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ORIGINAL STUDY

Late function and complications of hook plate implantation for distal-third clavicle fractures : a retrospective study

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In this study, the examined data was analysed from61 patients with Neer type II clavicle fractures treated with hook plate implantation between January 2008 and February 2011. The patients were divided into three groups depending on the removing time of plates after the fractures healing : early removal (<3 months, n=20), delayed removal (3-6 months, n=35), and retained plate (>6 months, n=6). All patients underwent clinical and radiographic follow-up in the outpatient department for a median of 18 months and every fracture healed eventually. Shoulder function was evaluated using the Constant shoulder score. The mean Constant shoulder score was greater, indicating better function, in the early removal group than the delayed removal and retained plategroups (96 [range 89-100] *vs.* 77 [65-89] and 61 [57-78], respectively ; p=0.000). The complication rateswere10%, 22.9%, and 50% in the early, delayed removal and retained plate groups, respectively (p=0.043). As a conclusion, the removal timing of the hook plate for distal clavicle fractures plays an important role in subsequent shoulder function and complications.

Keywords : Distal-third clavicle fractures ; locked plate ; hook plate ; functional outcomes ; complications.

INTRODUCTION

Distal-third clavicle fractures account for 21-28% of all clavicle fractures, and approximately one quarter are unstable *(1,2)*. Neer classified clavicle fractures into three types *(3)*. In Neer type IIa fractures or distal-third fractures, the fracture is located medial to thecoracoclavicularcomplex. In type IIb fractures, the conoid ligament is ruptured, but the trapezoid ligament remains attached to the lateral clavicular fragment. Both fracture types are unstable because the proximal fragment is detached from the coracoclavicular ligaments, whereas the distal fragment remains attached to the coracoid process and scapula.

Despite decades of debate, there is still no consensus on the optimal treatment for unstable distal-third clavicle fractures (Neer type II). Conservative management leads to high rates of non-union, delayed union, malunion, *(4)* and acromioclavicular joint arthritis *(5)*. Surgical treatment is often recommended. A clavicle hook plate is commonly used to repair the distal clavicle

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fracture, with a hook positioned beneath the acromion providing rigid fixation and allowing early mobilisation.

Despite excellent clinical results with hook plate placement *(6)*, complications are common *(7,8)*. The timing of hook plate removal is also controversial. Although it is recommended that the implant be removed 8-12 weeks postoperatively to resume full shoulder range of motion *(9)*, two authors reported good outcomes without its removal *(10,11)*. Here, we retrospectively reviewed 61 unstable distal clavicle fractures (Neer type II) treated with hook plate fixation in our institution over 3 years in terms of the impact of the timing of hook removal after healing on shoulder function and complications.

PATIENTS AND METHODS

Between January 2008 and February 2011, 61 patients with acute distal-third clavicle fractures underwent surgery for hook plate implantation without any other type of fixation in the Orthopaedics Department of the Chinese PLA General Hospital (Table I). The fractures were due to falling from a height (65.6%, n=40), weight falling on the shoulder (18.0%, n=11), sports accidents (16.4%, n=10), a motorcycle accident, and a bicycle fall. The patients were divided into three groups by the time of plate removal: early removal, <3 months after the fractures had healed; delayed removal, 3-6 months after healing; and retained plate, plates in position for more than 6 monthsafter the fractures had healed. Two surgeons performed the operations, which were standardised.

Surgery was performed onthe patients under nerve-block anaesthesia, lying on their back in a beach chair. The injured limb could be moved freely. The hook plate was a modified, stainless steel, curved, 3.5-mm dynamic compression plate with a hook-like structure extending from the lateral end. The hook had two different depths (15 and 18 mm) to accommodate different thicknesses of the acromion process. Two different plate lengths with six or eight holes were available. The approach was the standard anterior approach just medial to the acromioclavicular joint over the fracture. As much as possible thesoft tissue was preserved and only the superior facet of the clavicle was exposed. After exposing the fracture site fully, the large comminutedfragments were temporarily fixed using bone-reduction forceps, and the fracture ends were reduced by direct visualisation. The depth of the acromion was determined bya depth gauge. The torn ligaments were repaired, and the damaged soft tissue was removed. The appropriate chosen hook plate was inserted into a soft-tissue tunnel made in the subacromial space behind the acromioclavicular joint. The plate was fixed on the medial side of the fracture with standard AO 3.5-mm cortex screws.

All operated shoulders were supported using a triangular sling for 1 week. Gentle mobilisation of the operated shoulders was started under the guidance of a physiotherapist after the pain resolved. Progressive passive and active-assisted shoulder exercises were initiated from 3 weeks postoperatively, with a strengthening exercise program starting 6 weeks postoperatively. Patients were advised to restrict abduction of the affected shoulder to 90°, external rotation to 30°, and forward

Table I .—Baseline data for the patients included in the study

Variable*	early removal group (n=20)	delayed removal group (n=35)	situ group (n=6)	F/	*p***
Age at trauma, years	45(20~52)	43(22~58)	46(18~77)	1.404	0.304
Male/female	12/8	24/11	4/2	4.467	0.606
Time from trauma to surgery, days	5.7(1~15)	6.0(3~17)	5.5(1.5~16)	2.361	0.851
median time to union	3.3(2~5)	3.4(2~6)	3.5(2~6)	0.375	0.885
Follow-up time, months	18(10~28)	17(11~25)	19(6~42)	2.735	0.097

* Continuous data are presented as median (range) ; categoric data as number. ** Three groups, Variance Analysis, Mantel Haenszel Chi-square between the groups.

Table II. — Analysis information of complication occurrence in three groups

Complications	Shoulder impingement				Subacromial erosion				Fractures				Rotator cuff injury				distal clavicle osteolysis			
	N	A	S	T	N	A	S	T	N	A	S	T	N	A	S	T	N	A	S	T
Early	2	41 25	F M	2 3																
Delayed					6	48 47 37 42 48 50	M F F M F F	6 9 9 6 9 9					2	45 34	M F	3 4				
Retaining					1	47	M	9	1	55	F	42					1	45	M	12

*: N:number; A: age; S: sex; T:time(month)

Table III .— Functional outcome in each subgroup and the number of complications per subgroup

Variable*	<3months (n=20)	3~6months (n=35)	>6months (n=6)	*F/*	*P value*
Pain	15(15~15)	10(5~15)	5(0-10)	80.628	0.000
Activities	20(19~20)	16(12~20)	14(10~18)	48.841	0.000
Range	38(35~40)	32(28~36)	24(20~30)	149.876	0.000
Power	23(20~25)	19(15~20)	18(10~20)	54.204	0.000
Constantshoulder score	96(89~100)	77(65~89)	61(57~78)	221.507	0.000
Complications rate	10%(2/20)	22.9%(8/35)	50%(3/6)	9.825	0.007

flexion only and to avoid sports and heavy physical activity until the plate was removed.

In all three groups, patients were followed up every month in the first half year post-operation. Then these patients were followed up every three months to record the complicationstatus. At the baseline and follow-up visits, data were collected on patient demographics, the time from injury to surgery, functional scores, time to bone union, time from fracture healing to removal of the plate, and complications. The same assessor evaluated the functional outcome for all patients using the Constant shoulder score, which was calculated using scores for pain, the activities of daily living, range of motion, and shoulder strength *(12)*. Fracture healing was evaluated clinically and radiologically by two senior orthopaedic surgeons and was considered to have healed with agreement between the two. The removal time was determined by the fracture healing status based on different physical conditions of our enrolled patients, which regards as the grouping standard. Some patients had to undergo a later plate removal who under the conditionof weaker constitutions.Once the fracture had healed if there is no surgical contraindication, the plate was removed.

The statistical analyses were performed with STATA v11.0 (Stata Corp, College Station, TX) with a level of significance $p<0.05$. Analysis of variance (ANOVA) was used to assess differences in the Constant scores. The chi-square test was used to compare differences in complication rates.

RESULTS

All 61 patients were followed in the outpatient department. Their median age was 44.5 (range 18-77) years. The median follow-up after surgery was 18 (range 6-42) months, time from injury to surgery was 5.9 (range 1-17) days, and length of hospital

stay was5 (range 4-20) days. The 20-day hospital stay involved one polytrauma patient. We had no cases with implant failure, plate or screw loosening. The bone union rate was 100%. The median time from surgery to union was 3.4 (range 2-6) months and the time to hook plate removal after healing was 3.8 (range 3-12) months. At the last follow-up, 90.2% of the plates (n=55) had been removed. Of the remaining six, one patient sustained clavicle fractures at the medial end of the hook plate (Fig. 1A) 42 months postoperatively after falling on the affected shoulder and required further open reduction and internal fixation, and the other five patients could not tolerate a secondary operation because of poor cardiopulmonary function.

One of our patients showed distal clavicular-osteolysis on radiographs immediately after implant removal (1 year after implantation). The patient was a 45-year-old male who often carried heavy weights on his shoulders. We believe that the long-retained hook plate was the major factor. The distal clavicle sustained the force of gravity on the shoulder plus the weight carried on the shoulder. The force was concentrated on the distal clavicle and caused the stress-shielding effect of the plate.

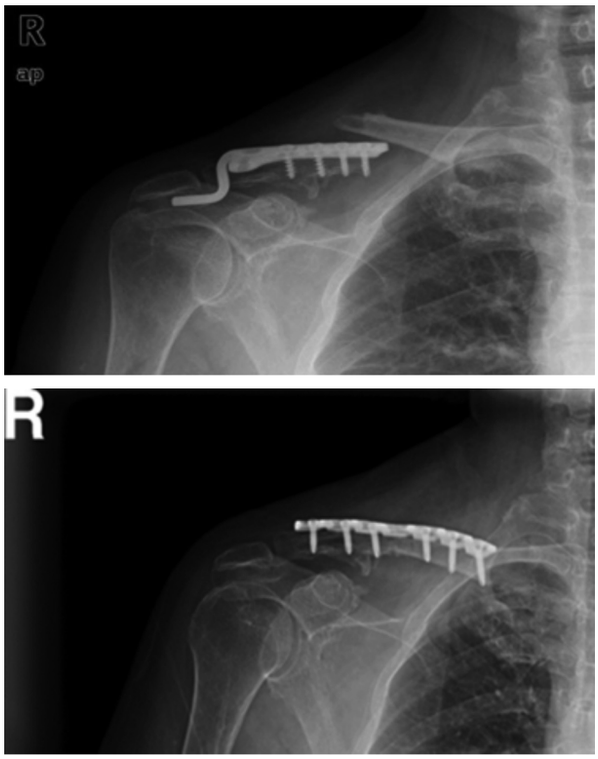

Fig. 1A-B. — The anteroposterior (AP) X-ray of a55-year-old woman with medial clavicular fractures medial to the hook plate at 42 months post-operatively (A) and presented a second operation with plate fixation (B).

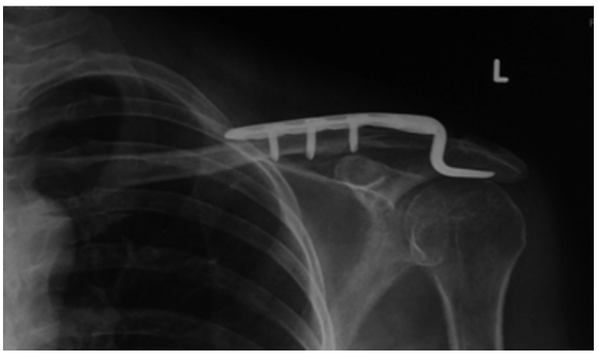

Fig. 2. — The anteroposterior (AP) X-ray of a 47-year-old man: left distal clavicle fracture with fixation with hook plate. X-ray at posteroperation 9 months shows subacromial osteolysis (lucency around the tip of the hook).

The complication rate in the early removal group was 10%, with two cases of shoulder impingement appeared in the second and third month respectively (Table I). The rate in the delayed removal group was 22.9%, with six cases of subacromialosteolysis (Fig. 3A-B) and two of rotator cuff injurydetected during 6-9 months after the fracture. The rate in the retained plate group was 50%, with one case each of medial clavicular fracture (peri-implant fractures) requiring secondary plate fixation caused by a fall on the affected shoulder 42 months postoperatively (Fig. 1B), subacromialosteolysis occurred in the 9th month (Fig. 3A-B), and distal clavicle osteolysis showed in the 12th month (Fig. 2). The complication rates differed significantly among the groups (p=0.043).

It should be mentioned that the plate had to be removed from the patient due to shoulder abnormalities after 6 months in Fig.3 (B), but this case was still included in the plate retaining group which met our grouping standard.

The mean Constant shoulder score was greater, indicating better function, in the early than the delayed removal and retained plategroups (96 [range 89-100] *vs*. 77 [65-89] and 61 [57-78], respectively; p=0.000; Table III).

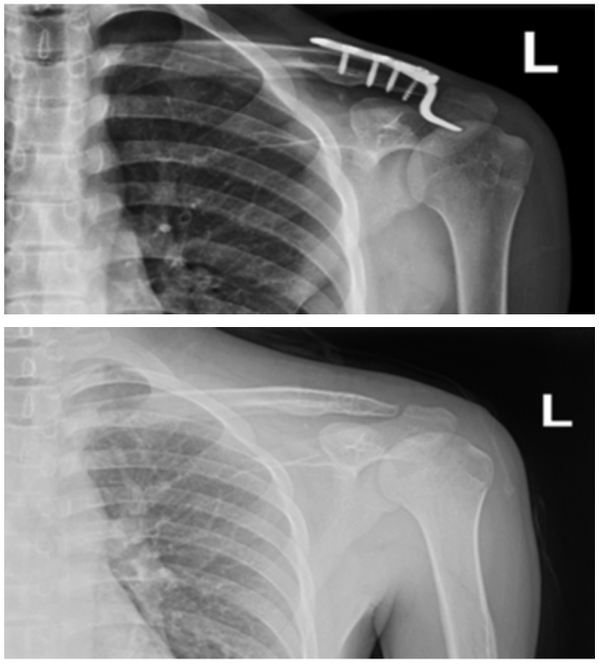

***Fig. 3A-B.* —** The antero-posterior (AP) X-ray of left shoulder of a 45-year-old man: left distal clavicle fracture fixation with hook plate. The immediate postoperative period with good fracture reduction and fixation (A). X-ray after implant removal with localized osteoporosis and osteolysis of the distal clavicle but no bone changes in the acromion (B).

DISCUSSION

Hook plate implantation is commonly used to treat distal-third clavicle fractures because of the relative ease of implant insertion, accurate maintenance of fracture reduction, and low risk of metalwork migration. Several studies have shown good results for bony union and shoulder function *(12-14)*. One of the main drawbacks is that the hook plate requires additional surgery to remove the plate once the fractures heal, at about 8-12 weeks, for recovery of full range of movement of the shoulder *(9)*. However, there is no consensus on the time and need for plate removal. Some authors have reported good outcomes without removal *(10,11)*.

In our 61 patients who underwent hook plate implantation for distal clavicle fracture, we observed excellent functional outcomes when the plates were removed within 3 months after the fractures had healed. However, with removal time >3 months after healing, the complications were greater and shoulder function lower than with removal before 3 months. Hence, after bone union of the clavicle, the earlier the plate is removed, the better the functional outcome.

One study reported that 20-36% of the patients with hook plate fixation had impingement symptoms *(11,15,16)*. Patients were unable to elevate or abduct the arm over 90° and had poorer Constant scores and less clinical satisfaction. They required plate removal. Two of our patients with early removal had impingement symptoms without rotator cuff injury, while two with delayed removal had rotator cuff injury and six had subacromialosteolysis. About 8-10 weeks after plate removal, the osteolysis disappeared on follow-up radiographs and the shoulder impingement was relieved. The impingement symptom rate was 16.4% (10/61), which was lower than in previous studies *(11,15,16)*.

We feel that all three complications were due to a mismatch between the plate and the patient's anatomy. Biomechanically, the vertical part and tip of the hook must contact the inferior surface of the acromion to maintain fracture reduction. In a cadaver study, El Maraghy *(17)* ascribed these complications to mismatch between the plate and subacromial space: in 89% of specimens, the hook pierced the subacromial bursa; in 60%, it contacted the belly of the supraspinatus muscle; and in 60%, the hook tip had focal contact with the undersurface of the acromion. Therefore, we speculate that when the implant retained for a long time, the pressure at the tip of the plate leads to subacromial erosion during the rotation of the clavicle. Similarly, contact with the supraspinatus tendon will lead to rotator cuff injury on abducting the arm. A simple hook plate would not be suitable for treating the great variation in acromion shape among humans. Therefore, the tip and plate must be bent to accommodate the dimensions and morphological features of the acromion before insertion.

In our study, two patients had impingement symptoms in the early removal group and two had subacromialosteolysis in the delayed removal group. Excessive shoulder abduction led to impingement between the tip of the hook plate and acromion. If the plate is implanted for a long time, subacromialosteolysis will occur. Postoperatively,

the rehabilitation is very important, but patients often are not instructed to restrict abduction of the affected shoulder to 90° by the physiotherapist *(8)*.

A clavicle fracture medial to the plate is a rare complication. In our case, a secondary fracture occurred 42 months after hook plate fixation when the patient incurred a second injury. We believe that the long-retained hook plate had a stress-shielding effect on the underlying cortical bone and exacerbated the clavicular osteoporosis. The stress comes from the medial end of the hook plate with abduction of the shoulder joint. However, the fracture was in a screw hole, which might represent a weak point in the clavicle.

In conclusion, the timing of hook plate removal in distal clavicle fractures is an important issue in terms of complications and function after healing. We found that delayed hook plate removal resulted in poor shoulder function and high complication rates. Shoulder function was excellent with hook plate removal within 3 months after fracture healing. The tip and plate must be bent to accommodate the dimensions and morphology of the acromion during surgery. The rehabilitation program must be administered correctly by a physiotherapist.

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