Hook plate fixation with coracoclavicular ligaments repair and augmentation for management of acute acromioclavicular joint dislocation

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Background
Several surgical techniques and implants have been proposed for the treatment of acute acromioclavicular joint (ACJ) dislocation. The purpose of the study was to assess the results of hook plate fixation combined with coracoclavicular (CC) ligaments repair and augmentation for the management of ACJ dislocation.
Patients and methods
Between March 2011 and October 2014, 22 patients (15 male and seven female) with ACJ dislocation were treated with open reduction and hook plate fixation with CC ligament repair and augmentation at Benha University Hospital. The inclusion criteria included patients with isolated ACJ dislocation grades III–V according to Rockwood classification. Exclusion criteria were neglected cases greater than 4 weeks, chronic dislocations, open dislocation, and fracture dislocation of the ACJ. The average age of the patients was 31.8±9.7 years, ranging from 18 to 60 years. The right side was affected in 14 patients and the left in eight patients. Functional outcomes were assessed according to range of motion (ROM) and the Constant–Murley scoring system, disabilities of the arm, shoulder and hand (DASH) score, and visual analog scale score for pain.
Results
The mean operative time was 66 min (50–90 min). The mean follow-up period was 20.3±7.8 months, ranging from 12 to 40 months. In all but one of the 22 cases, the plates were removed after 3–6 months. The mean postoperative shoulder forward flexion was 160.4±15.8°, the extension was 51±8.6°, internal rotation 58.1±11.7°, the external rotation was 68.1±12.7°, and the abduction was 160.4±18.3°. The mean constant score was 94±5.1. The mean DASH score was 8.7±4.8. The mean pain visual analog scale score was 1.2±1. No major complications occurred in this study, except for one case that developed an asymptomatic 1-cm widening of the AC distance after 12 months. No patient developed wound infection, redislocation, AC ligament ossification, or acromion osteolysis over the hook even in the only case of retained plate for 18 months.
Conclusion
The use of hook plate is a good choice for stabilization of acute ACJ dislocation. When combined with CC ligaments repair and augmentation, the complication rates were low, with good functional outcome.

Keywords:
acromioclavicular hook plate, acromioclavicular joint, acromial osteolysis, acromioclavicular dislocation, clavicular hook plate, Rockwood

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Introduction

Acromioclavicular (AC) joint dislocations are common injuries in young athletes, representing approximately 12% of all dislocations about the shoulder [1]. The AC joint is a diarthrodial joint between the lateral aspect of the clavicle and the medial facet of the acromion. Stability in the anterior-posterior plane is provided by the AC ligaments, with the superior ligament being the strongest. Superior-inferior stability is maintained by the trapezoid and conoid coracoclavicular (CC) ligaments [2].

AC joint dislocations typically occur after either indirect force from a fall on an outstretched arm or by a direct impact to the shoulder and mainly affect active patients involved in contact sports. This leads to bulging of the lateral aspect of the clavicle, pain, and impaired shoulder function [3,4] AC joint functions are to support the weight of the upper extremity through suspension of the scapula from the clavicle, and thus, once the ligaments are destroyed, many patients develop various degrees of disability [5].

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According to Rockwood classification [6] (grades from I to VI), there is widespread agreement that nonoperative treatment is recommended for grades I and II lesions, and surgical treatment is recommended for grades IV, V, and IV lesions. Still, there is an ongoing controversy about the treatment of grade III AC joint separations, especially for patients with high demands regarding the shoulder function. Many satisfying results were published with conservative management of grade III AC joint injuries. However, some authors have reported residual symptoms of weakness and pain in up to 50% of conservatively treated patients in cases of grade III AC joint injuries [2].

A biomechanical study done in 2006 has shown the importance of precise restoration of the acromioclavicular distance as a major factor to maintain joint stability against superior displacement under stress and to maintain anteroposterior (AP) stability [7].

Since Cooper performed the first surgical repair in 1861 using a silver wire [8], several surgical techniques and implants have been proposed including AC wire or suture fixation, transarticular pins or screws, hook plate fixation, transfer of the coracoid process with attached conjoined tendon, CC screws and CC fixation with natural or synthetic grafts and arthroscopic assisted reconstruction of CC ligaments [9–19].

The aim of this study was to evaluate the results of CC ligament repair and augmentation combined with hook plate fixation for treatment of acute Rockwood grade III–V AC joint injuries in patients with high demands regarding the functional outcome.

Patients and methods

A prospective study was held between March 2011 and October 2014 at Benha University Hospital that included 22 patients (15 male and seven female) with acute acromioclavicular joint (ACJ) dislocation. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Benha University, Egypt. The inclusion criteria included patients with isolated ACJ dislocation grades III–VI according to Rockwood classification. Exclusion criteria were physically inactive patients, open dislocation, fracture dislocation of the ACJ, as well as neglected (>4 weeks) and chronic AC joint dislocations.

The mechanism of injury was sports-related injuries in 10 patients, road traffic accidents in seven patients, and fall on an outstretched hand in five patients. The average age of the patients was 31.89.7 years ranging from 18 to 60 years (actually all patients from 18 to 43 years old with only one physically active 60-year-old patient presented with grade V injury). The right side was affected in 14 patients and the left in eight patients.

All patients were evaluated clinically and radiologically preoperatively. AP and lateral scapular views were obtained as a routine protocol. Stress AP view of the shoulder was taken with the patient standing and carrying 5 kg in his hand with the arm hanging down for precise grading. Computed tomography scan was obtained to diagnose grades IV and VI injuries once suspected. According to Rockwood classification, 11 patients were grade III, three patients were grade IV, eight patients were grade V, and no patients presented with grade VI.

Surgical technique

All patients were operated under general anesthesia, with the patient seated in a beach-chair position. A 'strap' skin incision was used from the tip of the coracoid process crossing the clavicle 2 cm medial to the ACJ toward the anterior border of the acromion process. The incision was carried down longitudinally through the subcutaneous tissues, the deltopectoral fascia was opened, the trapezius and deltoid muscle are dissected subperiosteally to expose the superior border of the clavicle and the ACJ, and the meniscus was excised. In type V injury, the deltoid and trapezius muscles were already disrupted. Four holes were drilled at the distal end of the clavicle 2, 3, 4, and 5 cm from ACJ, just anterior to the planned plate site. 2 Ethibond No. 5 sutures were used; the first suture was taken through the ruptured CC ligaments and passed through the two lateral clavicle holes. Then, a curved suture passer was used to pass the second Ethibond sutures around the base of the coracoid process as close as possible to its base and then passed through the two medial clavicular holes (Fig. 1).

A tunnel was carried out under the acromion, carefully avoiding injury of the supraspinatus tendon. The hook of plate (Fig. 2) was passed under the acromion process posterior to the ACJ, and its position is checked under image intensifier. The reduction was done by pressing the medial part of the plate downward on the clavicle either by direct manual pressure or by using a plate holder clamp (Fig. 3a). The hook acts as a lever and reduces the dislocated acromioclavicular joint. Then, the plate was fixed to the clavicle using a cortical 3.5-mm screw (Fig. 3b). After the reduction was ensured by the image intensifier, 2 Ethibond knots were tied over

the superior cortex of the clavicle anterior to the plate. The deltoid and trapezius were sutured, and the wound was closed in layers, and an arm sling was applied.

Postoperative care

The arm was immobilized in a sling. Passive range of motion (ROM) shoulder exercises were started as tolerated from the first postoperative day. Active-assisted pendular exercises began after suture removal at 2 weeks. Active movement was allowed after 6 weeks under the supervision of a physiotherapist. The hook plate was removed 3–6 months after surgery without removal of the 2 Ethibond knots over the superior cortex of the clavicle.

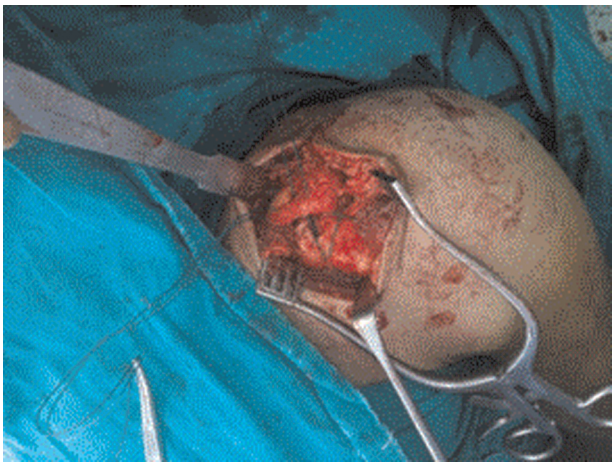
All patients were evaluated radiologically postoperatively to ensure reduction of AC joint (Fig. 3c) at 6 weeks and every 3 months. The CC distance and AC joint line symmetry were recorded. At final follow-up, shoulder ROM, Constant–Murley score, disabilities of the arm, shoulder and hand (DASH) score, and visual analog scale score (VAS) for pain were reported.

Results

The mean operative time was 66 min (50–90 min). The mean follow-up period was 20.3±7.8 months, ranging from 12 to 40 months. In all but one of the 22 cases, the plates were removed after 3–6 months. One patient (60 years old active male) refused to remove the plate and missed follow-up after the third month and presented after 18 months with full function and excellent ROM, with only mild pain while working, and his plate was removed after 18 months from surgery (Fig. 4).

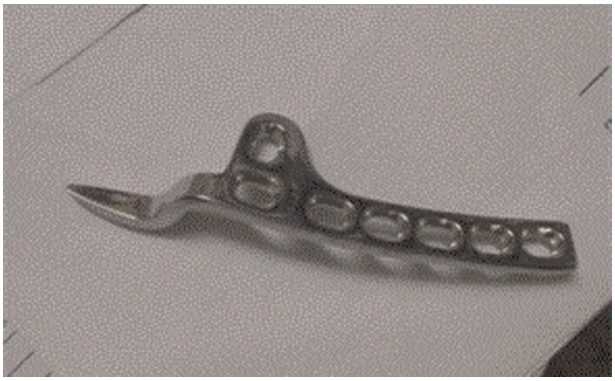
Regarding the range of motion at the end of follow-up, the mean postoperative forward flexion was 160.4 ±15.8°, ranging from 120 to 180°; the extension was 51±8.6°, ranging from 35 to 75°; the internal rotation 58.1±11.7°, ranging from 35 to 85°; the external rotation

Figure 1



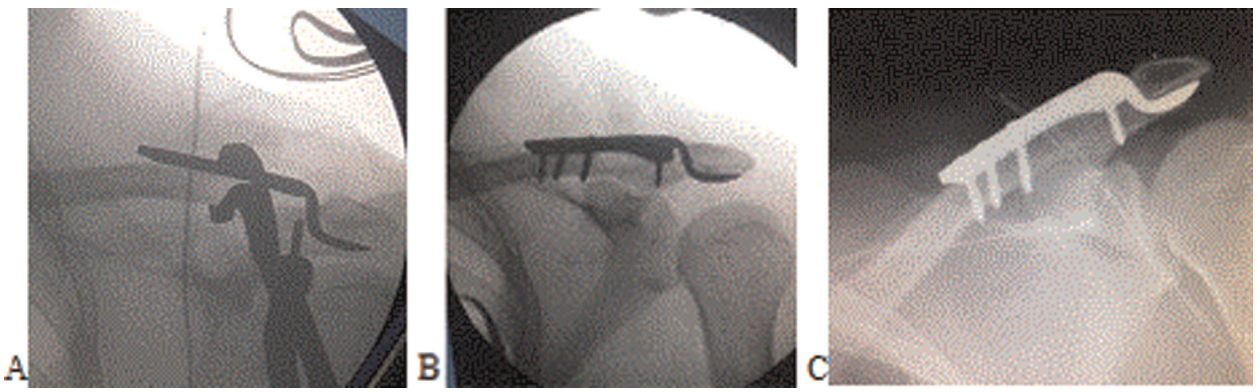
Ethibond sutures passed through the clavicular holes (left shoulder).

Figure 2



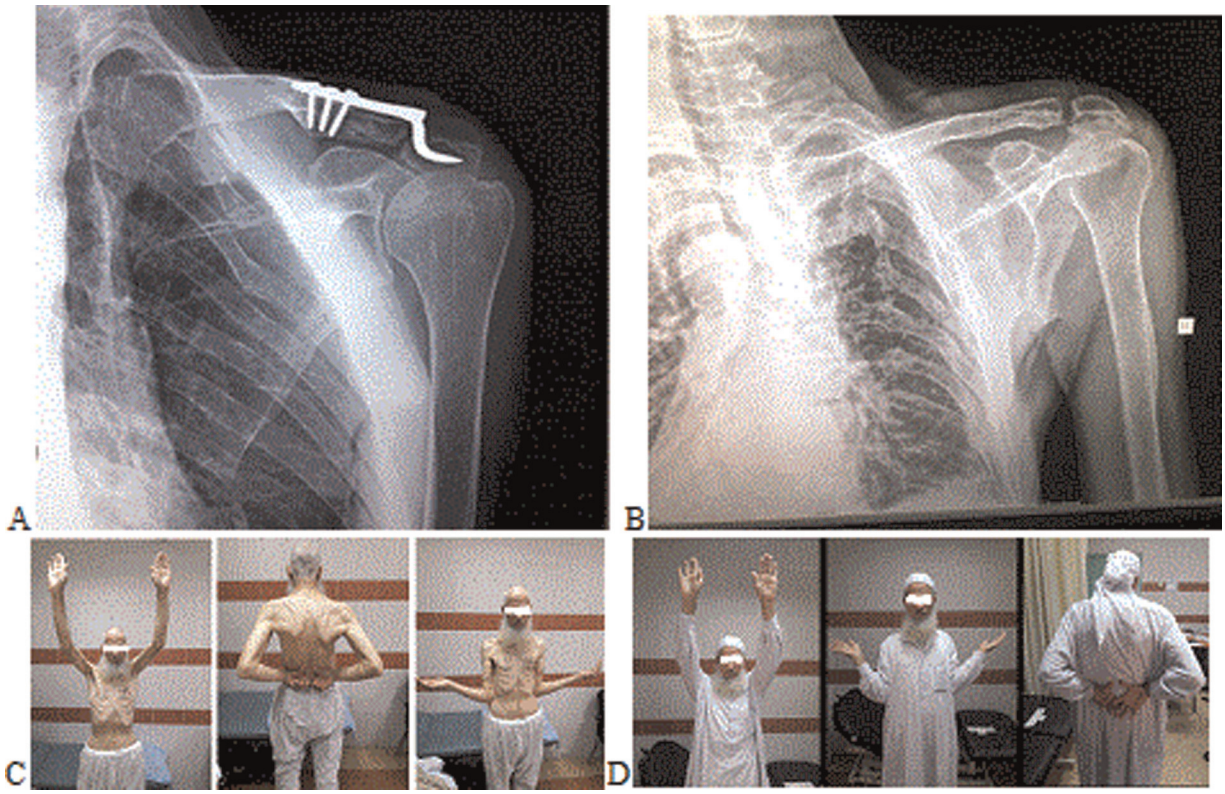
Hook plate (for left shoulder).

Figure 3



(a) Acromioclavicular joint reduction was done by pressing the medial part of the hook plate downward on the clavicle, and the hook acts as a lever and reduces the dislocated acromioclavicular joint. (b) The plate is fixed to the clavicle using cortical 3.5-mm screws and 4.0-mm cancellous screws. (c) Postoperative radiography.

Figure 4



A 60-year-old male patient with retained plate for 18 months. (a) Radiography after 18 months. (b) After plate removal. (c) ROM before removal. (d) Final ROM after plate removal.

was 68.1±12.7°, ranging from 45 to 85°; and the abduction was 160.4±18.3°, ranging from 120 to 180°.

The mean postoperative constant score was 94±5.1, ranging from 80 to 100. The mean DASH score was 8.7±4.8, ranging from 0 to 20. The mean pain VAS score was 1.2±1, ranging from 0 to 4 (Fig. 5).

No complications occurred in the current study, although one case developed a 1-cm widening of the AC distance after 12 months, which is not increased after this, and the patient was clinically free (Fig. 6). Two cases developed radiologic arthritic changes in the distal clavicle but without clinical complaint. No patient developed wound infection, redislocation, AC ligament ossification, or acromion osteolysis over the hook even in the only case of retained plate for 18 months.

Discussion

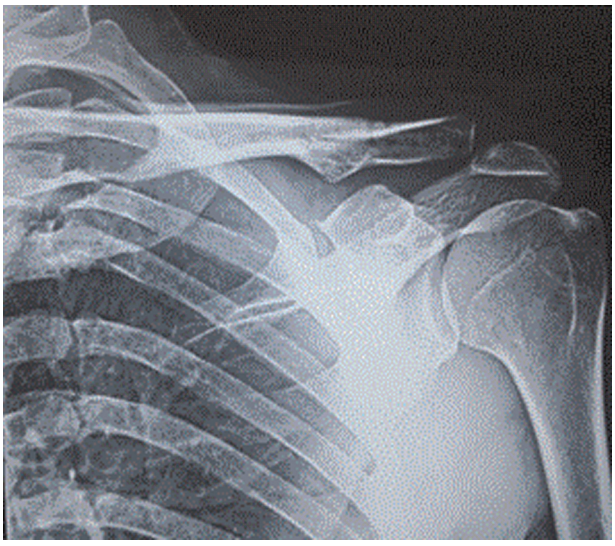
The ACJ is the articulation that connects the clavicle to the scapula. It is the pivot point between the clavicle, which is anchored as a strut to the sternoclavicular joint, and the scapula, which have a complex motion that is still not completely understood. This fact is what makes the treatment of ACJ injury confusing. Acromioclavicular dislocations are more common in men than in women (ratio 5 : 1), and these dislocations are more often incomplete than complete (2 : 1). The design and anatomy of the ACJ make it a resilient joint that can resist a significant amount of force before disrupting [20].

Rockwood's classification of AC dislocation is based on the degree and direction of clavicular displacement. It is now clear that grades I and II are the best managed conservatively [18]. There is a general agreement that types IV, V, and VI lesions should be treated operatively. However, controversy remains over the optimal management for grade III [21]. In 2011, Smith *et al.* [22] performed an evidence-based meta-analysis study over operative versus nonoperative management following Rockwood grade III AC separation. The primary functional outcome was the Constant score, which was significantly better following operative compared with nonoperative management. However, this is based on the complete data from one study [23]. The findings of this study indicated that operative management results in a better cosmetic outcome but with greater duration of sick leave compared with nonoperative management. There was no difference in pain, strength, loss of anatomical reduction, ossification of the CC or acromioclavicular ligaments, and incidence

Figure 5

A 28-year-old male patient with right acromioclavicular joint dislocation. (a) Preoperative radiography. (b) Postoperative radiography. (c) After plate removal. (d) and (E) Final ROM.

Figure 6



Mild widening of the acromioclavicular distance after 12 months in one patient.

of AC joint osteoarthritis compared with nonoperative management. However, Gstettner *et al.* [23] have shown that as the operative techniques improve regarding maintenance of reduction, the operative group having a statistically better outcome than the nonoperative group, which may be a shift from the old poor results of K-wire fixation.

Historically, surgical management of complete ACJ injuries includes open reduction, direct repair of the ACJ capsule, and rigid internal fixation of the ACJ, which carry high rates of residual pain, redislocation, and progression of arthritis in the acromioclavicular joint. Weaver and Dunn initially described their classic technique, which included transferring the coracoacromial ligament from the acromion to the clavicle, with resecting of the distal portion of the clavicle without internal fixation [24]. Since their initial study, a lot of surgical techniques for the management of ACJ injuries have been reported, with also multiple surgical modifications to the original operation [2].

It is difficult to state a superiority of a particular repair and reconstruction technique. More than 70 different surgical procedures have been described for the treatment of acute ACJ separations, including four main surgical treatment principles: first, primary ACJ fixation (with pins, screws, suture wires, plates, hook plates) with or without ligament repair or reconstruction; second, primary CC interval fixation (with Bosworth screw, wire, fascia, conjoint tendon, or synthetic sutures) with or without incorporation of AC ligament repair/reconstruction; third, distal clavicle excision with or without CC ligament repair with

fascia or suture, or coracoacromial ligament transfer; and fourth, dynamic muscle transfers with or without excision of the distal clavicle. The variety of techniques described illustrates the fact that the ideal method to treat symptomatic ACJ dislocation remains to be found [25].

In 2009, Leidel and colleagues published their retrospective comparative study on the temporary K-wire fixation with CC ligament direct repair versus PDS sling augmentation of Rockwood grade III ACJ separations. A total of 86 patients were included, with a mean follow-up of 3 years. In the K-wire group, the mean constant score was 87.8 versus 73.0 points in PDS group. The K-wire group had also significantly less pain, with low VAS pain scale in both groups, ranging on average between 0.5 and 1.9. Three patients experienced pin migration in the K-wire group, and there were seven patients complaining of clinical loss of ACJ reduction in the PDS group [26].

There has been increased use of arthroscopically assisted or all arthroscopic reconstruction of the CC ligament with graft or synthetic material [10]. The main advantage is to minimize soft tissue dissection, evaluate and treat concomitant intra-articular shoulder pathology, reduce skin or wound complications, and facilitate rehabilitation and earlier return to work or sports activities. However, the disadvantage may be increased surgical costs and the technical difficulty that are associated with arthroscopic reconstructive techniques [27–29].

The main principle of hook plate fixation of acute displaced ACJ dislocation is to maintain the indirect reduction of ACJ till healing of the CC ligaments and scarring of the CC interspace while permitting some rotatory motion between the clavicle and acromion. It is a not a new implant. Several studies evaluated the functional outcome after using multiple plate designs and names over the past 3 decades (Balser's hook plate [30], Wolter hook plate [31,32], Crook plate [33], Clavicle hook plate [34], AC hook plate with bent hook [35,36], AO hook plate [19], angular-stable locked hook plate [1]).

Most of these studies used the hook plate alone for the reduction of the AC joint until healing of the CC ligament occurs with scarring without direct CC ligament repair or augmentation. However, many complications appeared like fracture of the acromion [37], broken hooks [35,36], and medial clavicle fracture [38]. The most frequent complication was osteolysis of the under surface of the acromion. Eschler *et al.* [1] reported acromial osteolysis in nearly 20% of cases. Therefore, early plate removal (8–12 weeks) is recommended by many authors. However, the incidence of redislocations and subluxation after plate removal was still significant [35]. To prevent secondary loss of reduction, some authors such as De Baets *et al.* [34] do not recommend routine implant removal at all.

In this study, we tried to evaluate the result of CC ligaments repair plus CC sling augmentation with the use of AO hook plate as a force-neutralizing device till the healing of CC ligaments occurs. We believe that most of the complications associated with hook plate fixation were related to too much stress applied over the plate and the hook during shoulder motion. These stresses were diminished in this study by CC ligament repair and CC sling augmentation. Moreover, the reverse is true; the forces over the repaired CC ligaments were neutralized by the hook plate till complete ligament healing and CC interspace soft tissue scarring, which decreased the incidence of plate-related complications.

Faraj and Ketzer in 2001 performed a study over 10 patients: seven patients with AC joint dislocation and treated with Weaver–Dunn procedure combined with hook plate fixation to protect the repair, and three patients have been treated by hook plate fixation for lateral clavicular fracture, with a mean follow-up of 11 months (6–25 months). All these patients reported a satisfactory result. He had no cases of impingement syndrome, and he concluded that the combination of a Weaver–Dunn procedure with hook plate fixation has the advantage of protecting the ligament reconstruction without increased risk of subacromial impingement, and the routine removal of this plate is not necessary. When used for distal clavicular fracture, the ACJ is not disturbed. Once the fracture healed, they believe that it is not mandatory to remove the plate [40].

In 2004, De Baets and colleagues published their results over 12 patients with grade III AC joint dislocation treated by AC hook plate without CC ligaments repair. The average follow-up was 20 months (range 9–36 months). The mean Constant score was 91.3 (79–99). One patient noted a more hairy skin around the scar and two patients noted hypoesthesia. Three patients had a hump on the ACJ. Three had superficial wound infection. Degenerative changes in the ACJ were present in all 12 patients but without clinical complaint. Two patients had major AC ligament ossification. No patient had bone resorption due to the plate. Eight patients showed an increased distance between clavicle

and coracoid on the operated side compared with the contralateral side. The authors concluded that the discrepancy between radiographic and clinical results makes one wonder if the good early clinical results will not deteriorate over time [34].

Koukakis and colleagues in 2008 performed a study over 16 patients with grade III–V dislocation of the ACJ treated with hook plate fixation without ligament repair or reconstruction. The plate was removed after 8–12 weeks. The mean final Constant score was 96.4 (78–100). The VAS scale for pain was an average of 0.87 (0–6). Persistent instability after plate removal was present in one case, another case developed acromial osteolysis, and a third case had postoperative persistent clicking sensation. The last two cases improved after plate removal [19].

In 2011, Kienast and colleagues did a retrospective multicenter study over 225 patients with complete ACJ separations Rockwood III–V treated with AC hook plate without ligament repair or reconstruction within a mean follow-up period of 36 months (10–71 months). Removal of metalwork was done after 12 weeks. The postoperative VAS pain scale score was rated 2.7 [1–5]. The constant score showed an average of 92.4. They found signs of posttraumatic arthritis in the follow-up radiographs of 32 patients (14%). The other complications were seen in 24 patients (10.6%): one fracture of the acromion, six superficial soft tissue infections, seven redislocations after removal of the plate, four broken hooks, two cases of lateral clavicle bone infection, and four seromas [35].

In 2012, Eschler and colleagues did a comparative study over 27 patients treated by hook plate fixation and 25 patients by PDS augmentation for grade V ACJ injury. Both the techniques proved to be effective procedures for treatment of ACJ dislocations with a trend to better anatomical reduction after hook plate fixation. Obvious drawbacks of hook plate are the need of secondary implant removal and a higher rate of acromial osteolysis (18.5%). The functional outcome was comparable between both treatment principles regarding Constant, VAS, and DASH scores. The mean Constant score was 91.2 in the hook plate group and 94.6 in the PDS group. The mean DASH score was 3.4 in PDS group and 8.0 in HP group. Pain, as rated by the VAS scale, in HP patients was on an average of 0.77 and in PDS group was 0.80 [1].

In this study, the functional outcome was excellent. The mean postoperative forward flexion was 160.4 ±15.8°, the extension was 51±8.6°, the internal rotation was 58.1±11.7°, the external rotation was 68.1±12.7°, and the abduction was 160.4±18.3°. The mean postoperative Constant score was 94±5.1. The mean DASH score was 8.7±4.8. The mean pain VAS score was 1.2±1, ranging from 0 to 4.

No major complications occurred in the current study, although one case developed mild widening of the AC distance after 12 months. Two cases developed radiologic arthritic changes in the distal clavicle but without clinical complaint, which was in line with the data reported by Kienast *et al*. [35], Greiner *et al*. [39], Folwaczny *et al*. [41], and Pfahler *et al*. [42] that osseous arthritic changes of the acromioclavicular joint rarely contribute to lower clinical results. No patient developed wound infection, redislocation, AC ligament ossification, or acromion osteolysis.

Complications related to plate retaining for a long time are described by many authors. Acromion osteolysis over the hook and fracture are the most plate-retaining-related complications. In this study, these complications did not happen, although in one patient, the plate retained for 18 months.

Some authors consider that the plate could limit the mobility and rotation between clavicle and acromion which create some bone resorption of the acromion. Therefore, the hook plate is supposed by many studies to be removed after 3 months when the ligaments are supposed to be healed. May be the removal of the plate can be postponed and a more rapid shoulder mobilization can be started without problems, which was the case in the patient with retained plate. This can indicate that the plate does not abolish rotation between clavicle and acromion, which is supported by two studies [34,43]. Nevertheless, we find that implant removal, in general, is recommendable after 3–6 months.

This study result was better when compared with previous literature (Tables 1 and 2) using the hook plate alone with much lower complications rate and the better functional outcome according to the ROM, Constant, and DASH scores. Our result was also comparable to the short-term and mid-term results of arthroscopically and arthroscopically assisted techniques for reconstruction of the CC ligament [10,27–29] which have the disadvantage of increased surgical costs and the technical difficulty, whereas hook plate and Ethibond suture are available with low cost, and the surgical technique is more simple than arthroscopic techniques, which needs special training, instrumentation, and equipment not available in many centers, especially in developing countries.

Table 1 Functional outcome of different studies with different surgical techniques

	Surgical technique	Constant score	VAS score	DASH score
Leidel *et al. et al.* [26]	K-wire group	87.2	0.5	NA
Leidel *et al. et al.* [26]	PDS sling group	73.0	1.9	NA
Koukakis *et al. et al.* [19]	Hook plate	96.4	0.87	NA
De Baets *et al. et al.* [34]	Hook plate	91.3	NA	NA
Kienast *et al. et al.* [35]	Hook plate	92.4	2.7	NA
Eschler *et al. et al.* [1]	Hook plate group	91.2	0.77	8
Eschler *et al. et al.* [1]	PDS augmentation group	94.6	0.80	3.4
Chernchujit *et al. et al.* [44]	Arthroscopic reconstruction	95	NA	NA
This study	Hook plate	94	1.2	8.7

DASH, disabilities of the arm, shoulder and hand; PDS, adsorbable biological suture; NA, not available in the study; VAS, visual analog scale.

Table 2 Complications of the current study compared with other studies

	Surgical technique	Cases	Complications
Leidel *et al.* [26]	K-wire group	70	3 pin migration
Leidel *et al.* [26]	PDS sling group	16	7 loss of reduction
Koukakis *et al.* [19]	Hook plate	16	1 acromion osteolysis
			1 persistent click
			1 recurrent instability
De Baets *et al.* [34]	Hook plate	12	3 superficial infection
			2 AC ossification
			3 persistent hump
Kienast *et al.* [35]	Hook plate	225	1 fracture acromion
			6 superficial infection
			7 redislocation after removal
			4 broken hook
			4 seromas
			2 lateral end clavicle infection
Eschler *et al.* [1]	Hook plate group	27	5 acromion osteolysis
			2 redislocation
			2 superficial infection
Eschler *et al.* [1]	PDS augmentation group	25	3 redislocation
			1 superficial infection
Chernchujit *et al.* [44]	Arthroscopic reconstruction	13	1 recurrent deformity (new trauma)
			1 limited shoulder ROM
			3 mild loss of reduction
This study	Hook plate	22	1 cm AC widening in one case

AC, acromioclavicular; PDS, adsorbable biological suture; ROM, range of motion.

The limitation of the study was the relatively small number of patients (22 patients) and the lack of direct comparison with another group of patients treated with a different surgical technique. Moreover, there was a discrepancy between clinical and radiographic results regarding the presence of asymptomatic AC joint arthritis in some cases. Long-term follow-up study is recommended to document that good mid-term clinical results will not deteriorate over time.

Conclusion

The use of hook plate is a good choice for stabilization of acute AC joint dislocation. When combined with CC ligament repair and augmentation, the complication rates were decreased, and the functional outcome was excellent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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