# Acromioclavicular hook plate versus anatomical reconstruction of coracoclavicular ligaments using hamstring autograft in acromioclavicular joint dislocation

Rashwan Amr

Department of Orthopedic Surgery, Faculty of Medicine, Kasr AlAiny Hospital, Cairo University, Cairo, Egypt

Correspondence to Rashwan Amr, MD (Lecture), Tel: +20 111 220 1444; e-mail: amrsamir75@hotmail.com

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**Introduction**
Acromioclavicular joint (ACJ) injuries can result from a multitude of causes. Most injuries occur during activities with high-impact risks such as contact sports, football, ice hockey, and wrestling, with male athletes at greater risk than female athletes. The stability of AC joint depends on the joint capsule, the acromioclavicular (AC) and coracoclavicular (CC) ligaments, and the intraarticular fibrocartilaginous disc. The choice of the required surgical technique for the management of AC disruption is a controversial issue owing to the abundance of the surgical options described for treatment. However, the clinical superiority of these procedures remains debatable, and various complications have been reported.

**Hypothesis**
This hypothesis is that the anatomical reconstruction of the CC ligaments may render better long-term functional and radiological results compared with the use of a hook plate in ACJ dislocations.

**Patients and methods**
This is a prospective nonrandomized comparative study that was held between August 2011 and January 2017 at Cairo University Hospitals. It included 64 patients with acute AC dislocation type III–VI and divided into two groups: group A, which underwent anatomic reconstruction of CC and AC ligaments, and group B, which underwent ACJ dislocation using the hook plate. The mean age of group A patients was 43.22±11.46 years, whereas it was 41.56±8.70 years in group B. There were 22 male and 10 female patients in group A compared with 21 male and 11 female patients in group B. The mean time from injury was 8.41±3.41 weeks in group A compared with 9.91±1.59 weeks in group B. The average follow-up was 64.06±4.24 months in group A versus 63.94±3.79 months in group B. The clinical outcome was assessed preoperatively and postoperatively at 1, 2, and 5 years using the visual analog scale, Constant score, and American shoulder and elbow surgeon score. Radiological assessment included the measurement of the CC distance (vertical displacement) and the anteroposterior (horizontal) displacement preoperatively and postoperatively at 1 year and at the final follow-up.

**Results**
Regarding the clinical outcome, the visual analog scale score improved from 7.06±1.22 preoperatively to 1.06±1.07 at 5-year follow-up in group A, whereas it improved from 7.5±0.92 preoperatively to 2.97±0.59 at 5-year follow-up in group B, with $P$=0.000. Similarly, the American shoulder and elbow surgeon score improved from 26.64±8.15 preoperatively to 92.06±5.37 postoperatively in group A, whereas in group B, it improved from 19.87±7.56 preoperatively to 77.1±5.40 postoperatively ($P$=0.000). The constant score in group A improved from 20.44±2.66 preoperatively to 92.91±3.64 postoperatively, and in group B, it improved from 20.13±2.29 preoperatively to 80.53±4.76 postoperatively ($P$=0.000). The radiological assessment at the final follow-up showed that the anteroposterior (horizontal) displacement in group A was 4.31±2.62 preoperatively and became 1.06±1.01 postoperatively, whereas in group B, it was 5.56±2.12 preoperatively and became 3.41±1.29 postoperatively, with a statistically significant difference ($P$=0.000). The superior displacement in group A was 21.57±5.09 mm preoperatively and decreased to 10.61±1.02 postoperatively compared with 23.99±5.92 preoperatively, which decreased to 13.36±3.67 postoperatively in group B, with statistically significant difference ($P$=0.001).

**Conclusion**
The concomitant anatomical reconstruction of the CC and AC ligaments using autograft provides long-term functional outcome and mechanical stability in both the vertical and horizontal translation compared with the hook plate fixation in acute unstable ACJ dislocation.

**Keywords:**
acromioclavicular, coracoclavicular, hook plate, reconstruction

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## Introduction

Acromioclavicular joint (ACJ) injuries can result from a multitude of causes. Most injuries occur during activities with high-impact risks such as contact sports, football, ice hockey, and wrestling, with male athletes at greater risk than female athletes [1,2]. According to Rockwood classification [3], type I and II are treated conservatively, whereas the treatment for types IV–VI is essentially surgical. However, for type III, it is a controversial issue [4,5]. The stability of AC joint depends on the joint capsule, the acromioclavicular (AC) and coracoclavicular (CC) ligaments, and the intraarticular fibrocartilaginous disc [6]. The ACJ capsule is reinforced by anterior, superior, posterior, and inferior ligaments. The posterior and superior ligaments are the strongest and are invested by the deltotrapezial fascia. Biomechanical studies have shown that the AC ligaments and capsule are important in providing anterior-posterior stability to the ACJ [7]. The trapezoid ligament laterally and conoid ligament medially form the CC ligaments. They act as a static anterior-inferior stabilizer of the ACJ. The CC ligaments originate from the superior surface of the coracoid and diverge as they course superiorly, with the conoid ligament broadly inserting posteromedially onto the conoid tuberosity medially and the trapezoid ligament narrowly inserting anterolaterally at the trapezoid ridge at the inferior distal clavicle [8]. The distance between the distal end of the clavicle and medial edge of the conoid tuberosity in males is 47.2 ±4.6 mm and in females 42.8±5.6 mm, as well as the distance to the center of the trapezoid tuberosity in males is 25.4±3.7 mm and in females is 22.9±3.7 mm. These measurements represent the basis for the anatomical reconstruction of CC ligaments for restoration of the native biomechanical function [9]. Mazzoca *et al.* [10] have demonstrated that the cascade of injury in ACJ separations started with direct force to the lateral aspect of the shoulder with the arm in the adducted position driving the acromion inferiorly, while the clavicle remains in its position. Then, the AC ligament fails, followed by CC ligaments initially conoid ligament and finally the trapezoid ligament. More severe injuries may disrupt the deltoid and trapezius attachments to the clavicle. The choice of the required surgical technique for the management of AC disruption is controversial owing to the abundance of the surgical options described for treatment. Nevertheless, the clinical superiority of these procedures remains debatable, and various complications have been reported [11–13]. The use of hook plate for the management of AC dislocation was introduced by Balser [14]. It depends on superior fixation on the distal clavicle, and reduction is achieved through the transarticular hook resting on the inferior surface of acromion [15]. However, the use of the hook plate is not without complications, like subacromial impingement, erosion on the under surface of acromion, osteolysis, and acromion fractures [16,17], in addition to the need for the plate removal to avoid the hardware pain, discomfort, or failure [18]. In 2001, Jones *et al.* [19] described the use of autogenous tendon graft for the reconstruction of the CC ligaments in acute AC dislocations using two tunnels drilled through the clavicle at the conoid and trapezoid footprints. Ligamentous reconstruction of the CC and AC ligaments recreates the anteroposterior and superior-inferior stability of ACJ when compared with the modified Weaver Dunn procedure using the biomechanical studies [20]. Among the advantages of anatomic CC and AC ligament reconstruction over hook plate are the no need for plate removal or fear of plate failure [21]. The complications reported with the anatomic reconstruction of the CC and AC reconstruction include graft failure or attenuation, the clavicular and coracoid fracture due to drilling of the bony tunnels, and the donor site morbidity [22].

### Hypothesis

Our objective is to compare the long-term clinical and radiological outcomes of the anatomical reconstruction of the CC ligaments versus the use of the hook plate in acute unstable ACJ (III–VI). Our hypothesis is that the anatomical reconstruction of the CC ligaments may render better long-term functional and radiological

results compared with the use of the hook plate in AC dislocations.

## Patients and methods

This is a prospective nonrandomized comparative study that was held between August 2011 and January 2017 at Cairo University Hospitals. It included 64 patients with acute AC dislocation types III–VI according to Rockwood classification. Exclusion criteria included patients with chronic AC dislocations, AC arthritis, shoulder stiffness, rotator cuff tears, previous intervention on the same shoulder, and cervical disc disorders. The patients were divided into two groups: group A included 32 patients treated with anatomical reconstruction of the CC and AC ligaments using autogenous semitendinosus tendon, whereas the 32 patients of group B underwent open reduction and fixation of the dislocation using the hook plate. An informed consent was obtained from all the patients, and the study was approved by the Ethical Committee at Cairo University Hospitals. The mean age at group A was 43.22±11.46 years, whereas it was 41.56±8.70 years in group B. There were 22 male and 10 female patients in group A compared with 21 male and 11 female patients in group B. The dominant shoulder was affected in 28 patients (87.5%) in both groups. According to Rockwood's classification, there were 7, 14, and 11 patients having types III, IV, and V injuries, respectively. However, in group B, there were 4, 14, and 14 patients having types III, IV, and V injuries, respectively. The mean time from injury (weeks) was 8.41±3.41 in group A compared with 9.91±1.59 in group B. The average follow-up was 64.06±4.24 months in group A versus 63.94±3.79 months in group B. There were no statistically significant difference regarding the patients' demographic data in both groups. The patients' demographic data are shown in Table 1. The clinical outcome was assessed preoperatively and postoperatively at 1, 2, and 5 years using the visual analog scale (VAS), Constant score, and American shoulder and elbow surgeon score (ASES). Radiological evaluation included preoperative dynamic bilateral shoulder radiographs [anteroposterior (AP), lateral, axial, and Zanca views] with the patient standing and carrying 5 kg in each hand (Fig. 1a and b). Assessment included the measurement of the coracoclavicular distance (CCD) (vertical displacement) (from the upper border of the coracoid process to the inferior cortex of the clavicle, which is normally 11–13 mm, and if >5 mm difference from the contralateral side, it is considered ACJ subluxation) and the anteroposterior (horizontal) displacement preoperatively and postoperatively at 1 year (Fig. 1c and d) and final follow-up at 5 years, together with the evaluation of subacromial osteolysis.

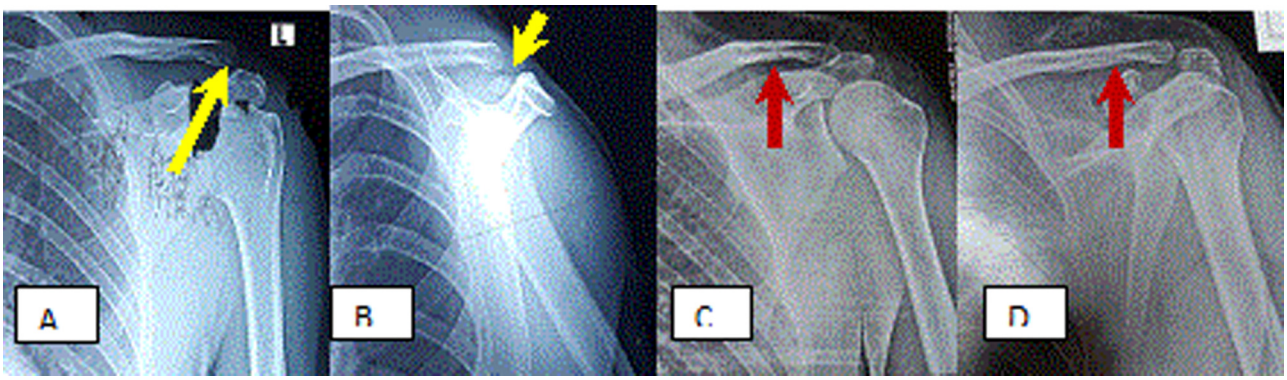
### Surgical technique

The patients were operated upon in the beach chair position under general anesthesia after full examination to ensure complete passive range of motion (ROM) and to exclude frozen shoulder. A vertical skin saber incision was centered over the AC joint and the coracoid process, and dividing the deltopectoral fascia, the AC joint was debrided, and under direct visualization, the joint was reduced. For group A, 8 mm from the lateral end of the clavicle was resected to avoid chondrolysis later on. Two tunnels were drilled 4.5 cm medial to the lateral end of the clavicle for conoid ligament and the another one 2.5 cm for the trapezoid. Both tunnels were drilled using a 4-mm drill bit directed posteriorly for conoid and anteriorly for trapezoid ligament (Fig. 2a). The semitendinosus tendon is harvested from the ipsilateral knee. Both

**Table 1 The patients' demographic data of both groups**

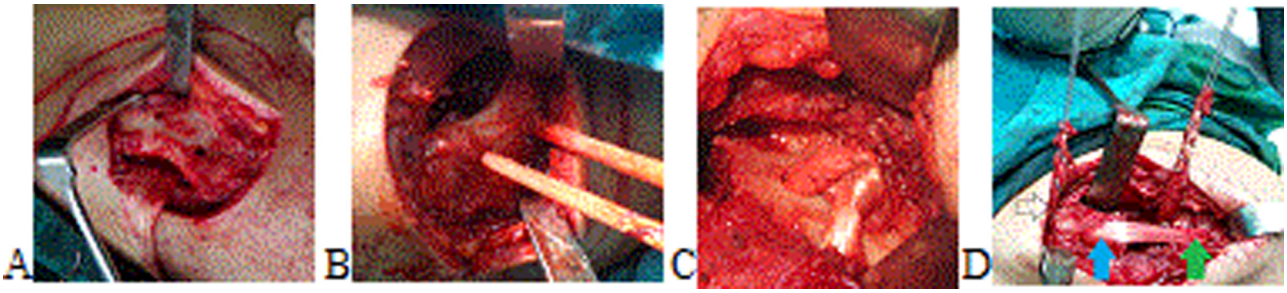
| | Group A (*N*=32) [*n* (%)] | Group B (*N*=32) [*n* (%)] |
|---|---|---|
| Mean age | 43.22±11.46 (18–55) | 41.56±8.70 (18–55) |
| Males | 22 (68.8) | 21 (65.6) |
| Females | 10 (31.2) | 11 (34.4) |
| Right shoulder | 26 (81.25) | 29 (90.63) |
| Left shoulder | 6 (18.75) | 3 (9.37) |
| Dominant shoulder | 28 (87.5) | 28 (87.5) |
| Rockwood classification | | |
| Rockwood type III | 7 (21.87) | 4 (12.5) |
| Rockwood type IV | 14 (43.75) | 14 (43.75) |
| Rockwood type V | 11 (34.38) | 14 (43.75) |
| Mode of injury | | |
| Direct trauma | 20 (62.5) | 20 (62.5) |
| Indirect trauma | 12 (37.5) | 12 (37.5) |
| The mean time from injury to surgery in weeks | 8.41±3.41 (5–11) | 9.91±1.59 (6–11) |
| Mean follow-up period in months | 64.06±4.24 (55–72) | 63.94±3.79(56–70) |

**Figure 1**




(a, b) Preoperative anteroposterior and scapular lateral views showing the acromioclavicular dislocation (yellow arrow). (c, d) Postoperative radiographies showing the reduction of the acromioclavicular joint and the two tunnels drilled in the lateral end clavicle (red arrow).

**Figure 2**




Reconstruction of the coracoclavicular and acromioclavicular ligaments. (a) Two drill holes on the superior surface of the clavicle. (b) Passing the two limbs of the graft through the drill holes of the clavicle. (c) Tying the two limbs of the graft at the anterior aspect of the clavicle. (d) The superior acromioclavicular ligament bridging the acromioclavicular between the blue and the green arrows.

ends were sutured, and the graft was passed in a figure of 8 configuration around the base of the coracoid process using a cerclage loop or Satinsky forceps from medial to lateral after abrading the periosteum on both sides of the coracoid for the healing of the graft with the coracoid. Both ends of the graft were passed using suture shuttle through the predrilled holes of the clavicle (Fig. 2b), and after reducing the ACJ, the two ends were tied over themselves (Fig. 2c) and secured using half hitches of Ethibond no. 2, leaving the lateral end of the graft longer. The remaining length of the graft was bridged over the AC joint to reconstruct the superior AC ligament (Fig. 2d) and passed through a drill hole 2 cm lateral to the AC joint in the anterior acromion to be passed into the subacromial space and retrieved again at the posterior aspect of the AC joint, reconstructing the posterior AC ligament, and then sutured with the previously tied ends of the graft keeping the knots anterior to the clavicle to avoid being prominent subcutaneously. For group B, through the same exposure and after joint reduction, the hook plate was applied to the superior surface of the distal end of the clavicle, and then the hook was introduced through the joint with the hook directed posterior and inferior to the acromion. Then, the plate was fixed to the distal end of the clavicle with screws. The hook plate removal was done after 3 months to avoid pain, discomfort, or implant failure. Postoperatively, the patients started pendular exercises and were instructed to avoid heavy weight lifting. At the third week, deltoid isometric exercises were started and active assisted ROM begun. At sixth week, full ROM was permitted with return to work. Heavy work with lifting started at the sixth month.

### Statistical analysis

Data were statistically described in terms of mean±SD, median, and range, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student's *t*-test for independent samples for comparing normally distributed data and Mann–Whitney *U*-test for independent samples for comparing non-normal data. For comparing categorical data, $\chi^2$ test was performed. Exact test was used instead when the expected frequency is less than 5. *P* values less than 0.05 were considered

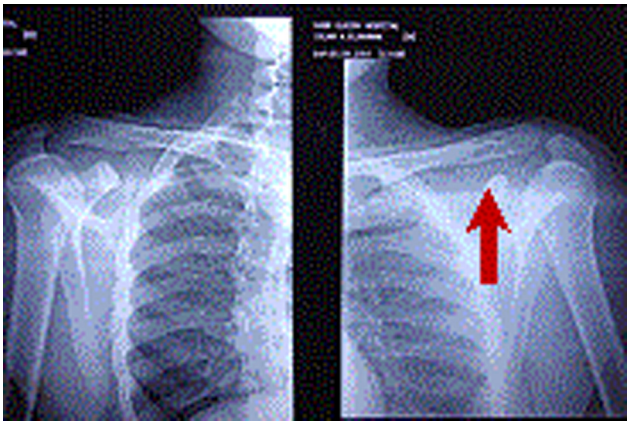
statistically significant. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp., Armonk, New York, USA) release 22 for Microsoft Windows.

## Results

Regarding the clinical outcome, the VAS score was 7.06±1.22 preoperatively and became 1.06±1.07 at the final follow-up in group A, whereas in group B, it was 7.5±0.92 preoperatively and became 2.97±0.59 at the final follow-up, with a statistically significant difference ($P$=0.000). Similarly, the ASES score was 26.64±8.15 preoperatively and improved to 92.06±5.37 at the final follow-up in group A, whereas in group B, it was 19.87±7.56 preoperatively and became 77.1±5.40 at the final follow-up, and this was also statistically significant ($P$=0.000). The Constant score in group A increased from 20.44±2.66 preoperatively to 92.91 ±3.64 at the final follow-up, and in group B, it was 20.13±2.29 preoperatively and increased to 80.53±4.76 at the final follow-up; this was also statistically significant ($P$=0.000). A total of 29 patients (90.6%) were satisfied in group A compared with 25 patients (78.1%) in group B. Moreover, 29 patients (90.6%) were able to return to their previous activities in group A compared with 27 patients (84.4%) in group B. The functional outcome scores are shown in Table 2.

The radiological assessment (Figs 3 and 4) at the final follow-up showed that the AP (horizontal) displacement in group A was 4.31±2.62 preoperatively and became 1.06±1.01 postoperatively, whereas in group B, it was 5.56±2.12 preoperatively and became 3.41±1.29 postoperatively, with a statistically significant difference ($P$=0.000). The superior displacement in group A was 21.57±5.09 mm preoperatively and decreased to 10.61±1.02 postoperatively compared with 23.99±5.92 preoperatively and decreased to 13.36 ±3.67 postoperatively in group B, which also was

**Figure 3**



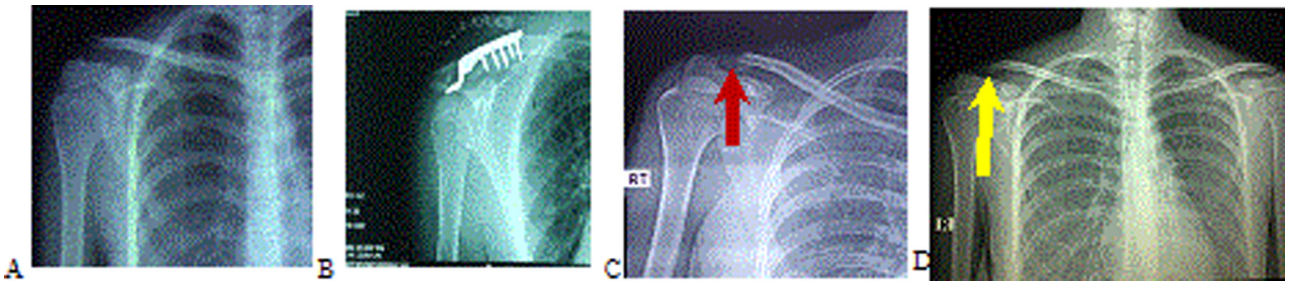
Five-year follow-up radiography after ligament reconstruction showing maintained acromioclavicular joint reduction (red arrow) compared with the normal contralateral side.

**Table 2 The preoperative and the postoperative functional scores (VAS, ASES, and Constant scores), patient satisfaction, and return to activities of both groups**

| | Group A ($n$=32) | Group B ($n$=33) | $P$ value |
|---|---|---|---|
| VAS | | | |
| Preoperative VAS | 7.06±1.22 (4–8) | 7.5±0.92 (4–8) | 0.109 |
| Postoperative VAS 1 years | 2.81±0.96 (2–5) | 4.81±0.59 (3–6) | 0.000* |
| Postoperative VAS 2 years | 2.38±0.87 (1–4) | 4.00±0.76 (2–5) | 0.000* |
| Postoperative VAS 5 years | 1.06±1.07 (0–3) | 2.97±0.59 (1–4) | 0.000* |
| ASES | | | |
| Preoperative ASES | 26.64±8.15 (13.3–38.3) | 25.87±7.56 (13.3–35.0) | 0.187 |
| Postoperative ASES 1 years | 81.41±4.95 (71.7–86.0) | 71.38±6.21 (60.0–86.0) | 0.000* |
| Postoperative ASES 2 years | 87.79±6.57 (76.7–95.0) | 74.02±4.96 (64.0–86.0) | 0.000* |
| Postoperative ASES 5 years | 92.06±5.37 (76.6–95.0) | 77.1±5.40 (64.0–93.0) | 0.000* |
| Constant score | | | |
| Preoperative Constant | 20.44±2.66 (17–28) | 20.13±2.29 (17–28) | 0.617 |
| Postoperative Constant 1 years | 86.00±6.26 (64–96) | 75.19±6.36 (64–90) | 0.000* |
| Postoperative Constant 2 years | 89.25±6.01 (72–98) | 77.19±5.05 (72–90) | 0.000* |
| Postoperative Constant 5 years | 92.91±3.64 (85–98) | 80.53±4.76 (72–90) | 0.000* |
| Patient satisfaction [$n$ (%)] | | | |
| Satisfied | 29 (90.6) | 25 (78.1) | |
| Not satisfied | 3 (9.4) | 7 (21.9) | |
| Return to activities | | | |
| Return | 29 (90.6) | 27 (84.4) | |
| No return | 3 (9.4) | 5 (15.6) | |

ASES, American shoulder and elbow surgeon score; VAS, visual analog score. *Statistically significant.

**Figure 4**




(a) Preoperative right-side acromioclavicular joint dislocation. (b) Immediate postoperative reduction by the hook plate. (c) Three months after plate removal showing osteolysis at the distal clavicle (red arrow). (d) At 5-year follow-up showing acromioclavicular joint subluxation (yellow arrow).

**Table 3 Radiological assessment of the subluxation of the distal end of the clavicle preoperatively and at the final follow-up 5 years postoperatively**

| | Group A (*n*=32) | Group B (*n*=32) | *P* value |
|---|---|---|---|
| Horizontal (AP) displacement in mm | | | |
| Preoperative | 4.31±2.62 (0–10) | 5.56±2.12 (0–10) | 0.078 |
| Postoperative | 1.06±1.01 (0–2) | 3.41±1.29 (0–6) | 0.000* |
| Vertical (superior) displacement in mm | | | |
| Preoperative | 21.57±5.09 (15–27) | 23.99±5.92 (8–19) | 0.164 |
| Postoperative | 10.61±1.02 (9–11) | 13.36±3.67 (10–16) | 0.001* |
| Subacromial osteolysis [*n* (%)] | 0 | 5 (15.63) | – |
| CCD difference >5 mm at the final follow-up [*n* (%)] | 2 (6.25) | 7 (21.87) | – |

AP, anteroposterior; CCD, coracoclavicular distance. *Statistically significant.

statistically significant (*P*=0.001). The radiological assessment results are shown in Table 3.

Regarding complications, two cases (6.25%) in group A had shown CCD difference greater than 5 mm compared with the contralateral side (subluxation of ACJ). Both patients were not complaining, and this had not affected their functional outcome. However, in group B, seven patients (21.87%) had CCD difference greater than 5 mm with normal contralateral side, which was apparent following the hook plate removal after 3 months. Moreover, five cases (15.63%) had shown acromial osteolysis, which caused dissatisfaction to the patients with the inability to return to the previous preinjury activity level. There were no cases of clavicular fractures in group A or B.

## Discussion

The AC injuries represent a challenge to the orthopedic surgeons regarding diagnosis and the choice of the appropriate surgical management. The ongoing debate regarding the choice of the most successful surgical technique for addressing the high-grade AC injuries is still unsolved. Numerous surgical techniques had been described, but all of them are not free from complications. The hook plate provides a rigid construct against the rotational, anteroposterior, and superior-inferior translation as well as allows early mobilization. The hook plate avoids direct damage to the joint, as no fixation through the AC joint using the Kirschner wires or pins is used [23–25]. However, the plate needs removal to avoid the implant failure, subacromial impingement, acromion erosion, or fractures of the distal clavicle [17,26–28]. From the biomechanical and anatomical aspects, the reconstruction of the CC ligaments using the tendon autografts does not cause any injury to the AC joint [19,29,30]. This technique avoids the insertion of metal implant with the subsequent need for its removal. In addition, it allows the concomitant reconstruction of the AC ligaments, adding more stability for the repair as mentioned in the study of Debski *et al.* [31]. The concomitant reconstruction restores the synergistic effect of the ACJ capsular ligaments controlling the horizontal displacement with the CC ligaments controlling the vertical movements [32]. The use of figure of 8 loop around the base of the coracoid avoids the need for coracoid drilling, which carries the risk of coracoid fracture. The results of this study showed that VAS score was 7.06 ±1.22 preoperatively and 1.06±1.07 postoperatively in group A, whereas in group B was 7.5±0.92 preoperatively and 2.97±0.59 postoperatively (*P*=0.000). Similarly, the ASES score was 26.64 ±8.15 preoperatively and 92.06±5.37 postoperatively

in group A, whereas in group B, it 19.87±7.56 preoperatively and 77.1±5.40 postoperatively ($P$=0.000). The Constant score in group A was 20.44 ±2.66 preoperatively and 92.91±3.64 postoperatively, whereas in group B was 20.13±2.29 preoperatively and 80.53±4.76 postoperatively ($P$=0.000). Radiologically, the AP (horizontal) displacement in group A was 4.31 ±2.62 preoperatively and 1.06±1.01 postoperatively, whereas in group B was 5.56±2.12 preoperatively and 3.41±1.29 postoperatively ($P$=0.000). The superior displacement in group A was 21.57±5.09 preoperatively and 10.61±1.02 mm postoperatively, whereas was 23.99±5.92 preoperatively and 13.36 ±3.67 postoperatively in group B ($P$=0.001). These results are comparable to the results obtained by Carofino *et al.* [29], who reported a series of 17 cases of ligament reconstruction and demonstrated significant improvements in the mean ASES scores (52–92), mean SST scores (7.1–11.8), and mean Constant Murley scores (66.6–94.7). Moreover, Millett *et al.* [22] reported 2-year follow-up results on 31 shoulders that underwent anatomic CC ligament reconstruction and found significant improvements in mean postoperative ASES scores (58.9 vs. 93.8, $P$<0.001) and SF-12 PCS scores (45.3 vs. 54.4, $P$=0.007). The results reported in multiple studies were also in agreement with the results demonstrated in this study [33–41]. However, the obtained results are not in agreement with the results obtained by Yoon *et al.* [42], showing superiority of the hook plate over the ligament reconstruction but using synthetic ligament. No clavicular fractures occurred in group A, and this may be related to the drilling of the tunnels with a 4-mm drill according to the recommendations by Millett *et al.* [22] to avoid clavicular fractures. The limitations of this study include being nonrandomized and no inclusion of type VI ACJ dislocation, and this may be owing to the rarity of this type of injuries. The points of strengths of this study are that it was a prospective study, the relatively good sample size, and the long follow-up period. The results of this study had shown the superiority of the reconstruction of the CC and ACJ capsular ligaments over the use of the hook plate for acute unstable ACJ dislocations regarding the functional and radiological outcomes, with a statistically significant difference.

## Conclusion

The concomitant anatomical reconstruction of the CC and AC ligaments using autograft provides long-term functional outcome and mechanical stability in both the vertical and horizontal translation compared with the hook plate fixation in acute unstable ACJ dislocation.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

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