surg Br.* 2008; 90: 697-707.
- Hackenburch W, Regazzoni P, Schwyzer K. Surgical treatment

- of lateral clavicular fracture with the clavicular hooked plate. *Z. Unfallchir. Versicherungsmed.* 1994; 87: 145-52.
26. Motta P, Maderni A, Bruno L, Mariotti U. Suture rupture in acromioclavicular joint dislocations treated with flip buttons. *Arthroscopy.* 2011; 27: 294-8.
27. Scheibel M, Droschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med.* 2011; 39: 1507-16.
28. Defoort S, Verbort O. Functional and radiological outcome after arthroscopic and open acromioclavicular stabilization using a doublebutton fixation system. *Acta Orthop Belg.* 2010; 76: 585-91.