Functional and radiological outcomes following management of Neer's type 2 unstable lateral clavicular fracture using the clavicular hook plate

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Purpose
The purpose of this study is to assess the clinical and radiological results following using clavicular hook plates (CHPs) for the management of Neer's type 2 unstable distal clavicular fractures (DCFs).
Methods
A total of 25 patients were treated with CHPs for DCFs. The American Shoulder and Elbow Surgeons (ASES) and the Constant and Murley scores were used to evaluate the shoulder functional outcomes at the end of at least 1-year after surgery. The radiological assessment involved bone union evaluation and comparison of preoperative and postoperative coracoclavicular distance.
Results
The mean Constant and Murley score was 90.28±3.66, while the mean ASES score was 92.44±4.91 at the end of at least 1-year follow-up. Bone union was established in all patients after a mean time interval of 2.42±0.57 months postoperative. The mean coracoclavicular distance showed significant improvement from 19.48±1.67 to 9.96±1.02 at 1-year follow-up. An overall complication rate of 48% was observed.
Conclusions
Successful functional and radiological outcomes are associated with using CHPs for the treatment of DCFs. However, the rate of complications with CHP was high.
Level of evidence
Level IV, Therapeutic study.

Keywords:
coracoclavicular distance, distal clavicle fractures, hook plate

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Introduction

Distal clavicle fractures (DCFs) account for 12-21% of all clavicular fractures [1]. Neer developed a classification for DCFs according to their position relative to the coracoclavicular (CC) ligaments to successfully classify and manage DCFS [2,3].

Neer type 2 DCFs are deemed unstable as a result of compromised CC ligaments and the powerful deforming forces acting on the fracture ends [4].

Operative management is favored for unstable Neer type 2 DCFs to achieve the proper fracture reduction needed for bone union and minimize the hazards linked to conservative treatment [5].

Surgical treatment aims to achieve stability of the distal clavicle, to avoid fracture nonunion, to permit early functional exercise, and to decrease complications [6]. Several operative options have been used for DCFs fixation including osteosynthesis with anatomically pre-contoured plates [7], clavicular hook plates (CHPs) [8,9], intramedullary screws, transient K-wire fixation [10], ligament bracing [11], and the conjunction of ligament bracing and plate osteosynthesis [12].

CHPs generate a stable lever that raises the acromion and depresses the fractured proximal clavicle maintaining fracture reduction while not hindering clavicular rotation [13,14]. CHPs have the advantage of achieving high union rates and satisfactory functional outcomes [13]. However, CHPs may lead to various complications including acromial osteolysis, peri-prosthetic fracture, shoulder stiffness, and subacromial impingement [15,16].

The present study aims to evaluate the functional and radiological results following the fixation of DCFs using CHPs.

Patients and methods

This is a prospective study done at Kasr Al Aini Hospital between October 2022 and June 2023. The research ethical Committee approved this study protocol [(Institutional Review Board (IRB) number: N-381-2023)]. All patients signed a consent before participating in the study. This study included 25 patients with DCFs who were treated with open reduction and internal fixation using CHPs.

The inclusion criteria were

(a) Acute Neer type 2 distal clavicle fractures less than 3 weeks from injury.
(b) Skeletally mature patients.

The exclusion criteria were

(a) Skeletally immature patients.
(b) Prior surgery to the ipsilateral shoulder joint.
(c) Pre-existing or associated injuries of the affected shoulder joint.

Functional and radiological assessment

The shoulder functional outcomes were assessed using the American Shoulder and Elbow Surgeons (ASES) and the Constant and Murley (CMS) scores and compared both preoperative and at 1-year follow-up. Preoperative and postoperative plain radiographs were done for radiological assessment (Figs 1,2). Radiological evaluation was done to assess bone union and coracoclavicular distance (CCD) both preoperative and at 1-year follow-up using plain radiographs. Measurement of the CCD was done from the upper aspect of the coracoid to the lower aspect of the clavicle. The minimum follow-up period for all patients was 1 year (range 12–14 months).

Statistical methods

Data were statistically described in terms of mean ± standard deviation (± SD), range, or frequencies (number of cases), and percentages when appropriate. Within-group comparison of numerical variables was done using a paired *t*-test. p value less than 0.05 was considered statistically significant. IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows was used for all statistical analyses.

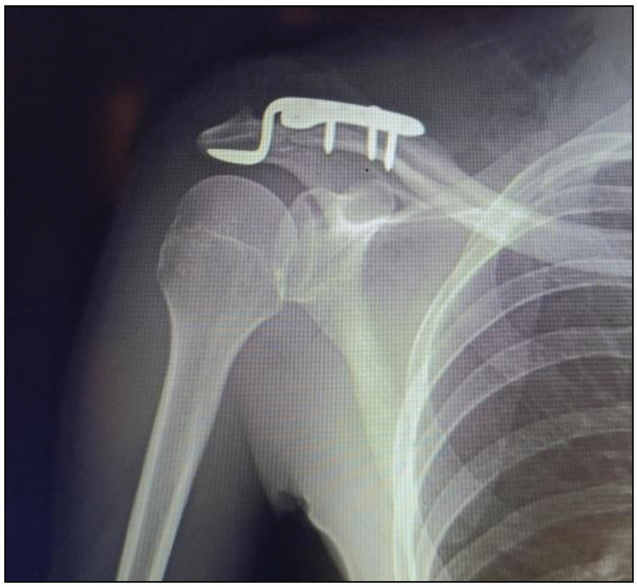
Operation procedures

General anesthesia was administered to all patients and all surgical steps were done in the beach chair position. A 6–8 cm straight horizontal skin incision was made over the distal clavicle across the acromioclavicular (AC) joint laterally. The deltoid-trapezoidal fascia was incised revealing the fracture site and both ends of the clavicle. Reduction of the clavicular fracture was done and temporarily fixed with two Kirschner wires under direct visualization. A small rent was done in the posterior aspect of the AC joint capsule to introduce the plate hook below the posterior aspect of the acromion. The appropriate plate length and hook depth were

Figure 1

Preoperative plain radiograph anteroposterior view of the right shoulder showing displaced Neer type 2 distal clavicular fracture and increased coracoclavicular distance.

Figure 2



Postoperative plain radiograph anteroposterior view of the right shoulder showing reduction of distal clavicular fracture using clavicular hook plate and normal coracoclavicular distance.

chosen and applied. The plate was contoured, if needed, to fit the clavicle ensuring proper fracture reduction. Acceptable fracture reduction and plate position were confirmed intraoperative under fluoroscopic guidance. Placement of 3.5 mm cortical screws was then done to fix the plate to the clavicle maintaining fracture reduction. Insertion of cortical screws was done into the distal clavicular fragment through the plate if the distal fragment was large enough to hold screws. Closure of the wound was done in layers.

Rehabilitation

All patients followed the same rehabilitation protocol after surgery. All patients were encouraged to start active range of motion (ROM) exercises to the elbow, wrist, and hand from day 1 after surgery. All patients were instructed to use an arm sling for 2 weeks postoperative. Pendulum exercises started 2 weeks following surgery. Active assisted ROM exercises started after radiographic evidence of bone union approximately 6-8 weeks postoperative. Active resisted ROM exercises were performed 12 weeks following surgery.

Results

The present study included 25 patients for whom CHPs were used for fixation of DCFs. The mean age of the patients at the time of surgery was 37.36 ± 9.87 years. There were 15 (60%) male, and 10 (40%) female patients. The right shoulder was injured in 16 (64%) patients, while the left shoulder was affected in nine (36%) patients. The mean time interval from injury to surgery was 5.8 ± 1.53 days. The mean follow-up period was 12.76 ± 0.83 months. Patients' demographic data are shown in (Table 1).

Table 1 Patients' demographic data

Age in years	37.36 ± 9.87 (18–52)
Sex, *n* (%)	
Male	15 (60)
Female	10 (40)
Affected shoulder joint, *n* (%)	
Right	16 (64)
Left	9 (36)
Follow-up period in months	12.76 ± 0.83 (12–14)
Time interval from injury to surgery in days	5.8 ± 1.53 (3–9)

Values are expressed in the form of mean±standard deviation (SD), range, number of patients, and their percentage within the group.

Table 2 Functional and radiological outcomes

	n=25	*P* value
1-year follow-up CMS	90.28 ± 3.66 (85–100)	
1-year follow-up ASES score	92.44 ± 4.91 (85–100)	
Preoperative CCD in mm	19.48 ± 1.67 (16–23.5)	<0.001
Postoperative CCD in mm	9.96 ± 1.02 (8.5–13)	
Time interval to achieve bone union in months	2.42 ± 0.57 (2–4)	
Time interval for plate removal in months	4.36 ± 1.04 (3–7)	

ASES, American Shoulder and Elbow Surgeons. Values are expressed in the form of mean±standard deviation (SD), and range; CMS, Constant and Murley score; n, number of patients.

Functional and radiological outcomes

The mean CMS was 90.28 ± 3.66, while the mean ASES score was 92.44 ± 4.91 at 1-year follow-up. Bone union was obtained in all patients. The mean time interval to achieve bone was 2.42 ± 0.57 months (range: 2–4). The mean CCD showed significant improvement from 19.48 ± 1.67 (range:16–23.5) preoperative to 9.96 ± 1.02 (range: 8.5–13) at the final follow-up (*P* value <0.001). Plate removal was done in all patients after a mean time interval of 4.36 ± 1.04 months postoperative (Table 2).

Complications

Several complications have been encountered in this study with a 48% overall rate of complications. Acromial osteolysis was observed in seven (28%) patients. Subacromial impingement was reported in three (12%) patients confirmed clinically by a positive Neer's impingement sign. Patients with subacromial impingement were treated conservatively with the resolution of symptoms and signs after CHP removal. One (4%) patient had a superficial wound infection after surgery and was treated successfully by repeated dressing and antibiotics with resolution of infection. One (4%) patient had postoperative stiffness and was treated with manipulation under general anesthesia during plate removal and regained acceptable shoulder range of motion.

Discussion

DCFs with associated CC ligament injury are essentially unstable fractures that need operative fixation to achieve bone union and avoid the unsatisfactory clinical outcomes that are linked to conservative treatment [17].

The principal finding of our study is that CHPs provided successful clinical outcomes with fracture consolidation achieved in all patients with DCFs. However various complications were observed in 12 (48%) patients. The mean CMS in our study was 90.28 ± 3.66 at 1-year follow-up. This was in line with various studies in literature [18,19]. A study by Teimouri *et al.* [18] documented that the mean CMS was 92 ± 5.3 6 months after using CHPs for the treatment of DCF, with no significant differences between CHP and T plate groups for fixation of DCFs regarding CMS. Zhang *et al.* [19] documented a mean CMS of 93.3 of 30 patients treated with CHPs

for fixation of DCFs, after a mean follow-up of 27.2 months, with no significant difference between locking plate and CHP groups in terms of CMS or bone union rate.

In our study, acromial osteolysis was observed in seven (28%) patients which is in line with a study published by Chen *et al.* [20] including 33 patients who reported that the prevalence rate of acromial osteolysis was 30.3% following using CHP for treatment of AC joint dislocation. Nevertheless, a prospective study by Lin *et al.* [21] mentioned that acromial erosion was encountered in 20 (50%) patients out of 40 patients who were treated with CHP for either DCF or AC joint dislocation.

Studies in the literature mentioned that acromial osteolysis was attributed to the compact proximity of the hook part with the undersurface of the acromion and that using a small hook depth was a contributing factor to the occurrence of acromial osteolysis [9,22].

A study by El Maraghy *et al.* [23] reported that the existence of geometric discrepancy between the hook part of CHP and the undersurface of the acromion is a presumed factor for the occurrence of complications after using CHPs.

In our study, subacromial impingement was observed in three (12%) patients, however, Lin *et al.* [21] reported a 37.5% rate of occurrence of subacromial impingement following using CHPs for treatment of DCFs and AC joint dislocation.

Subacromial impingement may be related to positioning the plate hook in the subacromial space narrowing the subacromial area. In addition, the plate hook also hinders the sagittal rotation of the AC joint and prevents the acromial posterior tilt leading to diminished internal rotation of the lateral clavicle [24]. Furthermore, the variable shape of the acromion and subacromial space in each patient and the resultant incongruency with CHP may lead to subacromial and rotator cuff pathologies [21,23].

In our study, CHP removal was done in all patients after a mean period of 4.36 months and this coincided with other studies in the literature [24,25]. Erdle *et al.* [25] advocated CHP removal in all patients and reported CHP removal after a mean period of 4.7 months, while another study by Ochen *et al.* [26] documented CHP removal in all patients after a mean period of 4.3 months who underwent management of DCFs using CHPs.

In our study, nonunion was not observed in any patient and all patients achieved bone union after a mean period of 2.42 months. This is in line with a study by Teimouri *et al.* [18] who documented bone union after a mean time interval of 2.3 ± 1.6 months in all of the 30 patients who underwent treatment of DCFs using CHPs. In addition, another study by Fahmy *et al.* [27] documented achieving bone union in 17 patients who were treated using CHPs for DCFs after a mean period of 10.1 ± 1.3 weeks.

Limitations

The main limitations of this study are the relatively short follow-up after surgery and the lack of comparison with different methods of treatment for DCFs.

Conclusion

A CHP is an effective method for the treatment of unstable DCFs with successful functional and radiological outcomes. However, the average incidence of complications linked to using CHPs for the management of DCFs was high.

Author contributions

The author contributed to the study's conception and design. Material preparation, data collection, analysis, and manuscript writing were performed by M.H.K.

Ethics approval

Approval was granted by the Ethics Committee of Cairo University (Institutional Review Board (IRB) number N-381-2023).

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Consent to publish

Patients signed informed consent regarding publishing their data and photographs.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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