Hook plate fixation with coracoclavicular ligaments repair and augmentation for management of acute acromioclavicular joint dislocation
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Abstract
Background: several surgical techniques and implants have been proposed for treatment of acute acromioclavicular joint (ACJ) dislocation. The purpose of the study was to assess the results of hook plate fixation combined with coracoclavicular ligaments repair and augmentation for management of acute acromioclavicular joint dislocation.

Patients and Methods: Between March 2011 and October 2014, 22 patients (15 male and 7 female) with acute acromioclavicular joint (ACJ) dislocation were treated with open reduction and hook plate fixation with coracoclavicular (CC) ligaments repair and augmentation at Benha University Hospital. The inclusion criteria included patients with isolated acute acromioclavicular joint dislocation grade III-V according to Rockwood classification. Exclusion criteria were neglected cases >4 weeks, chronic dislocations, open dislocation and fracture dislocation of the ACJ. The average age of the patients was 31.8 years (+9.7 years) ranging from 18 years to 60 years. The right side was affected in 14 patients and the left in 8 patients. Functional outcomes were assessed according to ROM and the Constant-Murley scoring system, DASH Score, and Visual Analogue Scale (VAS) Score for pain.

Results: The mean operative time was 66 minutes (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°), external rotation was 68.1° (±12.7°) and abduction was 60.4° (±18.3°). The mean Constant Score was 94 (±5.1). The mean DASH Score was 8.7 (±4.8). The mean pain VAS Score was 1.2 (±1). No major complications occurred in the current study except one case 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 AC joint dislocation. When combined with coracoclavicular ligaments repair and augmentation, the complication rates was low with good functional outcome.

Keywords: AC joint, AC hook plate, Acromioclavicular dislocation, Clavicular hook plate · Acromial osteolysis, Rockwood.

Introduction
Acromioclavicular (AC) joint dislocations are common injuries in young athletes representing about 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 acromioclavicular (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 affecting mainly 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). According to Rockwood classification (6) (grades from I to VI), there is widespread agreement that non-operative treatment is recommended for grade I and II lesions, and surgical treatment is recommended for grade IV, V, 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 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, coracoclavicular screws and coracoclavicular fixation with natural or synthetic grafts and arthroscopic assisted reconstruction of CC ligaments. (9-19)

The aim of the current study was to evaluate the results of coracoclavicular 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.

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**Patients and methods**

A prospective study, held between March 2011 and October 2014 at Benha University Hospital, included 22 patients (15 male and 7 female) with acute acromioclavicular joint (ACJ) dislocation. The inclusion criteria included patients with isolated acute acromioclavicular joint dislocation grade III-VI according to Rockwood classification. Exclusion criteria were physically inactive patients, open dislocation and fracture dislocation of the ACJ, neglected (>4 weeks) and chronic AC joint dislocations.

The mechanism of injury was sport related injuries in 10 patients, road traffic accidents in 7 patients and fall on an outstretched hand in 5 patients. The average age of the patients was 31.8 years (+_9.7 years) ranging from 18 years to 60 years (actually all patients from 18 to 43 years old with only one physically active patient 60 years old presented with grade V injury). The right side was affected in 14 patients and the left in 8 patients.

All Patients were evaluated clinically and radiologically preoperatively. Anteroposterior (AP) and lateral scapular views were obtained as a routine. 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. CT scan was obtained to diagnose grade IV, VI injury once suspected. According to Rockwood classification, 11 patients were grade III, 3 patients were grade IV, 8 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 AC joint towards the anterior border of the acromion process. The incision was carried down longitudinally through the subcutaneous tissues, the deltopectoral fascia was opened and the trapezius and deltoid muscle are dissected subperiosteally to expose the superior border of the clavicle and the AC joint and the meniscus was excised. In type V injury, the deltoid and trapezius muscle were already disrupted. Four holes were drilled at the distal end of the clavicle 2, 3, 4, 5 cm from AC joint, 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 2 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 2 medial clavicular holes (Fig. 1).

**Figure (1):** Ethibond sutures passed through the clavicular holes (left shoulder).

A tunnel 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 AC joint and its position is checked under image intensifier, 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 cortical 3.5 mm screw and (Fig.3B). After the reduction was ensured by the image intensifier, the 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, arm sling was applied.

**Figure (2):** Hook Plate (for left shoulder).

**Figure (3):** (A) AC joints reduction was done by pressing the medial part of the hook plate downward on the clavicle 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 screw and 4.0 mm cancellous screws (C) postoperative X-ray

**Postoperative care**

The arm was immobilized in a sling. Passive 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 (CMS), DASH Score and Visual Analogue Scale Score (VAS) for pain were reported.

**Results**

The mean operative time was 66 minutes (50-90min). 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°, internal rotation 58.1° (±11.7°) ranging from 35° to 85°, external rotation was 68.1° (±12.7°) ranging from 45° to 85° and 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 zero to 20. The mean pain VAS Score was 1.2 (±1) ranging from zero to 4. (Fig. 5)

No complications occurred in the current study although one case developed a 1cm widening of the AC distance after 12 month which is not increased after this and patient was clinically free (Fig. 6). 2 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.

![Figure (4)](image)

**Figure (4):** male patient 60 years old with retained plate for 18 months. (A) X-ray after 18 months. (B) After plate removal. (C) ROM before removal. (D) Final ROM after plate removal.
Figure (5): male patient 28 years old with right AC joint dislocation. (A) Preoperative X-ray. (B) Postoperative X-ray. (C) After plate removal. (D) and (E) final ROM.

Figure (6): mild widening of the AC distance after 12 months in one patient

Discussion

The acromioclavicular (AC) joint 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 AC joint 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 AC joint 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 best managed conservatively (18). There is a general agreement that type IV, V and VI lesions should be treated operatively. However, there is remaining controversy over the optimal management for grade III (21). In 2011, Smith et al (22) performed an evidence-based meta-analysis study over operative versus non-operative management following Rockwood grade III AC separation. The primary functional outcome was the Constant score which was a significantly better following operative compared to non-operative management. However, this is based on the complete data from one study.
The findings of this study indicated that operative management results in a better cosmetic outcome but with greater duration of sick leave compared to non-operative management. There was no difference in pain, strength, loss of anatomical reduction, ossification of the coracoclavicular or acromioclavicular ligaments, and incidence of AC joint osteoarthritis compared to non-operative management. While 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 non-operative group, which may be a shift from the old poor results of K-wires fixation. Historically, surgical management of complete AC joint injuries includes open reduction, direct repair of the AC joint capsule and rigid internal fixation of the AC joint 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 the distal portion of the clavicle without internal fixation (24). Since their initial study, a lot of surgical techniques for the management of AC joint 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 (AC) joint separations including 4 main surgical treatment principles: (1) primary ACJ fixation (with pins, screws, suture wires, plates, hook plates) with or without ligament repair or reconstruction; (2) primary coracoclavicular interval fixation (with Bosworth screw, wire, fascia, conjoint tendon, or synthetic sutures) with or without incorporation of AC ligament repair/reconstruction. (3) Distal clavicle excision with or without coracoclavicular ligament repair with fascia or suture, or coracoacromial ligament transfer; (4) 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 et al published their retrospective comparative study on the temporary K-wire fixation with CC ligaments direct repair versus PDS sling augmentation of Rockwood grade III AC joint separations. 86 patients were included with a mean follow-up of three 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 suffered pin migration in the K-wire group and there was 7 patients complaining clinical loss of AC joint reduction in the PDS group (26).

There has been increased use of arthroscopically assisted or all arthroscopic reconstruction of the coracoclavicular ligament with graft or synthetic material (27). The main advantages 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 with increased surgical costs and the technical difficulty that are associated with arthroscopic reconstructive techniques (28-30). The main principle of hook plate fixation of acute displaced AC joint dislocation is to maintain the indirect reduction of AC joint till healing of the CC ligaments and scarring of the coracoclavicular 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 last 3 decades (Balser’s hook plate (31), Wolter hook plate (32,33), Crook plate (34), Clavicle hook plate (35), AC hook-plate with bent hook (36,37), 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 ligaments repair or augmentation. However, many complications
appeared like fracture of the acromion (38), broken hooks (36,37), and medial clavicle fracture (39). The most frequent complication was osteolysis of the under surface of the acromion, Eschler et al reported acromial osteolysis in nearly 20% of cases (1). 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 (36). To prevent secondary loss of reduction, some authors as Faraj and Ketzer (41) and De Baets et al (35) do not recommend routine implant removal at all.

In the current 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 ligaments repair and CC sling augmentation. And the reverse is true; the forces over the repaired CC ligaments were neutralized by the hook plate till complete ligaments 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, 7 patients with AC joint dislocation and treated with Weaver-Dunn procedure combined with hook plate fixation to protect the repair. Three patients have been treated by hook plate fixation for lateral clavicular fracture with a mean follow-up of 11 months (6 to 25 months), all these patients were reporting 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 AC joint is not disturbed. Once the fracture healed, they believe that it is not mandatory to remove the plate. (40)

In 2004, De Baets et al 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 to 36 months). The mean Constant score was 91.3 (79-99). One patient noted a more hairy skin around the scar and 2 patients noted hypoesthesia. 3 patients had a hump on the AC joint. 3 superficial wound infection. Degenerative changes in the AC joint 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. 8 patients showed an increased distance between clavicle and coracoid on the operated side compared to 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 (35).

Koukakis et al in 2008 performed a study over 16 patients grade III-V dislocation of the AC joint treated with hook plate fixation without ligaments repair or reconstruction. Plate 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 2 cases improved after plate removal. (19)

In 2011 Kienast et al did a retrospective multicenter study over 225 patients with complete AC joint separations Rockwood III-V treated with AC-hook plate without ligaments 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 post traumatic arthritis in the follow-up radiographs of 32 patients (14%). The other complications were in 24 patients (10.6%), 1 fracture of the acromion, 6 superficial soft tissue infections and 7 redislocations after removal of the plate. 4 broken hooks, 2 cases of lateral clavicle bone infection and 4 seromas. (36)
In 2012, Eschler et al did a comparative study over 27 patients treated by hook plate fixation and 25 patients by PDS augmentation for grade (V) AC joint injury. Both the techniques proved to be effective procedures for treatment of AC-joint 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 average of 0.77 and in PDS group mean of 0.80. (1)

In the current study the functional outcome was excellent. The mean postoperative forward flexion was 160.4° (±15.8°), the extension was 51° (±8.6°), internal rotation 58.1° (±11.7°), external rotation was 68.1° (±12.7°) and 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 zero to 4.

No major complications occurred in the current study although one case developed mild widening of the AC distance after 12 month. 2 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 (36), Greiner et al (41), Folwaczny et al (42) and Pfahler et al (43) 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 the current 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 2 studies (35,44). Nevertheless, we find that implant removal, in general, is recommendable after 3-6 month. Current study result was better when compared to previous literature (table 1,2) 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 and mid-term results of arthroscopically and arthroscopically-assisted techniques for reconstruction of the coracoclavicular ligament (27-30) which have the disadvantage of increased surgical costs and the technical difficulty while hook plate and Ethibond suture are available with low cost and 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.

<table>
<thead>
<tr>
<th>Surgical technique</th>
<th>Constant score</th>
<th>VAS score</th>
<th>DASH score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leidel et al (26)</td>
<td>K wire group</td>
<td>87.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Leidel et al (26)</td>
<td>PDS sling group</td>
<td>73.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Koukakis et al (19)</td>
<td>Hook plate</td>
<td>96.4</td>
<td>0.87</td>
</tr>
<tr>
<td>De Baets et al (35)</td>
<td>Hook plate</td>
<td>91.3</td>
<td>N/A</td>
</tr>
<tr>
<td>Kienast et al (36)</td>
<td>Hook plate</td>
<td>92.4</td>
<td>2.7</td>
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<tr>
<td>Eschler et al (1)</td>
<td>Hook plate group</td>
<td>91.2</td>
<td>0.77</td>
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<tr>
<td>Eschler et al (1)</td>
<td>PDS augmentation group</td>
<td>94.6</td>
<td>0.80</td>
</tr>
<tr>
<td>Chernchujit et al (45)</td>
<td>Arthroscopic reconstruction</td>
<td>95</td>
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</tr>
<tr>
<td>Current study</td>
<td>Hook plate</td>
<td>94</td>
<td>1.2</td>
</tr>
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</table>

* N/A: not available in the study.

Table 2: Complications of the current study compared with other studies.

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<th>Complications</th>
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<td>70</td>
<td>3 pin migration</td>
</tr>
<tr>
<td>Leidel et al (26)</td>
<td>16</td>
<td>7 loss of reduction</td>
</tr>
<tr>
<td>Koukakis et al (19)</td>
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<td>16</td>
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<tr>
<td></td>
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<td>1 recurrent instability</td>
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<tr>
<td>De Baets et al (35)</td>
<td>Hook plate</td>
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<td>2 AC ossification</td>
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<tr>
<td></td>
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<td>3 persistent hump</td>
</tr>
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<td>Kienast et al (36)</td>
<td>Hook plate</td>
<td>225</td>
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<tr>
<td></td>
<td></td>
<td>6 superficial infection</td>
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<tr>
<td></td>
<td></td>
<td>7 redislocation after removal</td>
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<tr>
<td></td>
<td></td>
<td>4 broken hook</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>27</td>
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<tr>
<td></td>
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<td>2 redislocation</td>
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<tr>
<td>Current study</td>
<td>Hook plate</td>
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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. Also, there was a discrepancy between clinical and radiographic results regarding the presence of asymptomatic AC joint arthritic 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 ligaments repair and augmentation, the complication rates was decreased and the functional outcome was excellent.
References


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