

Clinical and radiological results on the fixation of Neer type 2 distal clavicle fractures with a hook plate



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ABSTRACT

Objective: The aim of this study was to analyze the clinical and functional results of hook plate fixation in Neer type 2 distal clavicle fractures.

Methods: We retrospectively analyzed 16 patients (11 males, 5 females) who were diagnosed with Neer type 2 distal clavicle fractures and treated with hook plate fixation between 2013 and 2014. Mean age was 38 (range: 27–61), and mean follow-up time was 14.3 (range: 12–18) months. Complications seen on radiographs were implant failure and subacromial osteolysis. The clinical results were evaluated with modified UCLA (University of California Los Angeles) scoring system.

Results: Bone union was achieved in all patients at the end of the first 4 months. Mean modified UCLA score was 32.75 (range 31–35). In 12 patients (68%), the implants had to be removed due to complications. After removal, the complaints regressed and shoulders' range of motion increased.

Conclusion: Clinical and radiological results on the fixation of Neer type 2 distal clavicle fractures with a hook plate are good in terms of fracture union and function. The major disadvantage of the method was the requirement of early implant removal due to the hardware related complications and good results can be achieved only after plate removal. Optimizing the length of hook plate may lower the rate of complications.

Level of evidence: Level IV, Therapeutic study.

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Introduction

Neer type 2 distal clavicle fractures are more likely to displace as the coraco-clavicular ligaments are ruptured.¹ The proximal fragment is displaced superiorly and posteriorly due to the weight of the upper extremity and detachment of the coraco-clavicular ligaments from the clavicle. Therefore, Neer type 2 fractures are accepted as unstable.¹ Surgical treatment appears to have become the standard therapy as it increases the union rates and the shoulder functions.^{1–4} The presence of a wide variety of methods indicate that there is still no agreement as the optimal method of fixation to use. All fixation methods have superiorities or deficiencies when compared to each other and none of them has been nominated as the 'gold standard'.^{5–23}

In the last decade, the clavicular hook plate has been used extensively in the treatment of displaced lateral clavicle

fractures.^{6,7,9–13,15,16,19,20,23} Although this plate achieved a high percentage of union, implant-related complications such as acromial osteolysis and peri-implant fracture are well recognized by the orthopaedic surgeons and many of them have advised against prolonged retaining of the implants.^{6–13,15,16,19,20,24–27} However shortening the time of hook plate fixation may lead to incomplete healing of the fracture site or ligaments. Recent biomechanical studies are focused on the shape and length of the plate to reduce the aforementioned complications.^{27–29} But to the best of our knowledge, the novel findings of these studies are not verified in clinical practice. Thus, we retrospectively analyzed our clinical and radiological results in the light of the novel literature and based on the high rate of our early implant-related complications we aimed to highlight the importance of selecting suitable clavicle hook plate implants for the fixation of Neer type 2 distal clavicle fractures.

Materials and method

Sixteen patients (11 males and 5 females) with Neer type 2 distal clavicle fractures, who underwent open reduction and hook plate

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(TST IND, Istanbul, Turkey) fixation between 2013 and 2014 were retrospectively studied. Titanium hook plates consisted of three types with 4, 6 and 8 holes. We used hook plates with 4 holes, 6 holes and 8 holes in 2, 11 and 3 patients, respectively. All operations were performed in the first 4 days after the trauma. Mean age was 38 (range: 27–61) and mean follow up was 14.3 (range: 12–18) months. Active motion exercises of the elbow, wrist, and hand were begun immediately after the operation, and circular shoulder movements were begun 1 week after surgery. The shoulder was protected with a sling only outside for rest. Patients' daily activities were not restricted during this period. The arm sling was removed after the 6th week and movements over 90° were allowed. After radiological fusion was observed, forceful movements were allowed. The patients were evaluated with physical examination on postoperative weeks of 2, 6, 12, and 16; and with both radiologic studies and physical examination on the postoperative months of 3, 4, and 12. In radiologic evaluation, the presence of a bridging callus in at least 3 cortices or the disappearance of the fracture line was accepted as union. Complications noted on radiology, including implant failure, acromial osteolysis, and acromioclavicular (AC) joint arthrosis were also recorded. The clinical results were assessed with modified UCLA (University of California Los Angeles) scoring system.¹¹

Results

There were no intraoperative complications. Radiographs showed union on the 3rd postoperative month in 13 patients, and on the 4th month in 3 patients. Three patients developed

superficial skin infections after the operation, and they healed uneventfully with wound care. Radiological evaluation revealed a radiolucent area, located where the hook part touched the acromion, in 4 patients on the 3rd month, and in 6 patients on the 4th month. This was accepted as acromial osteolysis (Fig. 1). The plates were removed in all these 10 patients (62%) within the following month. One patient had a plate fracture on the 6th month (Fig. 2). During the plate removal, sufficient union was seen, therefore an additional procedure was not found to be necessary. Seven patients (42%) developed symptoms of subacromial impingement syndrome (SIS) after an average period of 2.5 months. Diagnosis was confirmed with a positive Neer test. Mean modified UCLA score at the final follow up was 32.75 (range 31–35). Twelve patients (68%) underwent plate removal due to acromial osteolysis, impingement syndrome and implant failure. After removal, the complaints regressed and shoulders' range of motion increased. At the final follow up; mean modified UCLA score was 32.75 (range 31–35). There were no acromioclavicular joint arthrosis in the patients (Table 1).

Discussion

Hook plates provide a good union rate and enables early motion and rehabilitation in the surgical treatment of unstable distal clavicle fractures. Satisfactory good clinical results require early plate removal after the union is achieved because complications which are associated with the hardware are not rare. Subacromial osteolysis and implant failure are the most significant common complications. Various incidence rate of osteolysis was given in the

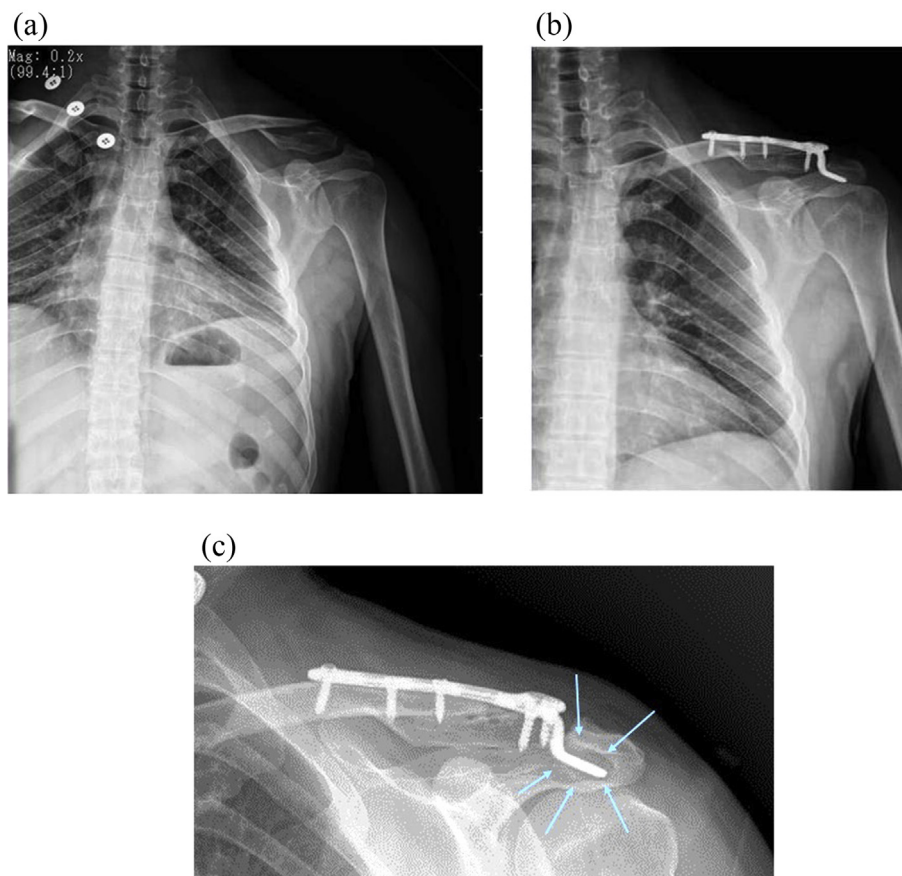


Fig. 1. (a) Anteroposterior radiograph of the right shoulder of a 33-year-old man who sustained a Neer type 2 distal clavicle fracture. (b) Early postoperative radiograph of the internal fixation using a hook plate with six holes. (c) Bony union was achieved after 12 weeks but the radiograph shows the subacromial osteolysis (blue arrows) around the tip of the hook of the same patient before implant removal (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

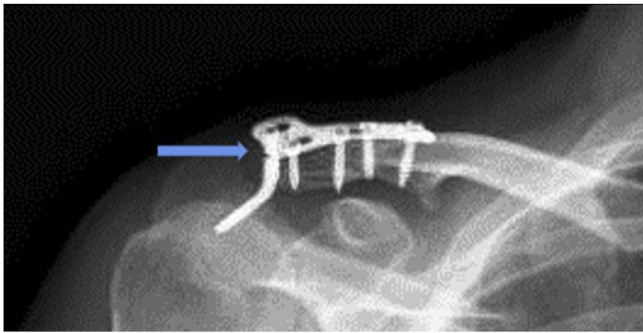


Fig. 2. Anteroposterior radiograph of a fully united Neer type 2 distal clavicle fracture with a four-hole hook plate failure (blue arrow) after 6 months which required implant removal (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

literature. The average incidence rate (62%) of osteolysis in our study was high when compared to the other studies. In the study of Lin et al²⁴ 50% of the patients demonstrated acromial erosion and the average incidence rate of osteolysis was 30.3 in the study of Chen et al.²⁶ According to them the only solution was to remove the implant after bony union and ligamentous healing. The average time when osteolysis was observed after the operation was 6 months in the study of Prasad et al,¹⁶ and 3 months in the study of Maramatsu et al.¹⁰ We observed a radiolucent area on the under-surface of the acromion in 10 patients (62%) after an average period of 3.6 months and removed the plates after the radiological confirmation of bone union. After the plate removal, the osteolysis disappeared on follow-up radiographs.

The optimal time to remove the hook plate still remains controversial.^{7,8,10–13,16,20,23,24,26} Physical examination and conventional radiographic modalities are not very specific to diagnose the accurate ligamentous healing. Thus, studies focus on the question of 'how to optimize the design of hook plate and what is the optimal time to remove the hook plate in order to decrease the incidence of acromial osteolysis.'^{27–29} The results of the biomechanical study of Shih et al²⁸ indicated that using a longer clavicle hook plate with more holes decreased the stress value in the clavicle and mitigated the force that clavicle hook plates exert on the acromion. Applying a longer hook plate can reduce the likelihood of developing acromial osteolysis. In our study we observed

the acromial osteolysis in hook plates with 4 or 6 holes but not in 3 hook plates with 8 holes. The findings of our study can serve as a clinical verification for the results of this biomechanical study. The implant breakage in one patient with four holes may also be explained by the same hypothesis that stress value impressed on the hook was more to cause an implant failure. It may also be associated with the micro-movement in acromioclavicular joint and biomechanical incapacity of a short plate. The radiographs of the patients were routinely evaluated on the postoperative months of 3, 4, and 12 months. The plate of this patient may have occurred before and realized by us on the 6th month graphies which were taken on the request of the patient. Another important issue is the subacromial morphometric assessment of the clavicle hook plate. ElMaraghy et al²⁷ demonstrated a high degree of variability in the positioning of the subacromial hook in their study. The uniqueness of each patient's anatomy and its impact on appropriateness for clavicle hook plate fixation should be considered in each case to reduce the implant-related complications.

Regarding the higher rate of early major complications like acromial osteolysis, implant failure and refracture, surgical fixation of Neer type 2 clavicle fractures with a hook plate is controversial.^{7,8,11,12,16,18–23} In a meta-analysis by Stegeman et al⁸ the hook plate and other fixation methods in the treatment of fractures were compared. There was no difference between the hook plate and other methods with respect to functional results and time to union. But the hook plate fixation was associated with an 11-fold increased risk of major complications compared to intramedullary fixation and a 24-fold increased risk compared to suture anchoring. Fleming et al¹⁸ reviewed 19 patients who underwent surgery with superior precountered locking plates for displaced distal-third clavicle fractures. All patients achieved union by 4 months and no plates have been removed. Wu et al⁶ compared hook plates and Kirschner tension band wiring for unstable lateral clavicle fractures and found equivalent rate of complications. Esenyel et al²² achieved painless osseous union in all patients with coracoclavicular screw in the treatment of Neer type 2 fractures of the distal clavicle. The results of our study for union rate and shoulder function was similar to the literature with respect to hook plate fixation of Neer type 2 distal clavicle fractures. But the complication rate of our study was higher when compared with the results of distal clavicular locking plates.

The clavicle hook plates were developed to treat acromioclavicular ligament injury or distal clavicular fracture with

Table 1
Demographics of the patients operated with a hook plate.

Case no	Age/Sex	Follow-up (month)	Time when radiologic union was seen (week)	Modified UCLA score at the final follow-up	Time when acromial migration was seen (months)	Implant removal (month)	Other complications
1	M/27	13	12	32	4.month	5	^a SIS
2	M/33	17	16	35			Superficial inf
3	M/52	13	16	32	4.month	5	
4	F/61	14	12	32	3.month	6	SIS
5	M/45	16	12	31	3.month	4	
6	M/44	13	12	32	4.month	5	
7	F/34	13	12	33			Superficial inf
8	M/32	13	12	33	4.month	4	SIS
9	M/29	12	16	32		6	Plate failure
10	F/57	12	12	34	3.month	4	Superficial inf. ^a SIS
11	M/36	17	12	35			
12	M/28	14	12	33			
13	F/29	18	12	32	3.month	5	
14	M/33	13	12	33		4	SIS
15	M/30	15	12	33	4.month	5	SIS
16	F/38	16	12	32	4.month	5	SIS

^a SIS: Subacromial impingement syndrome.

comminution. The hook plate is a solid plate that withstands forces that are applied to the fracture fragments. The high mechanical stability provided by the plate results from the hook part which is inserted to the subacromial space. However studies have shown that the hook is also the cause for the most common complications, 5%–68% of the patients have complaints related with subacromial impingement, bursitis, and rotator cuff injury.^{8,12,13} In an anatomical study of ElMaragaghy et al²⁷ it is shown that most of the complications were related with the geometric incongruency between the hook part of the plate and the lower aspect of the acromion. In seven of our patients, symptoms related to subacromial impingement and a positive Neer test was noted at a mean period of 2.5 months after the operation. A radiographical study was not considered necessary. After the removal of the implants clinical symptoms resolved in all patients. Lin et al²⁴ clinically and radiologically assessed 40 patients who were operated with the hook plate, and evaluated the subacromial area with ultrasound. Fifteen of the patients had subacromial bursitis and three had partial rotator cuff tears. The authors noted that advanced age increased was the possibility of both disorders. Therefore they concluded that age related degenerative changes could affect the development of these complications. Chandrasenan et al¹⁵ performed a diagnostic arthroscopy on 3 patients with postoperative shoulder pain and limited range of motion. One patient had erosion on the undersurface of the acromion, one had supraspinatus tendon tear, and one had AC joint arthrosis. The authors demonstrated the contact of the hook part with these conditions. Muramatsu et al¹⁰ and Tiren et al⁷ stated that acromial migration and osteolysis were also related to the pressure caused by the tight contact of the hook part with the lower aspect of the acromion, and that a short hook depth was a risk factor. The hook located in the subacromial space makes this area more crowded which may cause subacromial impingement. The hook also blocks sagittal rotation of the AC joint and inhibits the posterior tilt of the acromion resulting in decreased internal rotation of the distal clavicle.²⁹ These may be the factors for subacromial impingement symptoms. Rotator cuff tear has also been observed in some cases.¹⁵ Subacromial impingement and rotator cuff pathologies may be related with the different morphology in each individual and its anatomic discrepancy with implants may be the reason why complications occur in some patients and not in all of them.^{24,27} These complications can be minimised by performing an anatomic fit of the plate during the procedure. Up to date hook plates do not fulfill the expectations completely.

The most significant advantage of hook plate fixation in the treatment of distal clavicular fractures is the possibility of initiating early physical therapy which is useful for the restoration of shoulder functions. However it is generally accepted that the mechanical effects of the plate on the anatomically close subacromial bursa and the AC joint results in potentially serious complications. These complications may be avoided to some extent with removal of the implants after fracture healing. Close and frequent follow up of the patients is therefore significant. The functional results of our study in the short term were satisfactory. Postoperatively, the arm was placed in a shoulder sling for resting after shoulder exercises. Patients' daily activities were not restricted during this 6-week period. Rehabilitation program was not aggressive. Arm exercises up to shoulder level were allowed. The patient was instructed to move his/her arm in over 90° of abduction or flexion until confirmation of union. Acromial osteolysis is related directly with location of the hook plate under the acromion rather than the rate of shoulder motion. Kim et al²⁹ investigated the reasons of subacromial impingement following the fixation of distal clavicle fractures with a hook plate in a vivo analysis of AC joint motion using three-dimensional computed tomography. In their study,

acromial erosion was found in all patients. The hook in a hook plate is located posterior to the center of the AC joint. This causes a discrepancy between the center of rotation of the distal clavicle and the rotation axis of the plate. Therefore, erosion of the acromion or limitation of the motion can occur.

This study had some limitations. It was a retrospective study and not randomized. Also, we did not compare the different methods of treatment. The number of patients was also too small to allow statistical analysis to compare complications of patients with different number of plate holes. But the strength of the study was the uniformity of the included fractures and the number of patients for such a rare fracture.

In conclusion our data shows that the clinical and radiological results on the fixation of Neer type 2 distal clavicle fractures with a hook plate are good in terms of fracture union and function. However, the major disadvantage of this method was the requirement of early implant removal due to the hardware related complications. Good clinical results may be achieved only after plate removal. The complications may be related with the morphology of the lower aspect of the acromion where the hook part is inserted and the length of the plate part. Optimizing the shape and the length of hook plate and using different sizes according to individuals' needs may lower these complications. Using a long hook plate with more than 6 holes can be a good option to reduce the incidence of acromial osteolysis. Future studies with large number of patients are needed to confirm these findings.

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