



Clinical and anatomical outcomes of isolated coracoclavicular fixation after acromioclavicular joint injury: is it stable enough or is additional horizontal fixation necessary?



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Background: Recently, an emphasis has been put on anatomical reduction of acromioclavicular (AC) joint both in vertical and horizontal planes for management of AC joint injuries due to persisting horizontal instability. Therefore, an additional AC fixation in horizontal plane has been recommended. However, relation between horizontal AC joint instability and clinical outcomes is still controversial. This study aims to evaluate outcomes of isolated coraco-clavicular fixation using arthroscopic assisted single coraco-clavicular tunnel technique in grade III and V AC joint injuries and to investigate the correlation between anatomical and clinical outcomes.

Methods: This study was conducted with 19 patients with grade III or V AC joint injury. Clinical outcomes included postoperative pain intensity and functional outcomes (Constant Score, American Shoulder and Elbow Surgeons, and Subjective Shoulder Value). Radiological evaluations were performed using radiographs and postoperative computed tomography scans. Degree of initial injury and postoperative stability both on axial and coronal planes were evaluated after radiological assessment. Correlations between anatomical and clinical outcomes were investigated using Pearson's correlation test.

Results: At the final follow-up assessment, the mean pain score was 1.8 ± 1.8 , mean American Shoulder and Elbow Surgeons score was 81.0 ± 15.4 , mean Subjective Shoulder Value was 81.3 ± 19.6 , and mean Constant Score was 86.3 ± 14.8 . The mean loosening ratio and AC distance were $43.5 \pm 30.6\%$ and 4.3 ± 12.4 mm, respectively. No correlation was observed between postoperative anatomical and clinical outcomes ($P > .05$).

Conclusion: Additional AC fixation on horizontal plane is not a prerequisite for all injuries, there is no significant association between horizontal instability and clinical outcomes and indications of an additional AC fixation needs to be determined.

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The acromioclavicular (AC) joint plays a crucial role to establish anatomical relation between axial skeleton and upper extremity and it is an important component of shoulder girdle. AC joint injuries are common with an overall incidence rate of 9.2 per 1000 person years in young athletes²¹ and comprise approximately 12% among all shoulder injuries.^{6,16,18} These injuries may cause chronic pain and disability, especially in athletes and young population. Both coracoclavicular (CC) and AC ligaments make contribution to

AC joint stability in conjunction with joint capsule.⁹ Previous biomechanical studies have shown that vertical stability of the joint is mainly ensured by CC ligaments while AC ligaments are relatively more important regarding maintenance of horizontal stability.¹⁰

Management of AC joint injuries is among the most controversial topics in shoulder surgery and treatment is most commonly determined according to six-grade classification described by Rockwood. Although consensus seems to be present in favor of surgical treatment for grades IV–VI and conservative management for grades I–II, management of type III injuries still constitutes a major controversy.^{15,19,23} Therefore, an update has been suggested for Rockwood classification by the ISAKOS (International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine)

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Upper Extremity Committee regarding grade III injuries, in order to enhance the knowledge on and clinical approach to these “gray zone” injuries.³ Multiple surgical techniques have been described for management of AC joint injuries but none have been demonstrated to be superior to others with respect to clinical outcomes.^{17,19} Intraoperative determination of horizontal stability is difficult in arthroscopic single plane CC fixation procedures and localization of coracoid fixation can influence reduction in horizontal plane. Therefore, an emphasis has been recently put on restoration of not only vertical but also horizontal stability as previous biomechanical studies have reported that isolated CC stabilization does not provide sufficient horizontal stability.^{4,24}

However, there is still controversy with respect to relation between horizontal AC joint instability and clinical outcomes.^{5,14,20} The purpose of this study is to evaluate clinical and radiological outcomes of AC joint injuries treated with arthroscopic assisted single coraco-clavicular tunnel (SCT) technique and to investigate the relation between anatomical and clinical outcomes.

Materials and methods

This retrospective review was conducted at 2 different university hospitals which are tertiary referral centers for shoulder disorders and trauma. Institutional review board approval (E-45446446-010.99-17064) was obtained from relevant board. All included patients received informed consent at the final follow-up control. Patients who underwent AC joint fixation using arthroscopic assisted SCT technique between January 2017 and February 2020 were included to the study. Inclusion criteria were acute (within 6 weeks of the injury) and type III or V AC joint injuries according to Rockwood classification. Exclusion criteria were as follows: (1) age <18 years, (2) age >65 years, (3) presence of a fracture, (4) type III injuries which were treated conservatively (sedentary patients who did not have scapular dyskinesia), (5) presence of concomitant lesions (cuff tear or labral injury), (6) presence of apparent glenohumeral or AC joint arthritis seen on preoperative radiographs, and (7) history of any rheumatic condition. Type IV injuries were also excluded as they were treated using a fixation on horizontal plane with open surgery.

All procedures were performed by 2 senior authors under general anesthesia and patients positioned in a beach chair position. After establishing a standard posterior portal, a diagnostic arthroscopy was carried out for any concomitant intra-articular pathology. Then anterior portal was established and coracoid base was identified by following subscapularis tendon medially. Soft tissue covering the coracoid base was debrided using radiofrequency. A small longitudinal incision originating from about 3–4 cm medial to AC joint was made and drill guide was positioned under coracoid. A guide wire was drilled using drill guide under fluoroscopic vision through clavicle and coracoid. Then holes were drilled over the guide wire through the clavicle and coracoid. A nitinol wire was passed through opened holes for shuttling the Twinbridge endobutton (Smith & Nephew, Memphis, TN, USA) to settle under the coracoid base. The AC joint reduction was carried out by the aid of an assistant and checked fluoroscopically. Once the inferior button was seated against the coracoid, the superior button was positioned onto the sutures exiting the hole on the clavicle and the sutures were tied. Final reduction was assessed under fluoroscopic view.

Immobilization with a simple sling was followed for all patients for a duration of 4 weeks. Active elbow and wrist motion was allowed immediately after surgery. Active range of motion (ROM) and strengthening exercises were initiated gradually starting from the sixth week postoperatively respecting the pain-free ROM limits. Full daily physical activity was allowed at 3 months and return to

sports was allowed at 6 months, after surgery according to recovery of each individual.

A clinical follow-up of each patient was regularly performed at postoperative 2 weeks, 6 weeks, 3 months, 6 months, 12 months and each following year. All patients who underwent arthroscopic assisted AC fixation with SCT technique during study period were assessed for eligibility. Patients who met inclusion criteria were contacted and an appointment was made for final clinical and radiological assessments. The clinical evaluations included assessment of postoperative pain intensity using a visual analog scale (VAS); assessment of objective shoulder function using Constant shoulder score⁸ and assessment of subjective shoulder function using American Shoulder and Elbow Surgeons (ASES) shoulder score²² and the Subjective Shoulder Value (SSV) score.¹¹ All clinical assessments were performed by a single independent reviewer.

All patients had preoperative and early postoperative (first day postoperatively) standard comparative anteroposterior (AP) radiograph of AC girdle. At final follow-up evaluation, late postoperative comparative AP shoulder radiographs and computed tomography (CT) scans of the affected shoulder were obtained. All radiographs were obtained by a single radiology technician following a standardized protocol. Comparative AP radiographs of bilateral AC joints were obtained with patients in an erect position and midcoronal plane of the patient parallel to the image receptor in a manner to place the AC joint at the center of image receptor with affected arm in a neutral position by the patient's side. Beam angle was 10° cephalad relative to horizontal plane pointing the center of AC joint. The CC distance was measured as the distance between the tip of the dorsal surface of the coracoid and opposing undersurface of the clavicle on preoperative, early postoperative, and late postoperative AP radiographs. Implant loosening and loss of vertical stability during follow-up period was determined as loosening ratio (percentage) (Fig. 1). Horizontal stability was evaluated on postoperative axial CT images and interpreted as AC distance, which was measured as the distance between the most anterior point of the lateral clavicular end and the acromion (Fig. 2). Posterior clavicular displacement was remarked with negative values. AC distance higher than 10 mm was considered as major horizontal instability. All radiological measurements were performed using a software (RadiAnt DICOM Viewer Version 5.5.0, Medixant, Poznan, Poland).

Statistical analysis

All statistical analyses were performed using GraphPad Prism Software for Windows (Version 8.0.1, San Diego, California, USA). Mean, median, range, standard deviation, and percentage were used as descriptive statistical methods to analyze the study data. The correlations between anatomical outcomes (preoperative, early postoperative, late postoperative CC distance, loosening percentage, and postoperative AC distance) and clinical outcomes (Constant Score [CS], ASES score, SSV score and pain score) were statistically evaluated using Pearson's correlation test. Statistical significance level was set at $P = .05$ for all analyses.

Results

Twenty-four patients underwent arthroscopic assisted AC joint fixation with SCT technique during the study period, of which 19 patients who met the inclusion criteria were included to study. Four patients were excluded and 1 patient did not show up to the final follow-up appointment. Included patients consisted of 16 males and 3 females (84.2% and 15.8%). The mean age of patients was 35.1 ± 9.8 years, mean follow-up duration was 30.2 ± 3.1 months,

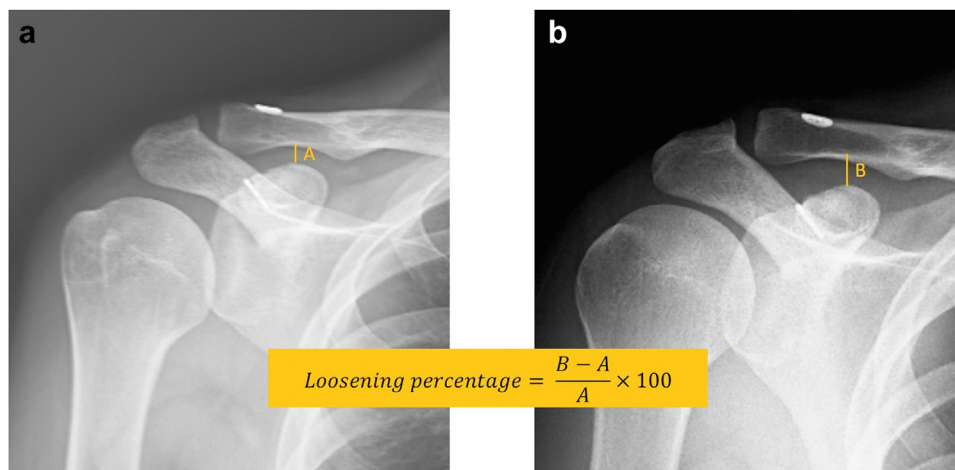


Figure 1 (a) Early postoperative and (b) late postoperative anteroposterior shoulder radiographs of a patient. A and B indicate coracoclavicular (CC) distances measured on these radiographs. Loosening ratio = $(B-A)/A \times 100$

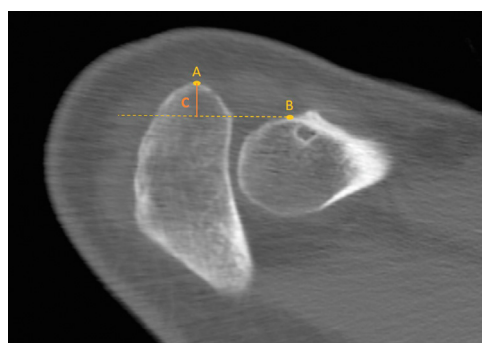


Figure 2 Axial computed tomography scan of a patient. A indicates the most anterior part of the acromion and B indicates the most anterior part of the lateral end of the clavicle. C is the acromioclavicular (AC) distance, which is the distance between points A and B and is used to determine the horizontal stability of AC joint.

and mean body mass index was $25.8 \pm 3.2 \text{ kg/m}^2$. There were 10 right shoulders and 9 left shoulders. Mechanism of injury was car accident in 2 patients (10.5%), sports injury in 12 patients (63.1%), and fall from a standing height in 5 patients (26.3%). There was no professional overhead athlete among the included patients. There were 3 football players, 1 hiker, and 2 runners who used to participate in these sportive activities for recreational purposes. The mean time from injury until surgery was 6.8 ± 5.2 days. Only in 2 patients, the surgery time exceeded 2 weeks (17 and 18 days after injury).

According to Rockwood classification, there were 10 (52.6%) type III injuries and 9 (47.6%) type V injuries (Table 1). On preoperative radiographs, mean CC distance was 19.6 ± 4.7 mm. Assessment of early postoperative radiographs which were obtained on the first day after surgery revealed that the mean early postoperative CC was 6.5 ± 2.6 mm. On radiographs which were obtained at the final follow-up control, the mean late postoperative CC distance was 9.8 ± 2.9 mm. Implant loosening was assessed comparing early and late postoperative CC distances and interpreted as loosening ratio. In overall population, the mean loosening ratio was 76.3 ± 118 %. However, in 2 patients (10.5%) (patients 5

and 16), loosening ratio was higher than 100% (Table 1). These patients were considered as fixation failures rather than implant loosening and the mean loosening ratio was 43.5 ± 30.6 % excluding these 2 patients. Assessment of postoperative CT scan images showed that mean AC distance was 4.3 ± 12.4 mm. While no horizontal instability occurred in 4 patients (21.1%) (AC distance = 0 mm), 5 patients (26.3%) had posterior clavicular displacement, and 10 patients (52.6%) had anterior clavicular displacement. Among patients who had horizontal clavicular displacement, 2 patients had major horizontal instability (AC distance > 10 mm) (one in posterior and one in anterior direction) (Table 1).

At the final follow-up assessment, the mean pain score was 1.8 ± 1.8 and 12 patients (63.2%) had no or minimal pain (VAS score, 0-2). Satisfactory subjective functional outcomes were observed with a mean ASES score of 81.0 ± 15.4 and SSV of 81.3 ± 19.6 . The mean CS was 86.3 ± 4.8 and 14 patients (73.7%) showed good objective functional outcome (CS $\geq 85/100$).

Severity of initial AC joint injury as assessed according to preoperative CC distance correlated with subjective functional outcomes (ASES score and SSV) ($P = .035$ and $.026$, respectively) but not with either pain (VAS) outcomes ($P = .168$) or objective functional outcomes (CS) ($P = .104$) (Fig. 3). No association was observed between postoperative CC distance and clinical outcomes ($P = .991$, 0.786 , 0.472 , and 0.262 , respectively for pain score, CS, ASES score, and SSV) (Fig. 4). Similarly, other anatomical outcomes (degree of implant loosening and horizontal stability) did not correlate with either pain or functional outcomes ($P = .854$, 0.786 , 0.952 , and 0.688 for loosening ratio and 0.981 , 0.489 , 0.836 , and 0.578 for AC distance, respectively) (Figs. 5 and 6).

During follow-up period, one patient developed postoperative frozen shoulder that did not respond well to aggressive rehabilitation. Manipulation under general anesthesia and arthroscopic capsular release was performed and agreeable shoulder ROM was achieved at the final follow-up assessment. Mild AC joint arthritis was present on postoperative radiographs of two patients (patients 13 and 14) without apparent deterioration of clinical outcomes. Severe heterotopic ossification was observed on postoperative images of one patient (Patient 5) which was located on trajectory of the tunnel (Fig. 7). Despite the presence of heterotopic ossification and fixation failure, this patient had considerable satisfactory clinical outcomes.

Table 1
Radiological and clinical outcomes of patients.

Patient number	Injury type	Loosening percentage (%)	AC distance (mm)	VAS	Constant	ASES	SSV
1	III	5.1	7.3	5	68	58.3	70
2	V	0	4.2	5	58	54.9	40
3	V	72.5	-5.6	0	100	95.0	100
4	III	80.8	0	4	62	51.6	50
5	III	177.8*	7.0	0	96	93.3	90
6	V	85.1	-4.4	3	85	64.9	60
7	III	27.4	0	1	96	93.3	100
8	III	0	0	0	92	91.6	100
9	V	63.5	5.8	0	90	78.3	85
10	III	79.1	-5.6	0	100	95.0	100
11	V	80.0	13.6	2	94	80.0	90
12	III	13.6	8.0	0	98	93.3	95
13	III	41.1	9.6	2	92	90.0	80
14	V	9.3	5.8	3	83	74.9	75
15	III	51.2	-5.2	0	100	95.0	100
16	V	531.3*	0	3	85	78.3	70
17	V	28.8	5.8	2	85	86.7	90
18	V	54.4	-12.2	4	55	64.9	50
19	III	48.3	4.8	0	100	100	100

VAS, visual analog scale; SSV, Subjective Shoulder Value; ASES, American Shoulder and Elbow Surgeons; AC, acromioclavicular.

*Loosening ratio >100% considered as repair failure.

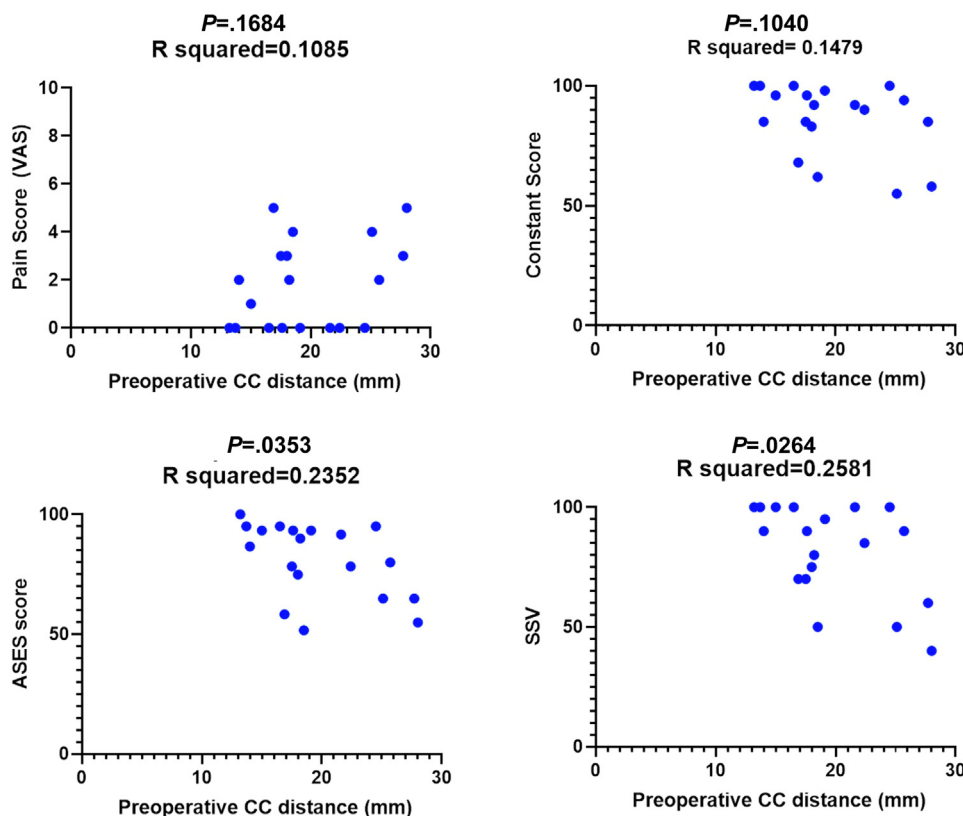


Figure 3 Correlation graphs illustrating relationship between preoperative coracoclavicular distance and clinical outcomes. VAS, visual analog scale; SSV, Subjective Shoulder Value; ASES, American Shoulder and Elbow Surgeons; CC, coracoclavicular.

Discussion

The most important finding of the present study was that arthroscopic assisted SCT technique showed good clinical outcomes notwithstanding persistent vertical or horizontal instability and that there was no correlation between clinical and anatomical outcomes. Unlike recent reports suggesting addition of an AC fixation in order to establish stability both in horizontal and coronal

planes^{1,2}; results of this study showed that isolated CC fixation provides sufficient stability and agreeable clinical outcomes for most of the cases and that indications for an additional AC fixation need to be clarified.

Current knowledge lacks evident data and there are published reports indicating conflicting results about contribution of an additional AC fixation to biomechanical and clinical outcomes. A recent biomechanical study showed that addition of a stabilizing

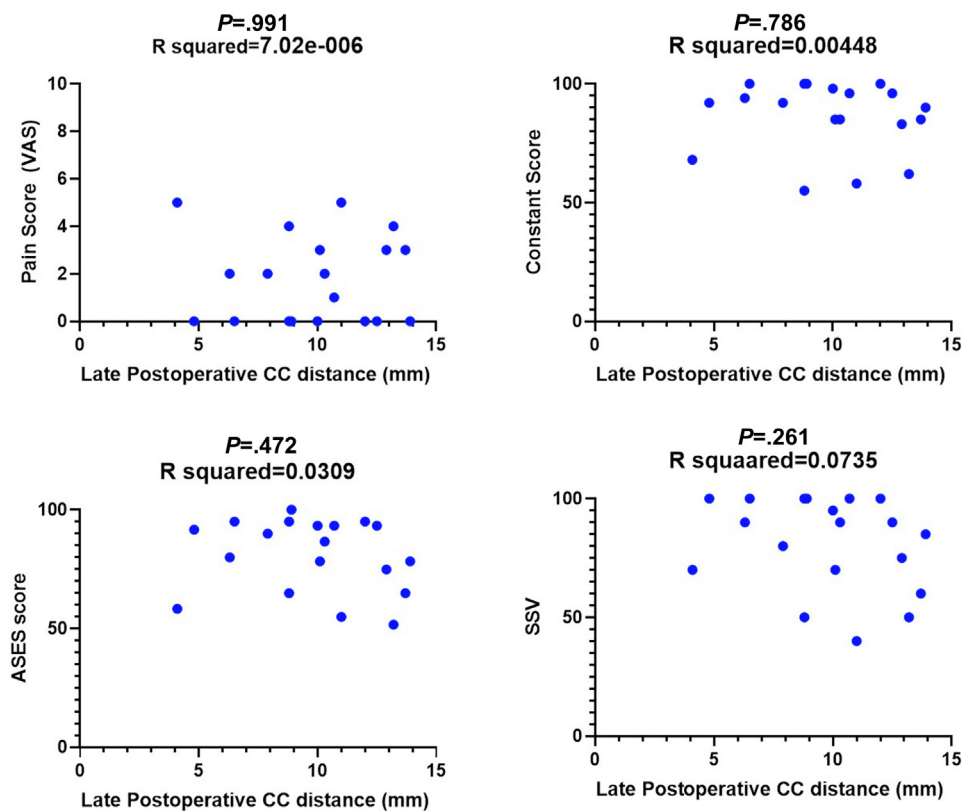


Figure 4 Corralation graphs illustrating relationship between late postoperative coracoclavicular distance and clinical outcomes. VAS, visual analog scale; SSV, Subjective Shoulder Value; ASES, American Shoulder and Elbow Surgeons; CC, coracoclavicular.

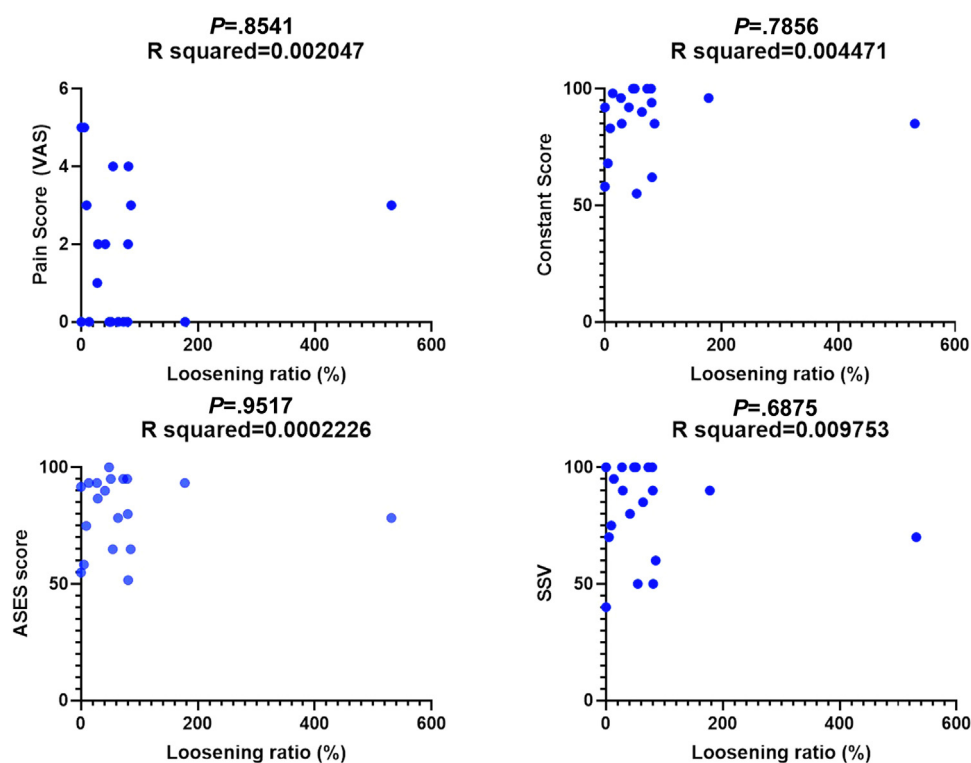


Figure 5 Correlation graphs illustrating relationship between loosening ratio and clinical outcomes. VAS, visual analog scale; SSV, Subjective Shoulder Value; ASES, American Shoulder and Elbow Surgeons.

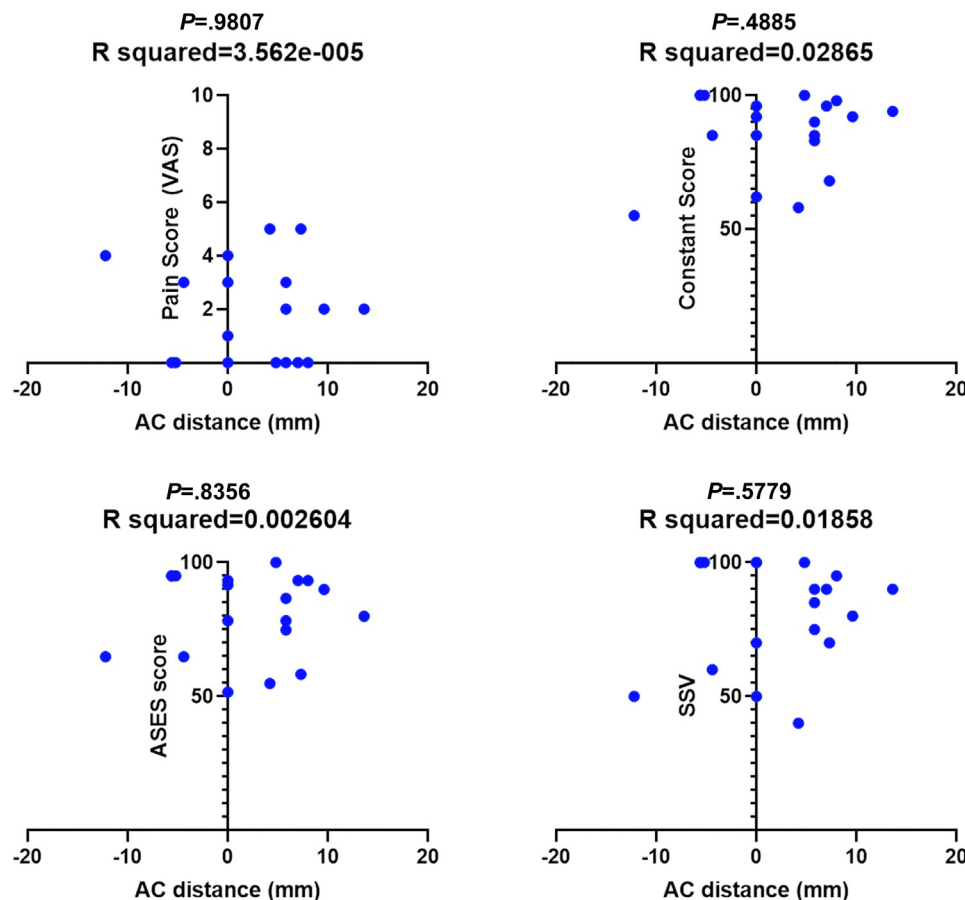


Figure 6 Correlation graphs illustrating relationship between acromioclavicular (AC) distance and clinical outcomes. Negative values for AC distance reflect on posterior horizontal instability. VAS, visual analog scale; SSV, Subjective Shoulder Value; ASES, American Shoulder and Elbow Surgeons; AC, acromioclavicular.

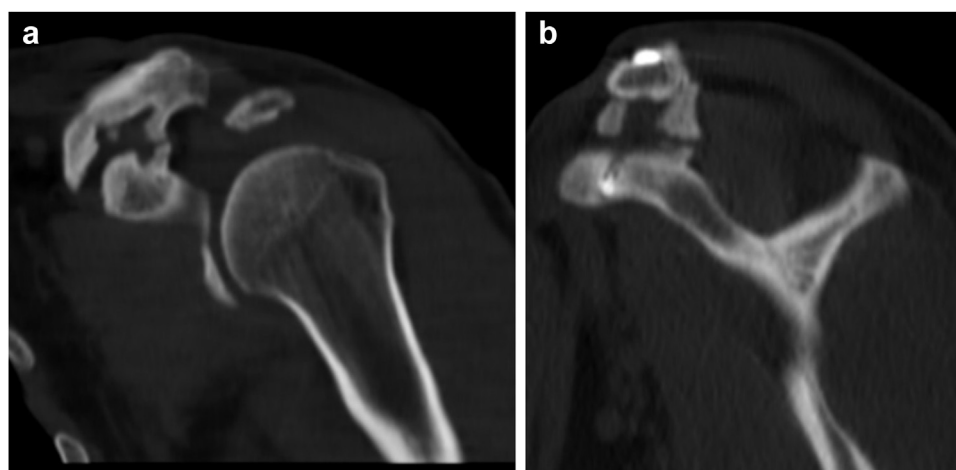


Figure 7 (a) Coronal and (b) sagittal computed tomography scan images of a patient showing apparent heterotopic ossification located around the tunnel.

suture across AC joint to either single or double clavicular tunnel CC reconstruction did not result with significant improvement in horizontal stability and all constructs had inferior horizontal stability compared to native joint. Results of this study implied the importance of an intact AC joint capsule and deltotracheal fascia to maintain horizontal stability.¹³ Another biomechanical study by Theopold et al showed that addition of an AC cerclage had negligible effect to horizontal stability in the presence of a double

CC reconstruction.²⁶ In contrast to these reports, several biomechanical studies reported significant improvement in horizontal stability with additional AC augmentation compared to isolated CC ligament reconstruction.^{12,24}

Recent clinical data is mostly in favor of anatomical restoration of AC joint in bidirectional planes with additional AC stabilization in order to obtain better clinical results. A systematic review by Aliberti et al suggested better clinical results with incorporation of

AC ligament reconstruction to current CC fixation procedures due to restoration of horizontal stability.¹ In contrast to findings of the present study, Barth et al showed that anatomical outcome significantly correlates with functional outcome and accurate reduction is a prerequisite for better results. Authors suggested that isolated CC stabilization is not sufficient to provide lasting stability and recommended that AC joint should be approached routinely in addition to CC fixation.² However, literature still lacks evident data to draw such assertive conclusion and clear indications of additional AC stabilization should be determined. In accordance with the present study, Schiebel et al reported good to excellent results in acute high-grade AC joint injuries treated with double CC tunnel technique despite persistent vertical or horizontal instability in some cases.²⁵ A recent systematic review accordingly demonstrated that additional AC augmentation does not improve functional outcomes despite better restoration of horizontal stability biomechanically. Moreover, no difference in complication or revision rates was found between isolated CC ligament reconstruction and cases with additional AC augmentation.¹⁴

Even though additional AC stabilization would provide better horizontal stability, its contribution to clinical outcomes is questionable since the findings of this study showed that isolated CC fixation seems to be sufficient to provide satisfactory clinical outcomes despite persisting instability and that no correlation was present between clinical and anatomical outcomes. In severe AC joint injuries, owing to disruptions of the AC ligaments, CC ligament and deltoidtrapezial fascia; both static and dynamic stability of AC joint is impaired, thus leading to an unstable AC joint. Recent literature suggests that reconstruction of each stabilizing component of AC joint, both CC and AC ligaments, should be addressed in order to obtain an accurate reduction of the joint which is essential to obtain good functional outcomes. Besides that, an AC fixation may reduce the stress on the CC fixation implant and prevent a possible implant loosening and fixation failure in long-term for these severe cases. Our findings showed that these recommendations are negligible for most patients; however, we still believe that they may be valid for some confined patient population where even small differences of clinical outcome may be of vital importance like in elite athletes. Therefore, we think that determination of clear indications of an additional AC stabilization is essential to guide clinical practice and further research with higher evidence is necessary on this topic.

Retrospective nature of the study constitutes the first limitation to our study. Second, absence of a control group treated with an additional AC stabilization limits the effect of the study. Small patient number is another limitation but we think that compared to previously published series, this study has a considerable patient size. Short- to mid-term results are presented in this study which also constitutes a limitation. Another limitation is classification of AC joint injury severity with Rockwood classification whose reliability and reproducibility has been challenged.⁷ The study population of current study was mostly constituted of sedentary individuals, which may also be another limitation since reported results may not apply for professional athletes.

Conclusions

Arthroscopic-assisted SCT technique is a favorable surgical option for treatment of AC joint injuries with good clinical outcomes. Clinical outcome and patient satisfaction is not correlated with structural outcome and good results can be achieved despite persistent horizontal instability. Therefore, additional AC fixation in the horizontal plane is not a prerequisite for all AC joint injuries. Further research is needed to clarify indications for a horizontal plane fixation of AC joint.

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