TightRope vs Clavicular Hook Plate for Rockwood III–V Acromioclavicular Dislocations: A Meta-Analysis

Xin Pan, MD1†, Rui-yan Lv, BD2†, Ming-gang Lv, BD2, Da-guang Zhang, MD3

1Department of Ophthalmology, The Second Hospital of Jilin University and 3Department of Orthopedics, The First Hospital of Jilin University, Changchun and 2Department of Orthopedics, The People’s Hospital of Shulan City, Shulan, China

Objective: To assess and compare the clinical outcomes and complications of TightRope® fixation vs hook plate fixation for the treatment of Rockwood III-VI Acromioclavicular joint (ACJ) dislocations.

Methods: Relevant studies were identified by searching PubMed, Embase, and Web of Science databases, from their inception to 12 April, 2019. The main outcomes of interest included Constant Score, University of California Los Angeles (UCLA) Shoulder Score, Visual Analogue Scale (VAS), coracoclavicular distance (CCD), and complications. Weight mean difference (WMD) with 95% confidence intervals (95% CIs) or risk ratio (RR) with 95% CIs was used to calculate the data.

Results: Four studies with a total of 179 patients were included in this study. Compared with hook plate, TightRope® fixation was associated with a significantly less VAS score for pain (WMD = -0.69, 95% CI: -1.10, -0.27; P = 0.001). However, there were no significant differences between the two surgical techniques in terms of Constant Score (WMD = 6.12, 95% CI: -3.84, 16.08; P = 0.229), UCLA (WMD = 7.96, 95% CI: -5.76, 21.68; P = 0.256), CCD (WMD = 0.24, 95% CI: -0.67, 1.15; P = 0.602), and complication rate.

Conclusion: Both TightRope® and hook plate techniques offered effective outcomes in relieving the pain of dislocation and improving function of ACJ. However, TightRope® fixation showed an advantage over hook plate in terms of postoperative pain. Further larger-scale RCTs are needed to verify our findings.

Key words: Acromioclavicular dislocations; Hook plate fixation; Meta-analysis; TightRope® fixation

Introduction

Acromioclavicular joint (ACJ) dislocation is one of the most common shoulder problems accounting for 50% of all sports-related shoulder injuries1,2. They often occur in athletic, young patients after blunt force to the shoulder3. ACJ injuries are classified by Rockwood classification system into types I-VI based on the radiographic criteria4. Treatment of ACJ dislocation is commonly guided by Rockwood’s classification5. According to the guideline, conservative treatment is usually recommended for type I and II graded lesion, and surgical treatment is advised for IV-VI injuries.

However, for type III injuries, the therapeutic schedule still remains controversial6,7. Some authors advocate conservative treatments for this type of injury, while some others have reported good clinical outcomes using the operative procedures7–9. There are a variety of surgical procedures that are used for ACJ dislocation, including coracoclavicular (CC) fixation, coracoacromial ligament transfer, hook plate, TightRope® fixation, AC or CC reconstruction10–12. But none of these techniques can be used as the gold standard for operative ACJ stabilization.

Address for correspondence Da-guang Zhang, MD, Department of Orthopedics, the First Hospital of Jilin University, No. 71 Xinmin Street, Changchun, China 130021 Tel: +86-0431-81875596; Fax: +86-0431-88782935; Email: daguangzhangmd@outlook.com

†These authors contribute equally to this manuscript

Received 3 December 2019; accepted 14 May 2020
Two commonly used surgical techniques – TightRope® fixation (supplementary file) and hook plate – have been reported of good clinical and radiological outcomes in the management of ACJ dislocations13,14. The TightRope® technique is a minimally invasive method used to stabilize the ACJ and augment the CC complex with a high-strength suture15,16. The clavicular hook plate method is an open procedure, in which the plate is fixed with screws on the upper surface of the clavicle and the hook is fixed transarticularly at the lower surface of the acromion17. This approach could improve the natural healing of ligaments when being used for ACJ dislocations17.

Currently, there have been several trials that compared the functional and radiological results between TightRope® and hook plate in patients with type III-VI ACJ dislocations. However, there has been no consensus as to which surgical technique is more suitable. Therefore, we conducted this meta-analysis to assess and compare the clinical outcomes of TightRope® fixation vs hook plate fixation for the treatment of Rockwood III-VI ACJ dislocations.

Materials and Methods

Ethical approval and patient consent are not required in this study, because this meta-analysis is performed based on the previously published studies. We carried out this meta-analysis in accordance with the Preferred Reporting Items for Systematic Reviews and meta-analysis (PRISMA) criteria18.

Search Strategy

A comprehensive literature search for articles published between the inception to 12 April 2019 was performed using PubMed, Embase, and Web of Science. The following combination of keywords and MeSH terms were used: ("acromioclavicular joint" [MeSH Terms] OR "acromioclavicular" [All Fields] AND "joint" [All Fields]) OR "acromioclavicular joint" [All Fields]) AND ("joint dislocations" [MeSH Terms] OR "joint" [All Fields] AND "dislocations" [All Fields]) OR "joint dislocations" [All Fields] OR "dislocation"[All Fields]) AND TightRope®[All Fields] AND (("clavicle" [MeSH Terms] OR "clavicle" [All Fields] OR "clavicula" [All Fields]) AND hook [All Fields] AND "bone plates" [MeSH Terms] OR "bone" [All Fields] AND "plates" [All Fields] OR "bone plates" [All Fields] OR "plate" [All Fields])). In addition, a manual search of references listed in included studies and published reviews were conducted to search for potentially eligible studies.

Study Selection

Studies that met the following inclusion criteria were considered: (i) Patient: adult patients were diagnosed with ACJ dislocations (Rockwood III-IV); (ii) Intervention: surgical fixation with TightRope®; (iii) Comparison: clavicular hook plate; (iv) Outcome: Constant Score, the University of California Los Angeles (UCLA) Shoulder Score, Visual Analogue Scale (VAS), coracoclavicular distance (CCD), and complications; (v) Study design: randomized controlled trial (RCT), case-control study, or cohort study. We excluded studies with the following properties: patients diagnosed with ACJ dislocations (Rockwood I-II); surgical fixation methods were not TightRope® or clavicular hook plate; studies did not provide outcomes of our interest; studies that were case reports, reviews, letters, or non-comparative observational articles. We would also contact the corresponding authors for original data when important information was not provided in the study.

Data Extraction

Two independent investigators performed the data extraction using a standardized Excel file. The following data were extracted from the included studies: first author’s name, year of publication, study design, sample size in each group, patient characteristics, duration of follow-up, and the outcome measures. Any disagreement between the investigators was resolved by discussion and consensus. When several studies that were from the same population or clinical trial were published, we only included the study with longest duration of follow-up, or with the most complete information.

Outcome Measures

Constant Score

Constant score is one of the most frequently used scoring systems for assessing shoulder outcomes worldwide19,20. The Constant score comprised items related to pain (15 points), activities of daily living (20 points), range of motion (40 points), and muscle strength (25 points), amounting to a full score of 10019,20. Constant scores of ≥90, ≥80, ≥70, and <70 are regarded as excellent, good, fair, and poor, respectively19,20.

The University of California Los Angeles Shoulder Score

The UCLA shoulder score is widely used for the evaluation of functional and quality of life outcome after arthroscopic rotator cuff repair with good reliability and validity21. This method assigns a score to patients based on five separate domains: pain (10 points), function (10 points), active forward flexion (5 points), strength of forward flexion (5 points), and overall satisfaction (5 points), with a total score of 35 points22. A higher score indicates increased shoulder function22.

Visual Analogue Scale

VAS has been in use for the measurement of intangible quantities such as pain, quality of life, and anxiety23. It consists of a line usually 100 mm in length, with anchor descriptors such as (in the pain context) “no pain” and “worst pain imaginable”23. A higher score indicates a higher level of pain23.

Coracoclavicular Distance

The CCD is defined as height in the contralateral shoulder between the upper border of coracoid process and the inferior cortex of the clavicle24. Increase in CCD by 50%–100% and higher than 100% with respect to the contralateral side was considered as subluxation and redislocation, respectively24.
Quality Assessment
The assessment of risk of bias in each RCT was conducted using the method recommended by Cochrane Collaboration. In accordance with the quality domains and scoring system, each RCT was classified as being “high” (seriously weakens confidence in results), “low” (unlikely to seriously alter the results), or “unclear” risk of bias.

The quality of non-RCT was assessed using modified Newcastle-Ottawa Scale (NOS). This method evaluated the study quality based on three items, including selection, comparability, and exposure (case-control study) or outcome (cohort study). The total scale of this method was 9 points, and a score of 8–9 points indicated high quality, 6–7 points being moderate quality, and ≤ 5 points being low quality.

Statistical Analysis
Meta-analysis was performed using STATA version 12.0 (Stata Corporation, College Station, TX, USA). Continuous variables were presented as weight mean difference (WMD) with 95% confidence intervals (CIs); while dichotomous variables were pooled as risk ratio (RR) with 95% CIs. Heterogeneity across studies was evaluated by Cochrane Q and $I^2$ statistic. The $P$ value less than 0.1 or $I^2$ exceeded 50% indicated significant heterogeneity. Pooled results were calculated with a fixed-effect model when there was no evidence of heterogeneity, or a random-effects model when significant heterogeneity was identified. For clinical heterogeneity, we performed sensitivity analysis by removing one trial at a time to explore the potential sources of heterogeneity. Since the number of included studies was less than 10, assessment of publication bias was not performed. A $P$ value less than 0.05 was judged as statistically significant except where a certain $P$-value had been given.

Results
Study Selection
The initial search yielded 482 studies, of which 316 were excluded because of duplicate records. After screening by title/abstracts, 157 were excluded because of the following reasons: reviews, editors, letters, or case reports, leaving nine studies for full-text review. Among these studies, five were excluded because three studies compared TightRope® with other techniques and two studies were single-arm study design. Finally, four studies were included in this meta-analysis for data analysis. A flow diagram of the study selection process is presented in Fig. 1.
Study Characteristics
The baseline characteristics of included studies are presented in Table 1. These studies were published between 2014 and 2018. Two of the studies were prospective/reportspective case-control studies, one was a prospective cohort, and one was an RCT. All the patients were diagnosed with Rockwood type III-VI ACJ dislocations, and patients in two studies were type III injury. The mean age and percentages of male gender varied from 18 years to 68 years, and 63.33% to 93.75%, respectively. The mean duration of follow-up in these studies ranged from 12 to 48 months. TightRope® fixation was carried out in these studies, but only one study reported that it was performed with double technique and the other three did not. In the hook plate group, two studies reported the time of plate removal, which were within 3 and 6 months of the initial surgery, respectively. Whereas, in the TightRope® group, no implant removal was implemented. Three of the included studies performed the TightRope® with arthroscopic-assisted techniques.

The quality assessment of three non-RCTs showed that, the NOS scores were greater than 6, which indicated that they were of moderate or high quality. The risk of bias for the only RCT showed that it was classified as being at high risk bias. The reason for this was that it was difficult to perform the blinding for the surgeon or outcome assessors.

Constant Score
Data on Constant Score was available in all of the included studies. Significant heterogeneity was found among these studies (I² = 93.0%, P < 0.001). Thus, a random-effect model was used to pool the data. The results showed that TightRope® had similar effect with hook plate in Constant Score (WMD = 6.12, 95% CI: −3.84, 16.08; P = 0.229) (Fig. 2). We

### Table 1: Baseline characteristics of patients in the trials included in the meta-analysis

| Study            | Country | Study design | Treatment regimen | No. of patients with III/IV/V/VI grade | Male/ Female | Age (mean ± SD, y) | Duration of follow-up (m) |
|------------------|---------|--------------|-------------------|----------------------------------------|--------------|--------------------|--------------------------|
| Bin Abd Razak35  | Singapore | Case-control | Arthroscopic TR | 16 | NR | 15/1 | 41.4 ± 12.3 | 23 (14–35) |
| Andreani36       | Italy | Case-control | Hook plate | 10 | NR | 9/1 | 49.2 ± 16.9 | 23 (14–35) |
| Cai37            | China | RCT | TR | 19 | NR | NR | 32.3 (19–60) | 24 (48–60) |
| Hook plate | 9 | NR | NR | 32.3 (19–60) | 24 (48–60) |
| Jensen38         | Germany | Cohort | TR | 30 | 30/0/0 | 19/11 | 42.8 ± 11.88 | 12 |
| Hook plate | 39 | 39/0/0 | 26/13 | 41.79 ± 10.21 | 12 |
| Hook plate | 26 | 26/0/0 | 23/3 | 39 (18–54) | 17 (7–29) |
| Hook plate | 30 | 30/0/0 | 28/2 | 39 (18–68) | 48 (7–77) |

SD, standard deviation; RCT, randomized controlled trial; NR, not reported; TR, TightRop.
conducted sensitivity analysis by excluding the trial with outlier, and results changed substantially (WMD = 12.19, 95% CI: 8.84, 15.54; \( P < 0.001 \)), but significant heterogeneity was still present (\( I^2 = 77.5\% \), \( P = 0.012 \)). Further excluding any single study did not change the overall estimate, but the evidence of heterogeneity did not disappear.

**Visual Analogue Scale Score**

Data on VAS was reported in three studies. No significant heterogeneity was identified among these studies. Thus, a fixed-effect model was used to summarize the data. Results showed that TightRope® was associated with a significantly less VAS score for pain than hook plate (WMD = -0.69, 95% CI: -1.10, -0.27; \( P = 0.001 \)) (Fig. 3).

**University of California Los Angeles Shoulder Score**

Data on UCLA Shoulder Score was reported in two studies. Since there was significant heterogeneity across the studies, a random-effect model was applied to pool the results. Compared with hook plate, TightRope® was
associated with a similar effect than hook plate in UCLA Shoulder Score (WMD = 7.96, 95% CI: −5.76, 21.68; P = 0.256) (Fig. 4).

**Coracoclavicular Distance**

Data on CCD was presented in three studies\(^\text{35-37,38}\). No significant heterogeneity was tested among the studies. Results from a fixed-effect model suggested that there was no significant difference in CCD between TightRope\(^\text{®}\) and hook plate (WMD = 0.24, 95% CI: −0.67, 1.15; P = 0.602) (Fig. 4).

**Complication**

All the included studies reported the data of complications\(^\text{35-38}\). Pooled estimates demonstrated that there were no significant differences in complications between the two techniques, including plate/screw breakage or loosening (RR = 0.42, 95% CI: 0.11, 1.66; P = 0.217), wound infection (RR = 0.18, 95% CI: 0.01, 3.44; P = 0.257), neural injury (RR = 0.43, 95% CI: 0.02, 10.20; P = 0.601), and redislocation (RR = 1.72, 95% CI: 0.55, 5.36; P = 0.346).

**Discussion**

The purpose of this meta-analysis is to assess and compare the clinical outcomes of TightRope\(^\text{®}\) fixation vs hook plate fixation for the treatment of Rockwood III–VI ACJ dislocations. The main findings of our study were that there was no significant difference in Constant Score, UCLA Score, CCD, and complication rate between the two surgical treatments. However, TightRope\(^\text{®}\) fixation showed a lower shoulder pain reported by VAS score. Our results indicated that both techniques could provide good clinical and radiological outcomes in relieving the pain of dislocation, and improving function of ACJ. However, TightRope\(^\text{®}\) fixation showed an advantage over hook plate in terms of postoperative pain.

There is a variety of techniques that have been performed for the treatment of ACJ dislocations, however, none of them is considered as the gold standard operative ACJ stabilization. In the past years, several studies\(^\text{31,34,39,40}\) that have been performed to explore the best operative technique for ACJ dislocation have had controversial conclusions. TightRope\(^\text{®}\) fixation and hook plate fixation are the two most frequently used treatments for ACJ dislocation because they can reduce the dislocation of ACJ.\(^\text{37}\) These two techniques have their own advantages, but also can cause treatment-related complications. Compared with hook plate, TightRope\(^\text{®}\) can lead to less damage to the surrounding soft tissue, which could decrease the blood loss of surgery and reduce the length of incision. Moreover, the TightRope\(^\text{®}\) technique is more stable than hook plate in the anatomic reconstruction of ACJ.\(^\text{41-42}\) Furthermore, there is no need for a second surgical procedure for implant removal when using the TightRope\(^\text{®}\) technique. Whereas, hook plate fixation also has its own advantage in that it can reduce both the vertical and horizontal planes.\(^\text{43}\) In the study conducted by Balke et al.\(^\text{44}\), the authors concluded that hook plate seemed to become the “standard therapy” in acute ACJ dislocations, in which 44% of surveyed surgeons regarded it as the favored surgical technique.

To the best of our knowledge, the present study is the first meta-analysis that compares the functional, radiological, and complication outcomes of TightRope\(^\text{®}\) fixation with that of hook plate fixation in patients with Rockwood III–VI ACJ dislocations. Reviewing the literature, there were several systematic review and meta-analysis that had been published to assess the effect and safety of different surgical techniques for acute ACJ dislocation.\(^\text{45-47}\) Arrirachakaran et al.\(^\text{45}\) performed a systematic review and meta-analysis to compare the postoperative outcomes and complications of hook plate vs suspensory loop fixation (LSF) in acute unstable ACJ. In that study, 16 and 25 studies were included for the analysis of hook plate fixation and LSF, respectively\(^\text{43}\). By pooling these data, they reported that LSF had less VAS score [unstandardized mean differences (UMD) = −1.19, 95% CI: −2.03, −0.35] but similar Constant-Murley score (UMD = 2.13, 95% CI: −1.43, 5.69) than hook plate. Moreover, the complication rate was significantly higher in LSF group than in hook plate group (RR = 1.69, 95% CI: 1.07, 2.60)\(^\text{45}\). The authors concluded that LSF showed better effects in shoulder function scores and postoperative pain than hook plate; however, it also produced higher complication rates than hook plate.\(^\text{45}\)

In another meta-analysis, Gowd et al.\(^\text{46}\) reviewed 58 articles with 1704 patients to compare the outcomes and complications of different techniques of ACJ reconstruction. Their results demonstrated that there were no significant differences between arthroscopic and open techniques in terms of loss of reduction (P = 0.858), overall complication rate (P = 0.774), and revision rate (P = 0.390)\(^\text{46}\). Moreover, open surgery was associated with a higher rate of clavicular/coracoid fractures than arthroscopic surgery (P = 0.048)\(^\text{46}\). The authors concluded that open and arthroscopic techniques showed similar effect and complication in the reconstruction of ACJ. The two meta-analyses support the current point that which surgical technique should be used as the ideal method for ACJ dislocation still remains inconclusive.

In the present meta-analysis, we found similar results with that of the previous two meta-analyses. TightRope\(^\text{®}\) was associated with higher shoulder function reported by Constant Score and UCLA Shoulder Score when compared with hook plate, but the differences between them were not significant. Our results were in accordance with the previously published studies, but in contradiction to the study reported by Bin Abd Razak et al.\(^\text{35}\). In that study, the authors performed a prospective case–control study of 26 patients with acute ACJ dislocation to compare the short-term outcomes of arthroscopic TightRope\(^\text{®}\) fixation with that of hook plate. At 1 year follow-up, TightRope\(^\text{®}\) had a significantly better Constant Score than hook plate (87.6 ± 11.7 vs 77.5 ± 12.3, P = 0.046)\(^\text{35}\). Moreover, they also found a significantly better shoulder abduction of TightRope\(^\text{®}\) than hook plate fixation at 6 months. The authors thought that the superior effect of
TightRope® over hook plate might be explained by the secondary surgery for removal of implant required by the hook plate technique32.

As for the postoperative shoulder pain, recent studies reported that patients treated with TightRope® had a significantly lower VAS score than those with hook plate. Cai et al.33 performed a prospective, randomized study to compare the clinical outcomes of TightRope® and clavicular hook plate for Rockwood type IIIACJ dislocation in adults. Sixty-nine patients were enrolled in that study, with 30 and 39 patients randomly assigned into the two groups. At the 3 and 12 months of follow-up, there were significant differences between the two groups in terms of VAS scores.33 The VAS score was significantly less in TightRope® group than in hook plate group (postoperative VAS score at 3 months: 1.20 ± 0.92 vs 2.21 ± 1.22; postoperative VAS score at one year: 0.97 ± 1.03 vs 1.92 ± 1.11)37. This is because TightRope® technique is a minimally invasive procedure, and it does not cause too much damage to the surrounding soft tissue37.

In this study, the incidence of complications regarding plate/screw breakage or loosening, wound infection, neural injury, and redislocation was comparable between the two surgical techniques. When hook plate fixation is used as the surgical regimen, subacromial impingement is the main concern. Lin et al.38 has reported that hook plate might induce shoulder impingement or even rotator cuff damage. In their study, 15 out of 40 ACJ dislocation patients (37.5%) who underwent clavicular hook plate developed subacromial impingement syndrome, and six of them had rotator cuff lesion.38 They advocated that the only solution for this was to remove the implant as soon as bony union and/or ligamentous healing was achieved. It should be noticed that there were no complications of shoulder impingement among the included studies in this meta-analysis.

There are several potential limitations in this study. First, the number of included studies was only four and the sample size was not too large, which would weaken the statistical power of the final results. Moreover, compared with larger trials, studies with small sample sizes were more likely to overestimate the treatment effect. Second, some of the included studies were retrospectively performed, which would result in selection bias. Third, there was significant heterogeneity among the included studies in Constant Score, which might be explained by the differences in patients’ characteristics, study design, type of ACJ injury, or timing of plate removal. These factors might have an impact on the data analysis.

In conclusion, the present study demonstrated that both techniques offered good clinical outcomes in relieving the pain of dislocation and improving function of ACJ. However, TightRope® fixation showed an advantage over hook plate in terms of postoperative pain. Therefore, in patients with ACJ dislocations, the surgical method should be chosen based on their status. Further larger-scale RCTs are needed to verify our findings.

Competing Interests

All the authors declare that they have no conflict of interest.

Funding

This work was supported by the Project of “13th five-year” Science and Technology Department of Jilin Province, grant number 20190201064JC.

Supporting Information

Additional Supporting Information may be found in the online version of this article on the publisher’s web-site:

Video S1. Supporting Information

Reference

1. Oussedik S. Injuries to the clavicle and acromioclavicular joint. Br J Hosp Med, 2007, 68: M68–M70.
2. Willimon SC, Gaskill TR, Millett PJ. Acromioclavicular joint injuries: anatomy, diagnosis, and treatment. Phys Sports Med, 2011, 39: 116–122.
3. Claydon RA, Court-Brown CM. The epidemiology of musculoskeletal tendinous and ligamentous injuries. Injury, 2008, 39: 1338–1344.
4. Rockwood C. Fractures in Adults, 2nd edn. Philadelphia: Lippincott-Raven, 1984; 860.
5. Tossy JD, Mead NC, Sigmond HM. Acromioclavicular separations: useful and practical classification for treatment. Clin Orthop Relat Res, 1963, 28: 111–119.
6. Phillips AM, Smart C, Groom AF. Acromioclavicular dislocation. Conservative or surgical therapy. Clin Orthop Relat Res, 1998, 353: 10–17.
7. Spencer EE Jr. Treatment of grade III acromioclavicular joint injuries: a systematic review. Clin Orthop Relat Res, 2007, 455: 38–44.
8. Hootman JM. Acromioclavicular dislocation: conservative or surgical therapy. J Athl Training, 2004, 39: 10–11.
9. Lizaur A, Sanz-Reig J, Gonzalez-Parreno S. Long-term results of the surgical treatment of type III acromioclavicular dislocations: an update of a previous report. J Bone Joint Surg Br, 2011, 93: 1088–1092.
10. Cote MP, Wojcik KE, Gomlinski G, Mazzocca AD. Rehabilitation of acromioclavicular joint separations: operative and nonoperative considerations. Clin Sport Med, 2010, 29: 213–225 vii.
11. Horst K, Dienstknecht T, Andruszkow H, Gradi G, Kobbe P, Pape HC. Radiographic changes in the operative treatment of acute acromioclavicular joint dislocation - tight rope technique vs K-wire fixation. Pol J Radiol, 2013, 78: 15–20.
12. Esenyel CZ, Ozturk K, Bulbul M, Ayanoglu S, Ceylan HH. Coracoclavicular ligament repair and screw fixation in acromioclavicular dislocations. Acta Orthop Traumatol, 2010, 44: 194–198.
13. Johansen JA, Gruetter PW, McFarland EG, Petersen SA. Acromioclavicular joint injuries: indications for treatment and treatment options. J Shoulder Elbow Surg, 2011, 20: S70–S82.
14. Simovitch R, Sanders B, Ozbaydar M, Lavery K, Warner JJ. Acromioclavicular joint injuries: diagnosis and management. J Am Acad Orthop Surg, 2009, 17: 207–219.
15. Salzmann GM, Walz L, Buchmann S, Glabgley P, Venjakob A, Imhoff AB. Arthroscopically assisted 2 bundle anatomical reduction of acute acromioclavicular joint separations. Am J Sport Med, 2010, 38: 1179–1187.
16. Zooker CC, Park BS, White KL, Hinton RY. TightRope® versus fiber mesh tape augmentation of acromioclavicular joint reconstruction: a biomechanical study. Am J Sport Med, 2010, 38: 1204–1208.
17. von Heideken J, Bostrom Windhamhne 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: 9–17.
18. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ, 2009, 339: b2535.

19. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res, 1987, 214: 160–164.

20. Constant CR, Gerber C, Emery RJ, Sojbjerg JO, Gohike F, Boileau P. A review of the Constant score: modifications and guidelines for its use. J Shoulder Elbow Surg, 2008, 17: 355–361.

21. Placzek JD, Lukens SC, Badalamenti S, et al. Shoulder outcome measures: a comparison of 6 functional tests. Am J Sport Med, 2004, 32: 1270–1277.

22. Kirkley A, Griffin S, Dainty K. Scoring systems for the functional assessment of the shoulder. Art Ther, 2003, 19: 1109–1120.

23. Heller GZ, Manuquera M, Chow R. How to analyze the visual analogue scale: myths, truths and clinical relevance. Scand J Pain, 2016, 13: 67–75.

24. Eschler A, Gradl G, Mittimeier 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 Traum Surg, 2012, 132: 33–48.

25. Higgins JP, Altman DG, Gotzsche PC, et al. The Cochrane Collaboration’s tool for assessing risk of bias in randomised trials. BMJ, 2011, 343: d5928.

26. Wells GA, Shea B, O’Connell D, Peterson J, Welch V, et al. (2011) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. Available: www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Accessed 25 November 2012.

27. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ, 2003, 327: 557–560.

28. Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. J Natl Cancer Inst, 1959, 22: 719–748.

29. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials, 1986, 7: 177–188.

30. Horst K, Garving C, Thometzi T, et al. Comparative study on the treatment of Rockwood type III acute acromioclavicular dislocation: clinical results from the TightRope®(R) technique vs K-wire fixation. Orthop Traumatol Surg, 2017, 103: 123–127.

31. Lademann A, Gueorgiev 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: 171–178.

32. Vascellari A, Schiavetti S, Battistella G, Rebuzzi E, Coletti N. Clinical and radiological results after coracoclavicular ligament reconstruction for type III acromioclavicular joint dislocation using three different techniques. A retrospective study. Joints, 2015, 3: 54–61.

33. Chaudhary D, Jain V, Joshi D, Jain JK, Goyal A, Mehta N. Arthroscopic fixation for acute acromioclavicular joint disruption using the TightRope® device. J Orthop Surg, 2015, 23: 309–314.

34. Zhang LF, Yin B, Hou S, Han B, Huang DF. Arthroscopic fixation of acute acromioclavicular joint disruption with TightRope®. Outcome and complications after minimum 2 (2–5) years follow-up. J Orthop Surg, 2017, 25: 2309499016684493.

35. Bin Abd Razak HR, Yeo EN, Yeo W, Lie TD. Short-term outcomes of arthroscopic TightRope®(R) fixation are better than hook plate fixation in acute unstable acromioclavicular joint dislocations. Eur J Orthop Surg Traumatol, 2018, 28: 869–875.

36. Andreani L, Bonicelli E, Parchi P, Piolanti N, Michele L. Acromioclavicular joint repair using two different techniques. Eur J Orthop Surg Traumatol, 2014, 24: 237–242.

37. 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: 226–233.

38. Jensen G, Køttkøhagen 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: 422–430.

39. Melenevsky Y, Yablom CM, Ramappa A, Hochman MG. Clavicle and acromioclavicular joint injuries: a review of imaging, treatment, and complications. Skeletal Radiol, 2011, 40: 831–842.

40. Rolf O, Hann von Weyhern A, Ewers A, Boehm TD, Gohike F. Acromioclavicular dislocation Rockwood III-V: results of early versus delayed surgical treatment. Arch Orthop Traum Surg, 2008, 128: 1153–1157.

41. Beitzel K, Obolilwe E, Chovaniec DM, et al. Biomechanical comparison of arthroscopic repairs for acromioclavicular joint instability: suture button systems without biological augmentation. Am J Med Sci, 2011, 39: 2218–2225.

42. 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 Sport Med, 2008, 36: 2398–2406.

43. Sim E, Schwarz N, Hocker K, Berzlanovich A. Repair of complete acromioclavicular separations using the acromioclavicular-hook plate. Clin Orthop Relat Res, 1995, 314: 134–142.

44. Balke M, Schneider MM, Akoto R, Bathis H, Bouillon B, Banerjee M. Acute acromioclavicular joint injuries. Changes in diagnosis and therapy over the last 10 years. Unfallchirurg, 2015, 118: 851–857.

45. Arirachakaran A, Boonard M, Piypapittayanun P, et al. Post-operative outcomes and complications of suspensory loop fixation versus hook plate in acute unstable acromioclavicular joint dislocation: a systematic review and meta-analysis. J Orthop Traumatol, 2017, 18: 293–304.

46. Gowd AK, Liu JN, Cabarcas BC, et al. Current concepts in the operative Management of Acromioclavicular Dislocations: a systematic review and meta-analysis of operative techniques. Am J Sport Med, 2019, 47: 2745–2758.

47. Arirachakaran A, Boonard M, Piypapittayanun P, Phiphonmongkol V, Chaijenkij K, Kongthavonskul J. Comparison of surgical outcomes between fixation with hook plate and loop suspensory fixation for acute unstable acromioclavicular joint dislocation: a systematic review and meta-analysis. Eur J Orthop Surg Traumatol, 2016, 26: 565–574.

48. 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.