

A retrospective comparative study of arthroscopic fixation for acute acromioclavicular joint dislocation: coracoid sling technique versus single-tunnel technique

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Research

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Abstract

Background

Arthroscopic fixation in acute acromioclavicular (AC) joint dislocation has become more popular and shown good clinical outcomes. This study aims to evaluate and compare the efficacy of single-tunnel technique (SST) and coracoid sling technique (CST) for the treatment of acute AC joint dislocation in order to provide more suitable treatment options and clinical recommendations for orthopaedic surgeons.

Methods

We retrospectively reviewed the charts of patients with acute Rockwood type IV and V AC joint dislocation who had undergone arthroscopic fixation procedure with SST or CST fixation between June 2009 and June 2018. A total of 90 consecutive patients identified from chart review were picked and divided into SST and CST groups, with 45 members in each group. The Visual Analog Scale (VAS) pain score, Constant shoulder functionality score, Karlsson AC joint score, the time of return to sports and activity, and plain radiographs of the affected shoulder at different time points of follow-up were all recorded for a minimum of 2 years postoperatively.

Results

The majority of the patients in both groups recovered to their preoperative activity levels with few complications. The average postoperative AC and coracoclavicular (CC) distances were significantly narrower than preoperative measurements in both groups, and no significant difference was observed between the two groups at 2 years post-op. The CST group had reduced operative time, shorter time of recovery of shoulder movements, higher Constant functionality scores and Karlsson AC joint scores, and fewer complications than the STT group at the last clinical follow-up.

Conclusions

CST technique achieved superior clinical outcomes with fewer complications compared to the traditional STT technique in arthroscopic treatment of acute AC joint dislocation. This technique could be considered as a reliable method for AC joint reconstruction.

1. Background

Acromioclavicular (AC) joint injury accounts for approximately 9% to 12% of all traumatic shoulder girdle injuries[1]. One in three of these shoulder injuries show radiological evidence of widening or dislocation of the AC joint. Overall, young men were at higher risk, and more than half of these injuries were sports related[2]. The Rockwood classification distinguishes 6 total grades of acute lesion severity and is the most commonly used system guiding treatment decision-making[3]. There still exists controversy regarding the indications for surgery, but a common consensus has been reached between the so-called “low-energy” and “high-energy” trauma patterns[4]. It is generally agreed that type I-II injuries result from low-energy trauma and should be treated conservatively using a sling or harness, whereas type IV-VI dislocations are caused by high-energy trauma and require surgical treatment. However, the treatment of type III lesions is still a matter of debate: some clinicians recommend surgery and others advocate for non-operative treatment.

Over 150 variations in surgical methods of treating symptomatic AC joint dislocations have been reported so far[5]. These various options range from rigid fixation with Kirschner wires, tension bands, or hook plates, to the Weaver-Dunn procedure, a ligament reconstruction procedure based on the transference of acromioclavicular (AC) ligament[6]. However, a consensus on the optimal surgical technique has yet to be reached. Arthroscopy allows for better, clearer visibility around the coracoid; in addition, extensive dissection of the deltotrapezial fascia is not required. The clearer visibility also puts important adjacent neurovascular structures at lower risk of damage[7]. Previous works have also reported good curative effects by using the arthroscopic TightRope system or paired Endobutton Technique (PET) for surgical treatment of acute AC joint dislocation.

The single-tunnel technique (STT) using the TightRope system or PET is the most widely used among these methods[8, 9]. However, drilling a bone tunnel through the clavicle to the coracoid process (CP) is the key procedure in this technique, which requires accurate localization in order to decrease the risk of fracture of CP. To solve this problem, we have created a new technique using the TightRope system or PET to fix the AC joint without creating the bone tunnel to CP. The purpose of this retrospective study is to analyze the clinical data and radiographic findings of the coracoid sling technique (CST) and compare its outcomes with that of STT. We hypothesize that fixation of the AC joint dislocation using CST will provide stable fixation and satisfactory clinical function.

2. Materials And Methods

2.1 Patients

The retrospective study was performed with the approval of the Ethics Committee and carried out in compliance with the Helsinki Declaration. All patients provided signed preoperative informed consent. Charts of patients with acute AC joint dislocation undergoing AC joint reconstruction with STT or CST between June 2009 to June 2018 at our institution were reviewed. Patient data were collected retrospectively through the electronic medical record system. The clinical variables of interest include patient's gender, age at surgery, injury mechanism, Rockwood classification of injury, and surgical technique. Inclusion in the study required at least 24 months of clinical follow-up postoperatively. All the study participants claimed preoperative shoulder pain and weakness

interfering with their activities of daily living. Typical symptoms include the following: pain over the AC joint, a feeling of AC joint instability with popping or grinding sensation, shoulder muscle fatigue, as well as shoulder deformity.

The inclusion criteria are as follows: 1) acute dislocations (< 14 days after injury); 2) age range from 18 to 45 years; 3) Rockwood type IV or V dislocation of the AC joint; 4) without osteoporosis; 5) all operations performed by the same surgeon; 6) postoperative follow-up time of at least 2 years. Exclusion criteria are listed as follows: 1) open and old dislocations; 2) previous shoulder complaints or surgery; 3) glenohumeral instability; 4) complicated by associated injuries, such as nerve or vascular injury, fractures, or dislocation of other parts of the ipsilateral limb.

Every patient received radiographs of the bilateral shoulder joints in anteroposterior (AP) and lateral scapular (Y) positions preoperatively.

2.2 Surgical techniques

All procedures were carried out by one senior surgeon and performed with the patient in the beach-chair position with the administration of an interscalene nerve block in combination with general anesthesia. An anterior cruciate ligament (ACL) tip-to-tip tibial aimer (Smith & Nephew, MA, USA), paired EndoButton device (Smith & Nephew, MA, USA) or TightRope system (Arthrex, Naples, FL, USA), and high strength wires (UltraBraide, Smith & Nephew, MA, USA) were used intraoperatively.

The similar procedure had been described in our previous publication[10]. To begin, a standard posterior portal was established for inspection of the shoulder joint using a 4.0 mm 30° arthroscope. Then, a standard anterolateral portal was established at approximately 1 cm off the posterolateral side of the acromion anterolateral portion. Radiofrequency dissector was used to dissect the anterior capsule over the subscapularis tendon. The lower surface of the subcoracoid was completely debrided in order to clearly expose the CP base. Next, a 2 cm incision was made over the AC joint to expose the distal clavicle (Fig. 1A). The reduction of dislocated AC joint is usually hampered by twisted or locked articular disc. Consequently, the articular disc was resected along with other structures unfavorable for reduction. Afterwards, a 2.4 mm Kirschner wire (K-wire) was applied for temporary fixation.

2.3 Single-tunnel technique (STT)

The tip of the ACL tip-to-tip tibial aimer was placed at the center of the CP base, while the targeting tip was positioned at the superior surface of the clavicle 2–3 cm medial to the AC joint line and 5 mm anterior to the rear border of the clavicle (i.e., the dividing point of the rear 1/3 anteroposterior diameter of the clavicle). Then, a 2.4 mm guide pin was drilled from the clavicle down directly in line with the base of CP, and a 4.5 mm reamer was used to create a tunnel through the clavicle and CP. A 2–0 polydioxanone suture (PDS) was used as a guiding suture and passed through the bone tunnel from clavicle to the CP. One Endobutton was pulled through the clavicle and CP tunnel and secured against the inferior cortex of CP, while another Endobutton was placed over the clavicular surface. The non-absorbable sutures on the Endobutton button were tightened and cinched after further reduction of the coracoclavicular (CC) distance.

2.4 Coracoid sling technique (CST)

Firstly, two bone tunnels were created using a 4.5 mm reamer at 1.5 cm (lateral tunnel) and 3.5 cm (medial tunnel) to the distal clavicle. A PDS guide line was inserted through the medial tunnel and directed to the medial side of the CP base, bypassing the lateral side of the CP base, and going through the lateral tunnel from the bottom up. One Endobutton was pulled into the medial tunnel, bypassing the CP base, and pulled out from the lateral tunnel. Another Endobutton was fixed at the socket of the medial tunnel, and the previous Endobutton was stuck at the lateral tunnel socket. The non-absorbable sutures on the Endobutton were tightened and cinched after further reduction of the CC distance (Fig. 1B, C). The principle behind the CST surgery is shown in a plastic shoulder joint model (Fig. 2).

Following fixation of the paired EndoButton device/TightRope system with any of the two aforementioned techniques, the high strength wires were used to restore the CC ligament. Finally, the K-wire was removed, the ruptured capsule was sutured, and skin was closed. Here, Endobutton removal is not required. The operative period of the two techniques were recorded and compared.

2.5 Rehabilitation Protocol

Both groups utilized the same rehabilitation program. The shoulder joint was placed in a sling sponge shoulder abduction immobilizer at 0° external rotation position for 6 weeks post-op. From the second postoperative day onwards, passive Gentle pendulums and Codman's were encouraged depending on the patients' pain tolerance level. Patients were instructed to not resume active movement of the arm until 6 weeks post-op. Patients were generally allowed to return to normal activities and daily work but limited sports until 3 months post-op depending on the level of rehabilitation. In addition, they were asked to refrain from contact sports prior to half year post-op.

2.6 Follow-up

Patients were followed-up at the outpatient setting at 3, 6, 12, and 24-months post-op. The following subjective and objective outcomes were recorded at each follow-up visit: Visual analog scale (VAS) for pain (0: no pain; 10: worst possible pain), Shoulder Constant score (100: no pain; 0: maximum pain), the time of return to normal activities and sports, self-reported symptoms and complications, as well as the Karlsson ACJ score (Grades A–C)[11].

The CC distance (vertical distance between the inferior border of the clavicle and superior border of the CP), and the AC distance (vertical distance between the superior edge of the acromion to the superior edge of the distal clavicle) in both groups were determined via radiographic analysis in millimeters (mm) and compared preoperatively and at 2 year postoperatively[12]. With respect to the contralateral side, an increase in CC distance by 50-100% and increase in CC distance higher than 100% were considered to be subluxation and redislocation, respectively[13].

2.7 Statistical Analysis

The measurement data was expressed as mean \pm SD and analyzed statistically using SPSS software (version 18.0; SPSS, Chicago, IL). The pairwise comparison was performed using paired t-test, and comparison between multiple groups was performed using SNK q test. All tests were conducted with a 95% confidence interval in which $p < 0.05$ was considered statistically significant.

3. Results

3.1 Baseline Characteristics

Table 1 tabulates the characteristics of the two groups of patients. A total of 90 patients who underwent arthroscopic acute AC joint dislocation fixation was selected. There was no statistically significant difference in age, body mass index (BMI), gender ratio, affected side, cause of injury, Rockwood classification, interval between injury to operation, or length of follow-up among the patient groups. A minimum of 2 years follow-up was required for all cases to be included in the study.

3.2 AC and CC distances measurement

Dislocation of the AC joint was present in both groups preoperatively. Radiographic examination showed complete reduction of the AC joint immediately post-op (PO 0 days) and remained stable at 2 years after operation (Fig. 3, 4).

At baseline, there was no significant difference in the average AC and CC distances of the injury joints between the two groups preoperatively ($p > 0.05$, Table 2). At the 2 year follow-up time point, the average AC and CC distances remained significantly narrower than before surgery in both groups ($p < 0.05$). Furthermore, no significant difference in average AC and CC distances was observed between the two groups at 2 years after operation ($p > 0.05$). Additionally, there was no significant difference in average AC and CC distances compared with the normal side shoulder joints in both groups at the final 2 year follow-up time point ($p > 0.05$).

3.3 Clinical outcomes

We were delighted to find that the CST group showed significantly reduced operative time when compared with the STT group (73.4 ± 12.9 vs 102.8 ± 16.7 min, $p < 0.01$, Table 3). The majority of the patients got rigid fixation and made a full recovery at the final follow-up visit in both groups.

In the CST group, 37 patients resumed their former sports and activities levels with an average time of 3.6 months post-op, while 8 patients were unable to return to their former activity level. In the STT group, 28 patients resumed their former sports and activities at an average of 5.2 months post-op, while 17 patients were unable to return to their former activity level, indicating patients that received CST treatment compared to STT treatment required a shorter time interval to resume their previous level of athletic activities ($p < 0.05$, Table 3).

At 2 years post-op, no significant difference in VAS scores were detected between the two groups ($p > 0.05$, Table 3). Nevertheless, the CST group had shorter time to recovery of shoulder movements, in addition to higher Constant functional scores and Karlsson AC joint scores than the STT group ($p < 0.05$). Thus, the CST group achieved better clinical outcomes compared to the STT group.

3.4 Complications

The paired EndoButtons or TightRope systems were properly placed in the majority of the cases upon reviewing the postoperative radiographs, especially in the CST group. However, complications did occur in several cases during the follow-up time period. In the STT group, there were two loss of reduction cases as the Endobutton on the CP side slipped out, but still achieved satisfactory outcomes after revision using the previous technique. Four patients were determined to have Rockwood type II dislocation at their last follow-up. Of these cases, two were caused by Endobutton erosion into the cortex of clavicle or CP, while the other two were due to Endobutton separation. Infection was observed in two cases and both made a complete recovery after medical treatment. In the CST group, there were two cases of postoperative infection. One fully recovered after conservative treatment. The other one reported reinfection at 4 months after operation and had a poor response to antibiotic treatment. Consequently, we removed the pair of Endobuttons and did not observe any sign of redislocation during the remaining follow-up period. There were no cases of neurovascular damage or post-traumatic arthritis of the injured AC joint in either group.

4. Discussion

The CC ligaments originate from the CP, developing along a superior-posterior course and inserting into the lateral-inferior side of the clavicle. It is a complex consisting of two individual ligaments, namely conoid ligament (medial aspect) and trapezoid ligament (lateral aspect). As a vertical stabilizer of the AC joint, it allows for 20° of movement of the shoulder when the CC ligaments stretch in response to clavicle rotation. The CC ligaments serve as a suspender for the clavicle and scapula. When the CC ligament is ruptured post trauma, the biomechanical balance of the surrounding structures is disrupted. The traction force from the sternocleidomastoid muscle will result in posterior upper shifting of the clavicle as well as separation of the AC joint[14]. The most frequently employed approach to AC joint dislocation is restoration and enhancement of the CC ligaments. Endobuttons are placed on the clavicle and CP and are subsequently connected with loop, non-absorbable sutures that serve the same function of the native CC ligaments, immobilizing the AC joint and restoring CC ligaments, which are prerequisites for biological fixation[15]. Meanwhile, the AC ligaments are suture-repaired during surgery, restoring the horizontal stability of AC joint, preserving the deltatrapezial fascia, and facilitating the restoration of AC stability.

The Tightrope system, consisting of one round clavicle titanium button and one long coracoid titanium button connected by non-absorbable sutures (No. 5 Ethibond suture), was initially used for the treatment of acute syndesmosis disruption. The paired Endobuttons device tightened with high strength wires have

a similar function. Their scope of application has been extended to treat AC joint dislocations[16]. The Tightrope system represents a promising method for stabilizing acute AC joint separation[17, 18], not only in higher grades of AC dislocations (type IV and V), but also in type III dislocations[19].

Creation of the bone tunnel from clavicle to CP is the key procedure in the SST. Usually, a tip-to-tip aimer would be applied for positioning purposes. However, this instrument is not available in some orthopaedic surgery departments, especially that of basic-level hospitals, which restricts the application of this technique. STT is technically difficult, has an increased risk of fracture, and is sometimes extremely challenging in patients with a small CP, which is an irregular structure with a relatively thin cortex[20, 21]. Both correct positioning and drilling an accurate bone tunnel requires a great deal of experience, and represents a significant challenge to the arthroscopist[17]. The excessive tension of the paired Endobutton might increase the risk of Endobutton slippage from the surface of clavicle and CP, especially when the Endobutton is placed on the uneven bone surface of the clavicle or the CP. Furthermore, the pressure of the Endobuttons on the cortex of clavicle and CP may be too concentrated, causing chronic bone erosion and eventually resulting in AC joint laxity[22, 23]. These complications caused by button intraosseous migration in cases treated with SST technique is primarily due to excessively broad bone tunnel and limited Endobutton plate area[24].

Conversely, CST requires less skill and is not as time consuming. Fewer steps are required in CST; most notably eliminating the need to drill the bone tunnel in CP, significantly reducing the tunnel related complications. We did not observe any cases of button slippage, erosion, or AC joint instability in the CST group. No special tools is required for this technique; therefore, it can be widely promoted in orthopaedic surgery departments in lower level of care settings. TightRope Endobutton restores the conoid profile of the CC ligaments in an approximately anatomically correct position and reconstructs the bio-mechanical stability of the joint. The TightRope provides long-term stability to the joint with superior strength and stiffness to the native CC ligaments. Meanwhile, fixation with TightRope preserves the micromotion of AC joint in addition to facilitating immediate stability, early shoulder exercise, and improved recovery[25]. In our study, patients were instructed to start rehabilitation exercise on the first postoperative day, and we found fast recovery times and high fraction of patients resuming their previous activity levels in the CST group. Moreover, our results found no significant difference in AC and CC distances between the two groups at 2 years follow-up, indicating both techniques could guarantee rigid fixation. Most importantly, our study patients treated with CST surgery were superior in functional outcomes as they achieved higher Constant functional scores and Karlsson AC joint scores than the STT group did.

Despite the merits shown, this study also presents some limitations. Firstly, the cases enrolled in this study were not as many as we had desired, and the postoperative follow-up period is relatively short. In order to draw more definitive conclusions, more cases treated with both surgical techniques will be added, analyzed, and will undergo follow-up in our future work. Secondly, the pressure of Endobuttons exerted on bone surface and the tension of sutures on CP was not measured. To address this, systematic biomechanical tests will be carried out to reveal the mechanism. Lastly, a deeper understanding of the technique is required to achieve desirable outcomes.

5. Conclusion

The presented study proved that application of CST technique achieved better clinical outcomes with fewer complications in arthroscopic treatment of in acute AC joint dislocation compared with traditional STT technique; this technique could be considered a reliable method for AC joint reconstruction.

Declarations

Ethics approval and consent to participate

This study was approved by the hospital ethics committee of the First Affiliated Hospital of Shenzhen University, Shenzhen Second People's Hospital, and all patients gave informed consent preoperatively.

Consent for publication

Not applicable.

Availability of data and material

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Study design: ZD, LP. Drafting manuscript: ZD. Data collection: ZD, YZ. Language editing: GZ. Data analysis: ZD. The author (s) read and approved the final manuscript.

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References

- [1] Mazzocca AD, Arciero RA, Bicos J. Evaluation and treatment of acromioclavicular joint injuries. *Am J Sports Med* 2007;35:316-329.
- [2] Skjaker SA, Enger M, Engebretsen L, Brox JI, Boe B. Young men in sports are at highest risk of acromioclavicular joint injuries: a prospective cohort study. *Knee Surg Sports Traumatol Arthrosc* 2020;10.1007/s00167-020-05958-x.
- [3] CA R. Injuries of the acromioclavicular joint. In: CA R, DP G, eds. *Fractures in adults* 1984:869-872.
- [4] Vrgoc G, Japjec M, Jurina P, Gulan G, Jankovic S, Sebecic B, et al. Operative treatment of acute acromioclavicular dislocations Rockwood III and V- Comparative study between K-wires combined with FiberTape((R)) vs. TightRope System((R)). *Injury* 2015;46 Suppl 6:S107-112.
- [5] Beitzel K, Cote MP, Apostolakis J, Solovyova O, Judson CH, Ziegler CG, et al. Current concepts in the treatment of acromioclavicular joint dislocations. *Arthroscopy* 2013;29:387-397.
- [6] Weaver JK, Dunn HK. Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. *J Bone Joint Surg Am* 1972;54:1187-1194.
- [7] Sirin E, Aydin N, Mert Topkar O. Acromioclavicular joint injuries: diagnosis, classification and ligamentoplasty procedures. *EFORT Open Rev* 2018;3:426-433.
- [8] Lu D, Wang T, Chen H, Sun LJ. A comparison of double Endobutton and triple Endobutton techniques for acute acromioclavicular joint dislocation. *Orthop Traumatol Surg Res* 2016;102:891-895
- [9] Torkaman A, Bagherifard A, Mokhatri T, Haghighi MH, Monshizadeh S, Taraz H, et al. Double-button Fixation System for Management of Acute Acromioclavicular Joint Dislocation. *Arch Bone Jt Surg* 2016;4:41-46.
- [10] Xu J, Liu H, Lu W, Li D, Zhu W, Ouyang K, et al. A retrospective comparative study of arthroscopic fixation in acute Rockwood type IV acromioclavicular joint dislocation: single versus double paired Endobutton technique. *BMC Musculoskelet Disord* 2018;19:170.
- [11] Karlsson J, Arnarson H, Sigurjonsson K. Acromioclavicular dislocations treated by coracoacromial ligament transfer. *Arch Orthop Trauma Surg* 1986;106:8-11.
- [12] Moya D, Poitevin LA, Postan D, Azulay GA, Valente S, Giacomelli F, et al. The medial coracoclavicular ligament: anatomy, biomechanics, and clinical relevance—a research study. *JSES Open Access* 2018; 2:183-189.
- [13] Taleb H, Afshar A, Shariyate MJ, Tabrizi A. Comparison of Short-Term Clinical Outcomes of Hook Plate and Continuous Loop Double Endobutton Fixations in Acute Acromioclavicular Joint Dislocation. *Arch Bone Jt Surg* 2019;7:545-550.
- [14] Nakamura Y, Urashima M, Matsuura A, Nishihara R, Itoh A, Kagemoto M, et al. Stereotactic directional vacuum-assisted breast biopsy using lateral approach. *Breast Cancer* 2010;17:286-289.
- [15] Struhl S, Wolfson TS. Continuous Loop Double Endobutton Reconstruction for Acromioclavicular Joint Dislocation. *Am J Sports Med* 2015;43:2437-2444.
- [16] 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;36:2398-2406.
- [17] Salzmann GM, Walz L, Buchmann S, Glabgyl P, Venjakob A, Imhoff AB. Arthroscopically assisted 2-bundle anatomical reduction of acute acromioclavicular joint separations. *Am J Sports Med* 2010;38:1179-1187.
- [18] Scheibel M, Droschel S, Gerhardt C, Kraus N. Arthroscopically assisted stabilization of acute high-grade acromioclavicular joint separations. *Am J Sports Med* 2011;39:1507-1516.
- [19] Horst K, Garving C, Thometzki T, Lichte P, Knobe M, Dienstknecht 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 Res* 2017;103:171-176.
- [20] Choi NH, Lim SM, Lee SY, Lim TK. Loss of reduction and complications of coracoclavicular ligament reconstruction with autogenous tendon graft in acute acromioclavicular dislocations. *J Shoulder Elbow Surg* 2017;6:692-698.
- [21] Hou Z, Graham J, Zhang Y, Strohecker K, Feldmann D, Bowen TR, et al. Comparison of single and two-tunnel techniques during open treatment of acromioclavicular joint disruption. *BMC Surg* 2014;14:53.
- [22] 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;23:309-314.
- [23] Motta P, Maderni A, Bruno L, Mariotti U. Suture rupture in acromioclavicular joint dislocations treated with flip buttons. *Arthroscopy* 2011;27:294-298.

[24] Boileau P, Old J, Gastaud O, Brassart N, Roussanne Y. All-arthroscopic Weaver-Dunn-Chuinard procedure with double-button fixation for chronic acromioclavicular joint dislocation. *Arthroscopy* 2010;26:149-160.

[25] Wellmann M, Zantop T, Petersen W. Minimally invasive coracoclavicular ligament augmentation with a flip button/polydioxanone repair for treatment of total acromioclavicular joint dislocation. *Arthroscopy* 2007;23:1132 e1131-1135.

Tables

Table 1 Demographic characteristics of the two groups at baseline.

Parameter	STT	CST
Age (years)	31.5±4.3	29.7±3.6
Body mass index (BMI)	24.6±5.2	22.9±4.4
Gender		
Male	32	34
Female	13	11
The affected side		
Left	14	15
Right	31	29
Cause of injury		
Sports	26	23
Motor vehicle accident	14	15
Fall	5	7
Rockwood classification		
Type IV	15	12
Type V	30	33
Interval between injury to operation (days)	11.5±8.3	10.7±9.5
Length of follow up (months)	25.7±4.7	23.6±4.1

Table 2 Comparison of AC and CC distance in the both groups measured from preoperative and 2 year postoperative radiographs.

Group	AC distance					CC distance			
	Preoperative(IS)	Postoperative(IS)	Preoperative(NS)	p ^A	p ^B	Preoperative(IS)	Postoperative(IS)	Preoperative(NS)	p ^a
STT	5.8±1.2	2.3±0.9	1.6±0.8	<0.01	<0.01	13.6±3.0	9.2±1.9	7.7±1.6	<0.01
CST	5.6±1.5	1.9±0.7	1.5±0.6	<0.01	>0.05	13.3±3.4	7.7±2.3	7.3±1.9	<0.01
p	>0.05	<0.01	>0.05	-	-	>0.05	<0.01	>0.05	-

Note: IS: injury shoulder, NS: normal shoulder; p^A and p^a refer to the comparison of the AC and CC distance of the injury shoulder joints measured pre- and postoperatively, respectively. p^B and p^b refer to the comparison of the AC and CC distances of the injury shoulder joints measured postoperatively and the healthy shoulder joints measured preoperatively, respectively. p refers to the comparison of the CST and the STT group.

Table 3 Evaluation Results of Two Fixation techniques

Parameters	Preoperation		Postoperation		p value
	STT	CST	STT	CST	
Operation time (min)	-	-	102.8±16.7	73.4±12.9	<0.01
Cases return to former sports	-	-	28(62.2%)	37(82.2%)	<0.01
Time of return to sports (mon)	-	-	5.23±3.36	3.56±2.79	<0.01
VAS score	8.23 ± 0.72	8.19 ± 0.65	1.76±2.34	1.69±2.46	>0.05
Constant score	24.12 ± 2.37	22.47 ± 3.45	81.72±3.65	90.53±4.38	<0.01
Karlsson					
A	-	-	29	38	<0.01
B	-	-	11	6	
C	-	-	5	1	
Total Complications	-	-	8(17.8%)	2(4.4%)	<0.01
Loss of reduction	-	-	2(4.4%)	0	<0.01
Redislocation	-	-	4(8.9%)	0	<0.01
Infection	-	-	2(4.4%)	2(4.4%)	>0.05

Figures

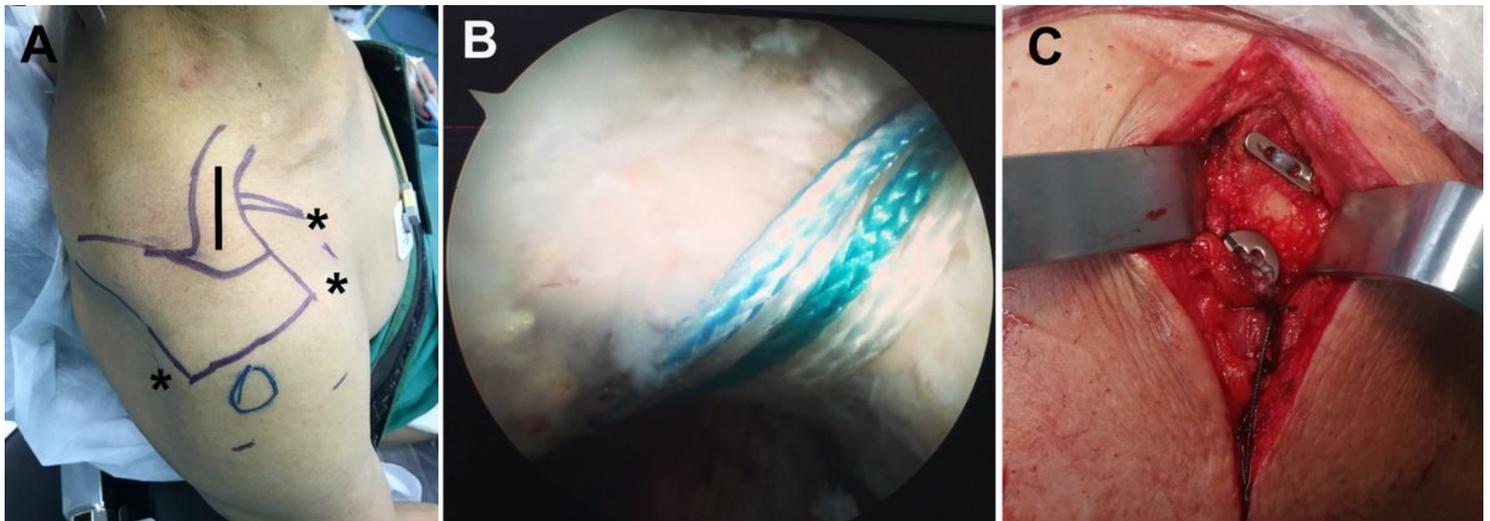


Figure 1
 CST surgery for treatment of the AC joint dislocation. (A) Three portals (mark as "*", standard posterior portal, anterior portal, and anterolateral portal) and one 2-cm transverse incision (mark as "—" directly over the AC joint) were made on the skin. (B) The non-absorbable sutures were hung at the bottom of the CP under arthroscopy. (C) TightRope fixation system being placed on the surface of clavicle.

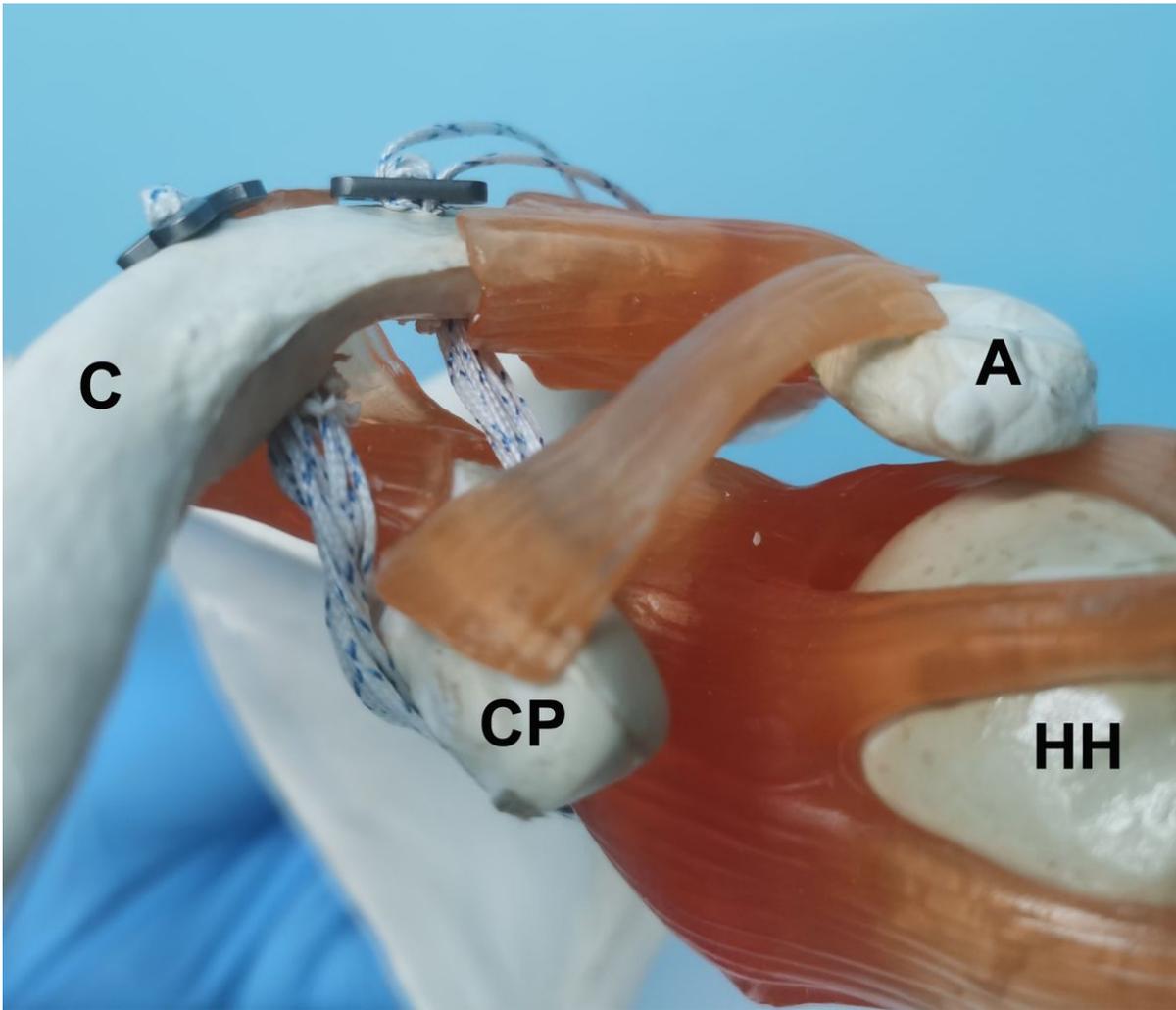


Figure 2

The principle of the CST surgery is shown in a plastic shoulder joint model. A: acromion. C: clavicle. CP: coracoid process. HH: humeral head.

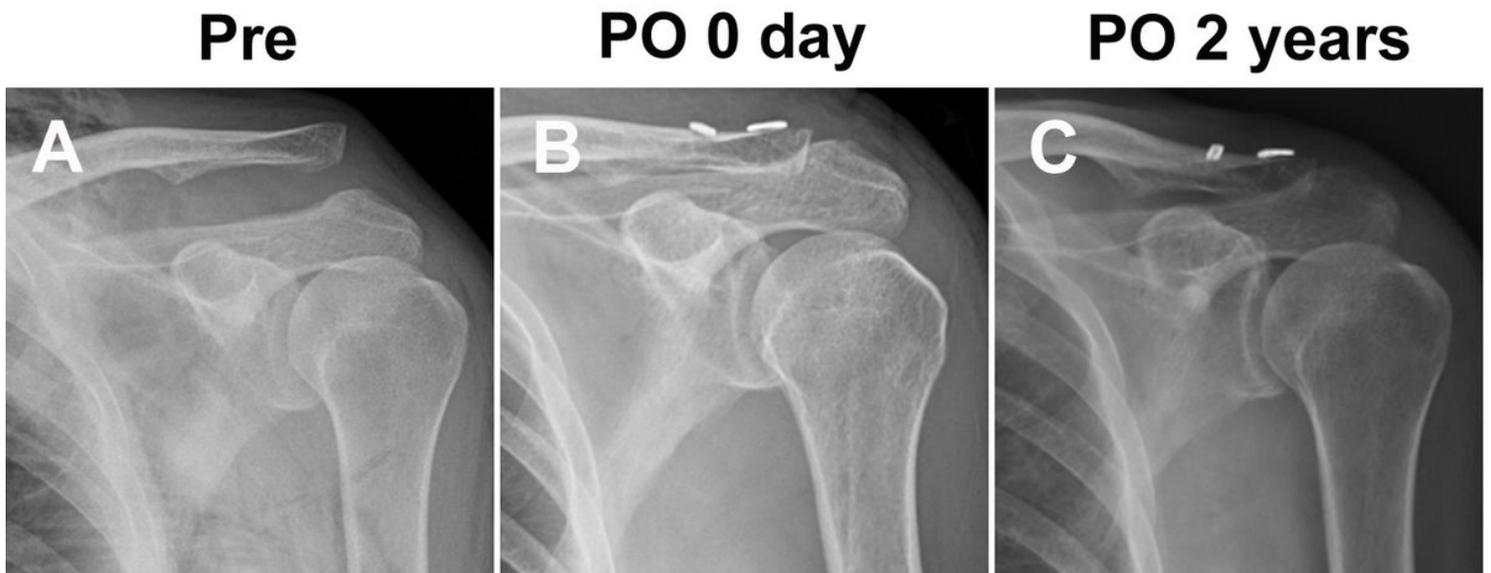


Figure 3

Pre- and post-operative radiographs of an AC joint dislocation using CST surgery. (A) AC joint dislocation preoperatively. (B) Restoration of AC joint immediately after CST surgery. (C) Restoration of AC joint at 2 years following CST surgery.

Pre

PO 0 day

PO 2 years

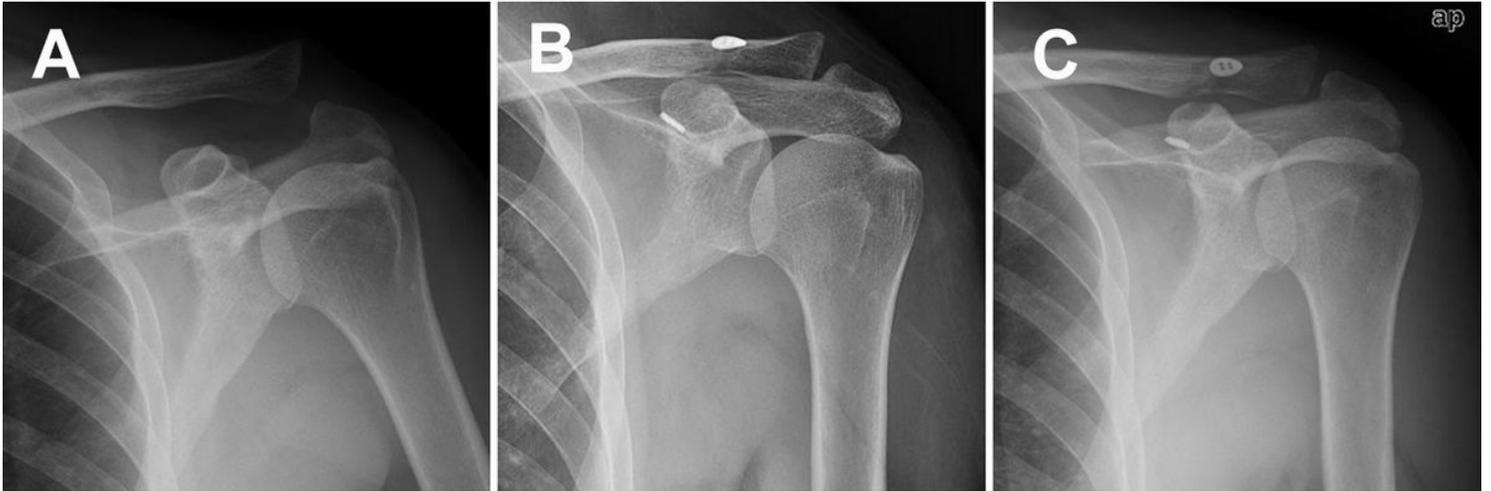


Figure 4

Pre- and post-operative radiographs of an AC joint dislocation using STT surgery. (A) AC joint dislocation preoperatively. (B) Restoration of AC joint immediately after STT surgery. (C) Restoration of AC joint at 2 years following STT surgery.