J Shoulder Elbow Surg (2019) 28, 2090–2097

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

SHOULDER

Open versus modified arthroscopic treatment of acute acromioclavicular dislocation using a single tight rope: randomized comparative study of clinical outcome and cost-effectiveness

Amr A. Abdelrahman, MD[a], Amr Ibrahim, MD[a], Khalid Abdelghaffar, MD[a], Tarek Mohamed Ghandour, MD[a,*], Diaa Eldib, MD[b]

[a]*Faculty of Medicine, Ain Shams University, Cairo, Egypt*
[b]*Faculty of Medicine, Benha University, Cairo, Egypt*

Purpose: The purpose of this study was to compare clinical outcome and cost-effectiveness between arthroscopic and open repair using TightRope in acromioclavicular joint dislocation III and IV.
Patients and methods: Fifty-two patients with acute acromioclavicular joint dislocation type III and IV were included. Patients were randomly allocated to either of 2 groups: Arthroscopic Repair Group (ARG) and Open Repair Group (ORG). Constant-Murley Score (CMS), visual analog scale (VAS) score, and coracoclavicular (CC) distance were measured preoperatively and 3 months, 6 months, 1 year, and 2 years postoperatively.
Results: CMS increased from 40.68 for the ARG and 40.70 for the ORG preoperatively to 84.18 and 84.45 after 2 years from operation. VAS score decreased from 60.59 for the ARG and 64.50 for the ORG 1 day after surgery to 18.04 and 17.87 respectively after 6 months. CC distance decreased from 29.27 mm in the ARG and 28.16 mm in the ORG preoperatively to 9.86 mm in the ARG and 10.54 mm in the ORG on postoperative day 1. Rewidening of the CC distance occurred after 6 months (13.27 mm for the ARG and 13.62 mm for the ORG) and 1 year postoperatively (15.77 for the ARG and 15.41 for the ORG) but remained stable at final follow-up. There was a significant difference in surgical time (80.00 minutes in the ARG compared to 52.79 minutes in the ORG) and cost of consumables (US$1729.95 in the ARG compared to US$851.87 in the ORG).
Conclusion: Open and arthroscopic repair of acute acromioclavicular joint dislocation yielded good clinical results, yet the arthroscopic technique is more expensive and has a longer surgical time.
Level of evidence: Level I; Randomized Controlled Trial; Treatment Study

Keywords: Acromioclavicular; dislocation; TightRobe; shoulder; arthroscopy; Rockwood

Acromioclavicular (AC) joint dislocation is a common shoulder injury, especially among athletes and has an estimated incidence of 17% of all shoulder injuries and 30%-50% of athletic shoulder injuries.[8,14] In most cases, these are caused by a direct fall on the ipsilateral shoulder

Institutional Review Board approval was not required for this treatment study.

*Reprint requests: Tarek Mohamed Ghandour, MD, Ain Shams University, Cairo, Egypt.
E-mail address: tarekghndr@yahoo.com (T.M. Ghandour).

1058-2746/$ - see front matter © 2019 Journal of Shoulder and Elbow Surgery Board of Trustees. All rights reserved.
https://doi.org/10.1016/j.jse.2019.06.007

tip. The indirect mechanism of injury with an extended arm is rare.[1,15] The Rockwood classification system is currently used and based on the degree and direction of the disrupted anatomy of the AC joint.[3,7,14]

Despite the high prevalence of this injury, there is no consensus about its optimal treatment. A variety of surgical procedures are described in the literature, such as an augmented suture with absorbable materials, stabilization with Kirschner (K)-wires in combination with or without additional wire loops, hook plates, or the Bosworth screw, but none can be considered the gold standard of operative AC joint stabilization.[6,7,13,14]

Another treatment option was offered by the TightRope system (Arthrex, Naples, FL, USA), which is a device designed originally for stabilization of the inferior syndesmosis of the ankle. It is 2 metal buttons, 1 oblong and 1 circular, joined by a continuous loop of FiberWire suture (Arthrex).[9,11]

This technique was developed as a minimally invasive procedure in the management of AC dislocations. Because of its minimally invasive approach, it reduces soft tissue damage and yields better cosmetic results.[9] Also, there is no need for reoperation to remove the hardware that might sometimes be necessary with other devices, such as wires, screws, or plates. Moreover, the complications of hardware failure, like breakage, dislocations, or bone fractures, are minimized.[10]

The purpose of our study is to compare the clinical outcome and cost-effectiveness between the arthroscopic and open surgical repair using the TightRope system fixation method in cases with AC dislocation type III and IV.

Our hypothesis that the arthroscopic treatment is superior to the open methods regarding the hospital stay, postoperative complications, level of pain, and function.

Methods

After approval from the ethical committee, we included 52 patients (34 males and 18 females) with acute isolated AC dislocation Rockwood type III and IV in a randomized prospective comparative study, which we conducted in Ain Shams University Hospitals between March 2011 and December 2016 (Fig. 1).

Eligible patients were adults with AC dislocation Rockwood type III and IV within less than 4 weeks from the injury. A radiograph confirmed the diagnosis. Magnetic resonance imaging (MRI) was done to exclude other associated injury or pathology.

Exclusion criteria were concomitant shoulder pathology (rotator cuff tear, biceps tendon lesions, ie, SLAP lesion or tendinitis, subscapularis tear, anterior shoulder instability, adhesive capsulitis, glenohumeral arthritis), associated injury, fracture or dislocation elsewhere, previous shoulder surgery, or psychological illnesses.

Randomization and blinding

Patients were randomly allocated between the 2 groups using randomly permuted blocks with a block size of 10 (www.randomization.com). In the first group, –the Arthroscopic Repair Group (ARG), the repair was done arthroscopically, and open surgical repair were used in the second group, the Open Repair Group (ORG). In all patients, we used the single TightRope system by Arthrex. A code was given to each patient, the code list was kept with the second author (A.I.), who was responsible for keeping the allocation code list, receiving and keeping the results of the Constant-Murley Score (CMS), the visual analog scale (VAS) scores, cost analysis, operating room time records, radiographer's assessments of the coracoclavicular (CC) distance, scheduling patient appointments, and contacting patients by phone. This particular author (A.I.) was not involved in the clinical assessment, surgical decisions, or rehabilitation program. All patients were operated on by 2 of the surgeons who comprised our surgical team (A.A. and T.G.), who have more than 10 years' experience in arthroscopy and shoulder surgery. The 2 surgeons (A.A. and T.G.) were not blinded to patient allocation, but they were not involved in pre- and postoperative clinical assessments or radiographic evaluation. All cases were assessed clinically by a single examiner (A.R.), who is an experienced shoulder and upper extremity surgeon. The CC distance was measured pre- and postoperatively in the AC projection by the same radiologist. Both the clinical examiner (A.R.) and the radiologist were blinded to patient allocation.

Preoperative assessment

During the preoperative clinical assessment (performed by K.A.), the CMS and active and passive range of motion were measured, and radiologic evaluation was done using the true anteroposterior view of the shoulder and AC projection (10° cephalic tilt with the beam centered over the AC joint) and MRI.

The CC distance was measured pre- and postoperatively in the AC projection, whereas the MRI was used to assess the condition of the rotator cuff, labrum, capsular structure, long head of biceps, and any associated pathology preoperatively. Data were collected and kept by the second author (A.I.).

Operative details

We positioned all the patients in a beach chair position with general anesthesia and interscalene block for postoperative pain.

In the arthroscopic group, we introduced the scope from the posterior portal and surveyed the shoulder joint for any concurrent pathology that might have been missed during the postoperative period. We created the anterior portal under direct vision to be as close as possible to the coracoid process.

Débridement of the inferior surface of the coracoid was completed for better visualization. We made another superior incision over the clavicle at the junction of its lateral one-third and medial two-thirds in line with the coracoid. Under arthroscopic guidance, the stirrup guide was placed under the coracoid base, with the other end at the clavicle. A 2-mm guide wire was drilled from the clavicle to the coracoid followed by removal of the

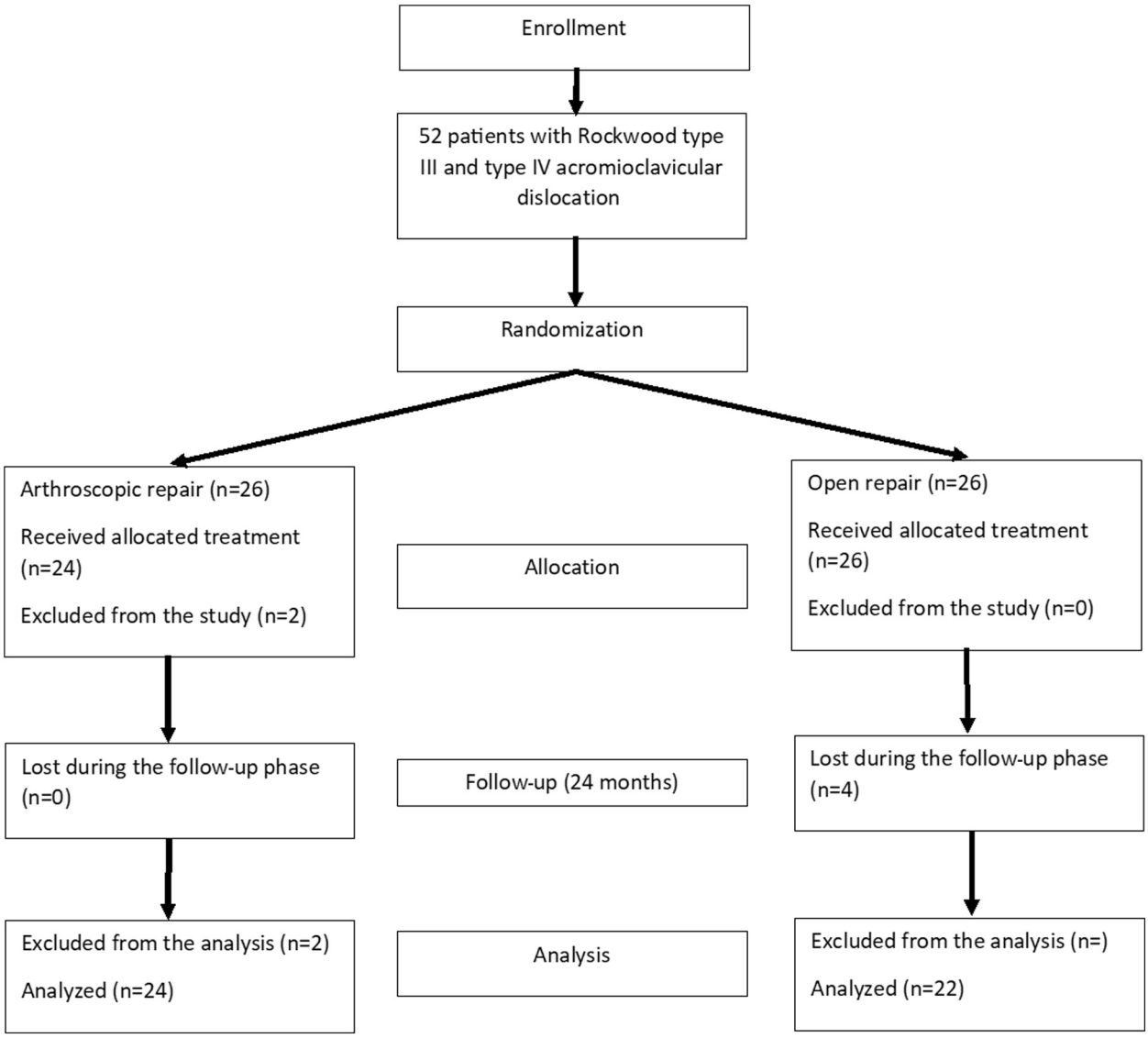

Figure 1 Study flow chart.

stirrup guide and drilling over the guide wire using a 4-mm cannulated drill bit. A nitinol wire was passed from the clavicle to the coracoid through the cannulated drill bit, with the tight rope attached to the outer end of the nitinol wire. From the anterior portal, the nitinol wire and the tight rope were retrieved and pulled until the metal button was seen under the coracoid and flipped. The clavicular end of the tight rope was then tightened to reduce the AC joint. The reduction was checked using intraoperative imaging before and after tightening the rope.

In the open group, we used a longitudinal strap incision from the junction of the lateral one-third and the medial two-thirds of the clavicle to the coracoid, followed by dissection of the subcutaneous tissue and incision of the deltopectoral fascia to identify the coracoid base. At this point, we placed 2 retractors at the medial and lateral edges of the coracoid. Again, the stirrup guide was placed on the inferior surface of the coracoid near its base. The following steps were done in the same order as the arthroscopic group, including the use of the intraoperative image intensifier to check the reduction before and after tightening the rope.

Postoperative phase

All patients in the 2 groups received the same rehabilitation program. Passive range of motion (pendulum exercises) and assisted forward flexion and abduction (finger wall climbing) were encouraged during the first 6 weeks. At the seventh week, an active exercise program was started. Weightlifting, pushing, and pulling were allowed 3 months after the surgery.

Before clinical assessment, patients were seen first by the second author (A.I.), who covered the wounds completely to ensure complete blinding of patient allocation before the assessment session. The Constant-Murley Score (CMS) was assessed by another author (K.A.) 3 , 6, 12, and 24 months postoperatively. All the patients completed their VAS questionnaires 1 day and 1,

3, and 6 months after surgery . The results were then received and kept by the second author (A.I.). Radiographic evaluation was done by the same radiographer to measure the CC distance on postoperative day 1, after 6 months , at 1 year , and at the final, 2-year follow-up. All measurements were received and kept by the second author (A.I.).

The cost was calculated in local currency (which value was converted to US dollars for the statistical analysis) based on 4 variables—cost of the consumables, anesthesia charges, operating room charges, and hospital stay and medications. The study was conducted in a university hospital where surgeon fees and cost of anesthesia do not vary on a case by case basis; hence, surgeon fees were not included as a variable. The duration of surgery was obtained from the operation theater log and counted from skin incision until closure. All data were collected, tabulated, and presented for the final statistical analysis at the end of the clinical part of the study.

Sample size

We conducted an a priori test for sample size calculation using the G*Power 3.1.9.2 software. We assumed a CMS mean difference between the 2 groups of 16 points, a standard deviation of 20 points, an alpha of 0.05, and power (1 – β) of 80%; 21 subjects had to be included in each group.

Our goal was to include 26 cases in each group to compensate for any lost subjects during the follow-up phase.

Statistics

We used SPSS software (version 20.0; IBM, Armonk, NY, USA) for statistical analysis of the data.

The range, mean, and standard deviation for the data were calculated. Shapiro-Wilk test was used to test all the data for normal distribution. χ^2 test was used to detect differences for nominal variables between the 2 groups. When numerical variables are found, the independent sample *t* test was calculated to detect any significant difference between the 2 groups, and 1-way repeated measures analysis of variance (ANOVA) was calculated to detect any statistically significant difference within the same group. Both 2-tailed significance (*P* value) and confidence interval were evaluated. The null hypothesis was rejected and the difference was considered statistically significant if the *P* value was $< .05$ and the 95% confidence interval did not include the zero value.

Results

Fifty-two cases with Rockwood type III and IV acute AC dislocation were included in this study. Patients were randomly distributed in 2 groups, with 26 cases in each group. Six cases were excluded from the final statistical analysis (4 patients were missed during follow-up and 2 cases refused to participate in the trial); only 46 cases (22 in the ARG and 24 in the ORG) were eligible for final analysis (Table I).

Table I Patient demographics

	ARG	ORG
Age	31.0 ± 7.87	28.83 ± 7.32
Sex		
Male	15	17
Female	7	7
Laterality		
Right	13	14
Left	9	10
Rockwood classification		
Type III	16	17
Type IV	6	7

ARG, Arthroscopic Repair Group; *ORG*, Open Repair Group.

Table II Repeated measures analysis of variance, Wilks Lambda test

Group	Variable	Value	*F*	η2	*P* value
ARG	CMS	0.01	448.92	0.98	<.001
	VAS	0.02	267.57	0.97	<.001
	CC distance	0.01	439.19	0.98	<.001
ORG	CMS	0.01	387.35	0.98	<.001
	VAS	0.03	223.30	0.97	<.001
	CC distance	0.03	213.88	0.96	<.001

ARG, Arthroscopic Repair Group; *ORG*, Open Repair Group; *CMS*, Constant-Murley Score; *VAS*, visual analog score; *CC*, coracoclavicular.

The mean age was 31 and 28.83 years for the ARG and ORG, respectively. The right arm was affected in 13 patients in the ARG and 14 patients in the ORG. Rockwood type III dislocation was encountered in 16 patients in the ARG and 17 patients in the ORG (Table I).

We did not find any statistically significant difference between the 2 groups in terms of age, sex, laterality, or Rockwood grading. Other confounders were controlled by randomization at the level of the study design, which ensured equal distribution among the 2 groups.

In terms of in-group statistics, there was a statistically significant improvement in CMS, VAS, and the CC distance in both groups over the follow-up phase as shown in results of the 1-way repeated measures ANOVA, which was used to evaluate the null hypothesis that there was no change within each group (Table II).

A significant improvement was found in the function, represented by the mean level of the CMS score, which went from 40.68 for the ARG and 40.70 for the ORG preoperatively to 84.18 and 84.45 after 2 years from the operation. This finding was also proved by the ANOVA pairwise comparison, which indicated that there were highly significant changes from the preoperative stage through M3, M6, Y1 till Y2 ($P < .001$; Fig. 2).

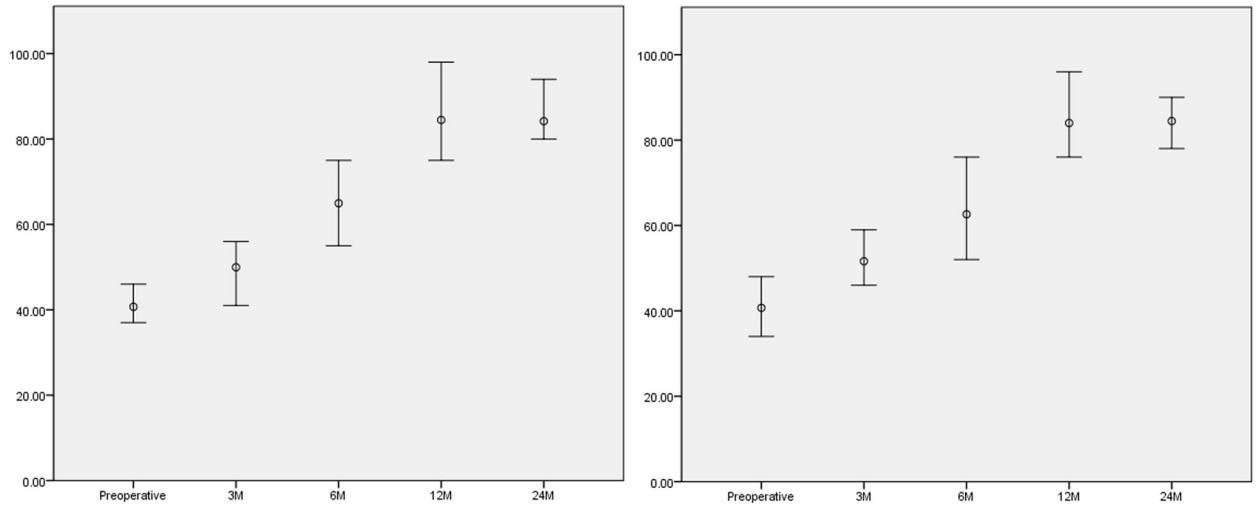

Figure 2 Changes in the Constant-Murley Score (CMS) over the follow-up phase in the Arthroscopic Repair Group (ARG) (left) and the Open Repair Group (ORG) (right).

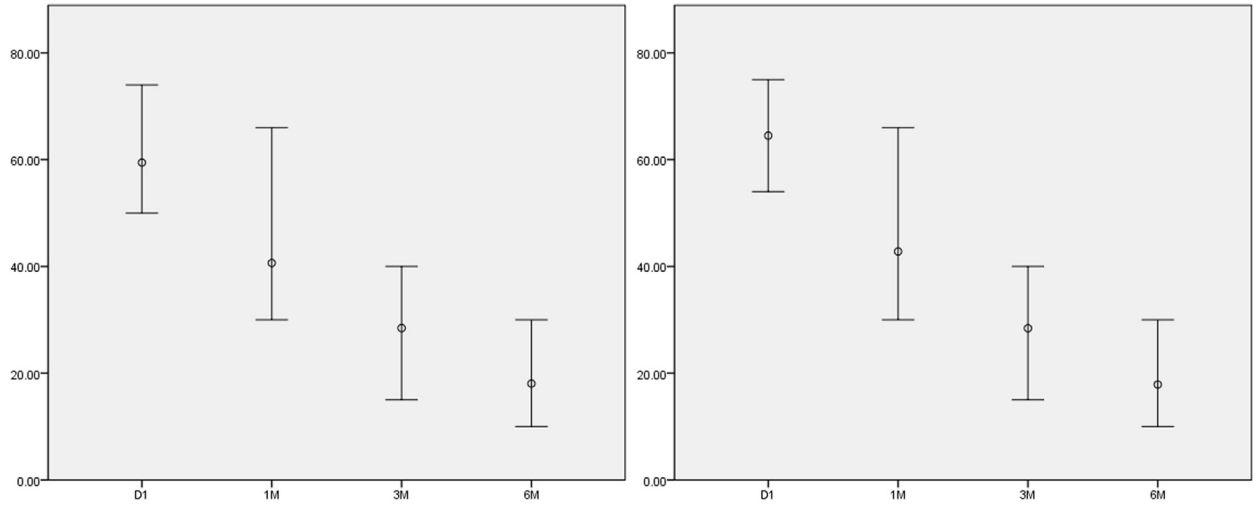

Figure 3 Changes in the visual analog score (VAS) over the follow-up phase in the Arthroscopic Repair Group (ARG) (left) and the Open Repair Group (ORG) (right).

The mean VAS score went from 60.59 for the ARG and 64.50 for the ORG 1 day after the surgery to 18.04 and 17.87 receptively after 6 months (P <.001; Fig. 3).

There was a statistically significant improvement in the CC distance from the preoperative period (29.2 mm in the ARG and 28.1 mm in the ORG) to the first day after the surgery (9.8 mm in the ARG and 10.5 mm in the ORG) (P <.001). However, the 1-way repeated measures ANOVA indicated a statistically significant increase in the CC distance 6 months (13.2 mm for the ARG and 13.6 mm for the ORG) and 1 year after surgery (15.7 for the ARG and 15.4 for the ORG) (P <.001; Fig. 4).

The independent sample t test, which was used to detect differences between the 2 groups, revealed no statistically significant difference in terms of the CMS, VAS score, CC distance, operating room and hospital charges, and length of the hospital stay (Table III).

This finding was supported by the 95% confidence intervals of the mean difference containing the zero value. So the null hypothesis that there was no change between the 2 groups could not be rejected (Table III).

However, the independent sample t test did find a significant difference between the 2 groups in terms of duration of surgery (80.00 minutes in the ARG compared to 52.79 minutes in the ORG) and cost of consumables (1729.95 USD in the ARG compared to 851.87 USD in the ORG). This finding was verified by the 95% confidence intervals of the mean difference excluding the zero value. So the null hypothesis that there was no change was rejected (Table III).

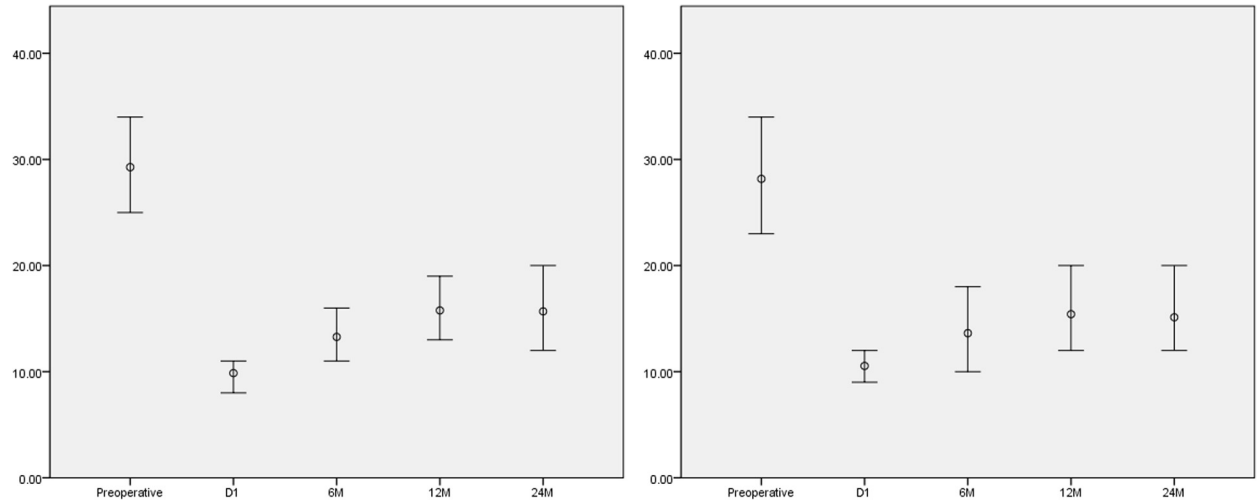

Figure 4 Changes in the coracoclavicular (CC) distance over the follow-up phase in the Arthroscopic Repair Group (ARG) (left) and the Open Repair Group (ORG) (right). *D1*, postoperative day 1; *6M*, 6 months postoperation; *12M*, 12 months postoperation; *24M*, 24 months postoperation.

Table III Independent sample *t* test

	ARG	ORG	*P* value	95% confidence interval of the mean difference	
				Upper limit	Lower limit
VAS					
1 d postoperation	60.59 ± 7.07	64.50 ± 6.97	.06	−8.085	0.267
1 mo postoperation	40.63 ± 7.61	42.79 ± 6.77	.31	−6.430	2.120
3 mo postoperation	28.45 ± 5.29	28.41± 5.07	.98	−3.044	3.120
6 mo postoperation	18.04 ± 4.36	17.87 ± 5.06	.90	−2.653	2.994
CMS					
Preoperative	40.68 ± 2.35	40.70 ± 3.93	.97	−1.97	1.92
3 mo postoperation	49.95 ± 4.05	51.62 ± 3.79	.15	−4.00	0.66
6 mo postoperation	64.95 ± 6.05	62.62 ± 6.00	.19	−1.25	5.91
12 mo postoperation	84.45 ± 6.52	84.00 ± 5.32	.79	−3.07	3.98
24 mo postoperation	84.18 ± 4.78	84.45 ± 4.10	.83	−2.94	2.38
CC distance					
Preoperative	29.27 ± 2.29	28.16 ± 3.30	.19	−0.59	2.81
1 d postoperation	9.86 ± 0.99	10.54 ± 0.97	.02	−1.26	0.09
6 mo postoperation	13.27 ± 1.42	13.62 ± 1.92	.48	−1.36	0.66
12 mo postoperation	15.77 ± 1.63	15.41 ± 2.28	.54	−0.83	1.54
24 mo postoperation	15.68 ± 2.18	C ± 2.17	.43	−0.854	1.96
Cost, USD					
Consumables	1729.95 ± 139.43	851.87 ± 81.29	<.001	810.95	945.20
OR charges	512.22 ± 58.62	518.41 ± 55.99	.71	−40.25	27.87
Hospital charges	198.95 ±21.60	202.95 ± 24.05	.55	−17.63	9.62
Hospital stay, h	20.59 ± 4.59	20.33 ± 5.21	.86	−2.67	3.18
Duration of surgery, min	80.00 ± 8.99	52.79 ± 9.87	<.001	21.57	32.84

VAS, visual analog score; *CMS*, Constant-Murley Score; *CC*, coracoclavicular; *USD*, US dollars; *OR*, operating room; *ARG*, Arthroscopic Repair Group; *ORG*, Open Repair Group.

We had superficial wound infection in 2 patients in the ORG that was treated with frequent dressings and oral antibiotics. Three patients, who were older than 40 years (1 in the ARG and 2 in the ORG), had postoperative shoulder stiffness, and they needed a more prolonged and more extensive rehabilitation program. In 1 patient in the ARG, we had an intraoperative coracoid fracture resulting from malpositioning of the coracoid hole near its tip, and they corrected by the repositioning of the coracoid hole by open surgery.

Discussion

In this study, we did not find any statistically significant difference between the arthroscopic and open repair techniques in terms of pain, function, length of hospital stay, and CC distance. However, we did find a higher cost of consumables and longer surgical time with the arthroscopic repair technique.

For the management of acute high-grade dislocation requiring surgical intervention, numerous open and minimally invasive procedures have been described and established. However, there is no gold standard technique for surgical reconstruction of acute high-grade AC joint dislocations.[5,13]

The TightRope system (Arthrex) is a device designed originally for the reduction and stabilization of the tibiofibular syndesmosis of the ankle. It has 2 metal buttons, 1 circular and 1 oblong, joined by a continuous loop of number 5 FiberWire®. This technique provides a reproducible, simple, minimally invasive technique for acute AC joint stabilization, which enables a rapid recovery for the acute injury.[11,12]

In our study, we used a longitudinal strap incision which was fashioned to be hidden under the clothes. Arthroscopic surgery causes less damage to the soft tissue envelope but has a steeper learning curve for its use when compared with open reconstructive procedures.[4]

In our study, the CMS and VAS scores at the final follow-up are comparable with the results of Venjakob et al,[12] who performed arthroscopically assisted reduction of the acutely dislocated AC joint using a suture-button device for patients with Rockwood type III, IV, and V. The CMS and VAS scores improved from 4.5 ± 1.9 and 34.5 ± 6.9 at baseline to 0.3 ± 0.6 and 91.5 ±4.7 at 58 months postoperatively.

We found improvement in the CC distance measured at the final follow-up (15.6 mm for the ARG and 15.1 mm for the ORG) when compared to the preoperative radiograph (29.2 and 28.1 mm). However, these results are inferior to the results of Chaudhary et al,[2] who treated 17 patients with arthroscopic fixation after acute AC joint disruption using the TightRope. They found that the CC distance decreased from 21.5 ± 5.2 mm preoperatively to 9.8 ± 3.5 mm at 6 months and a mild widening was found 10 ± 3.2 mm at 1 year.

We had a longer follow-up than Darabos et al,[3] who compared the TightRope and Bosworth screw fixation in 84 patients. In the Darabos et al study, the CC distance was reduced in the immediate postoperative radiograph (from 26.9 preoperatively to 7.0 mm and from 25.4 to 7.7 mm for the TightRope and the Bosworth screw, respectively); then rewidening occurred after 6 months of the surgery (15.7 and 19.2 mm, respectively). The improvements were lower than those in our study in terms of the final CC distance in the Bosworth screw patients after 6 months.

Limitations

Our study had some limitations, especially with the lack of an assessment method for the healing of the CC ligaments. Also, we cannot explain the rewidening of the CC distance that occurred during follow-up. This finding might be linked to the early initiation of pendulum exercises. Another limitation is that the AC ligament was not addressed, which might have also contributed to the rewidening of the CC distance. At the start of the study, we did not take into consideration the fiscal inflation that occurred in our country later in the study, which caused the prices of the medical equipment to fluctuate. This event, in return, had an impact on cost calculation and analysis.

Conclusion

Both open and arthroscopic repair of AC joint dislocation yielded good clinical results, yet the arthroscopic technique is more expensive and has a longer surgical time.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Babhulkar A, Pawaskar A. Acromioclavicular joint dislocations. Curr Rev Musculoskelet Med 2014;7:33-9. https://doi.org/10.1007/s12178-013-9199-2
2. 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 (Hong Kong) 2015;23:309-14. https://doi.org/10.1177/230949901502300310
3. Darabos N, Vlahovic I, Gusic N, Darabos A, Bakota B, Miklic D. Is AC TightRope fixation better than Bosworth screw fixation for minimally invasive operative treatment of Rockwood III AC joint injury? Injury 2015;46:S113-8. https://doi.org/10.1016/j.injury.2015.10.060
4. El Sallakh SA. Evaluation of arthroscopic stabilization of acute acromioclavicular joint dislocation using the TightRope system. Orthopedics 2012;16:e18-22. https://doi.org/10.3928/01477447-20111122-13
5. 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;132:33-9. https://doi.org/10.1007/s00402-011-1399-x
6. Fraser-Moodie JA, Shortt NL, Robinson CM. Injuries to the acromioclavicular joint. J Bone Joint Surg Br 2008;90:697-707. https://doi.org/10.1302/0301-620X.90B6
7. Hann C, Kraus N, Minkus M, Maziak N, Scheibel M. Combined arthroscopically assisted coraco- and acromioclavicular stabilization

of acute high-grade acromioclavicular joint separations. Knee Surg Sport Traumatol Arthrosc 2018;26:212-20. https://doi.org/10.1007/s00167-017-4643-2

8. Horst K, Dienstknecht T, Pishnamaz M, Sellei RM, Kobbe P, Pape HC. Operative treatment of acute acromioclavicular joint injuries graded Rockwood III and IV: risks and benefits in tight rope technique vs. k-wire fixation. Patient Saf Surg 2013;7:2-7. https://doi.org/10.1186/1754-9493-7-18
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 Sport Traumatol Arthrosc 2014;22:422-30. https://doi.org/10.1007/s00167-012-2270-5
10. Rosslenbroich SB, Schliemann B, Schneider KN, Metzlaff SL, Koesters CA, Weimann A, et al. Minimally invasive coracoclavicular ligament reconstruction with a flip-button technique (MINAR): clinical and radiological midterm results. Am J Sports Med 2015;43:1751-7. https://doi.org/10.1177/0363546515579179
11. Salzmann GM, Walz L, Schoettle PB, Imhoff AB. Arthroscopic anatomical reconstruction of the acromioclavicular joint. Acta Orthop Belg 2008;74:397-400.
12. Venjakob AJ, Salzmann GM, Gabel F, Buchmann S, Walz L, Spang JT, et al. Arthroscopically assisted 2-bundle anatomic reduction of acute acromioclavicular joint separations: 58-month findings. Am J Sports Med 2013;41:615-21. https://doi.org/10.1177/0363546512473438
13. Vrgoč G, Japjec M, Jurina P, Gulan G, Janković S, Šebečić B, Starešinić M. Operative treatment of acute acromioclavicular dislocations Rockwood III and V—comparative study between K-wires combined with FiberTape® vs. TightRope system®. Injury 2015;46S:S107-12. https://doi.org/10.1016/j.injury.2015.10
14. Weiser L, Nüchtern JV, Sellenschloh K, Püschel K, Morlock MM, Rueger JM, et al. Acromioclavicular joint dislocations: coracoclavicular reconstruction with and without additional direct acromioclavicular repair. Knee Surg Sport Traumatol Arthrosc 2017;25:2025-31. https://doi.org/10.1007/s00167-015-3920-1
15. Wellmann M, Kempka JP, Schanz S, Zantop T, Waizy H, Raschke MJ, et al. Coracoclavicular ligament reconstruction: biomechanical comparison of tendon graft repairs to a synthetic double bundle augmentation. Knee Surg Sport Traumatol Arthrosc 2009;17:521-8. https://doi.org/10.1007/s00167-009-0737-9