ORIGINAL ARTICLE

Hook versus locking plate fixation for Neer type-II and type-V distal clavicle fractures: a retrospective cohort study

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Abstract

Purpose This study examined the outcomes and complications after treatment of unstable distal clavicle fractures with hook or locking plate fixation.

Methods A retrospective search was performed of all acute distal clavicle fractures treated with open reduction and internal fixation from 2009 to 2019 at a Level I trauma center. Patients were separated into hook and locking plate fixation groups. Rates of union, complications, and reoperation, were extracted. QuickDASH (Disabilities of Arm, Shoulder, and Hand) scores were determined.

Results Thirty-one patients met the inclusion criteria and were included in the study. Of these, 12 patients were treated with hook plates and 19 were treated with locking plates. All fractures healed without loss of reduction, regardless of implant selection. There were no immediate or long-term complications in either group. 83% of hook plate patients underwent planned implant removal, while 37% of locking plate patients requested implant removal secondary to irritation. QuickDASH scores were comparable and excellent in both groups.

Conclusions Hook and locking plate fixation for Neer type-II and type-V distal clavicle fractures have comparably high rates of union. Hook plates were removed routinely per protocol, while locking plates were removed only if symptomatic and occurred significantly less often.

Keywords Distal clavicle fracture · Hook plate · Locking plate · Implant removal · Symptomatic implants

Introduction

Nonoperative management of unstable distal clavicle fractures leads to unacceptably high rates of nonunion [1]. Although hook plates can effectively maintain reduction until union, reoperation for implant removal is routinely recommended [2–5]. Compared to locking plate fixation, hook plating for distal clavicle fractures carries a unique set of complications, including acromial erosion and fracture, subacromial impingement, and rotator cuff tear [2–8].

Locking plate fixation for distal clavicle fractures has similar union rates compared to hook plates, but may not require a secondary operation for implant removal [5, 7, 9, 10]. Avoiding implant removal is advantageous to decrease healthcare expenditure and to prevent the burden of a secondary surgery to the patient [11]. However, given the limited number of studies comparing these two interventions, it remains unclear which strategy is optimal when treating these difficult injuries. Direct comparative data between these two commonly used implants are limited [5, 7, 9, 10].

The purpose of this study was to compare the results after hook and locking plate fixation for treatment of Neer type-II and type-V distal clavicle fractures. We hypothesized that locking plate fixation would yield similar union rates to hook plating and that implant removal would be performed less frequently.

Materials and methods

After institutional review board approval was obtained, a retrospective database search was performed to identify all distal clavicle fractures treated with open reduction and internal fixation (ORIF). Three orthopedic traumatologists

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performed all procedures at a single level-I trauma center from 2009 to 2019. Inclusion criteria were patients who sustained an acute distal clavicle fracture treated with ORIF. Pathologic fractures and nonunion repair were excluded. Minimum follow-up was to either implant removal or successful contact for telephone interview, for those with retained implants.

Standard demographic data, injury characteristics, implant specifics, and postoperative complications were extracted from medical records. Injury radiographs were examined to determine the Neer classification [12]. Final radiographs were reviewed to determine the maintenance of fracture reduction and healing, as defined by radiographic bridging bone. The incidence of fixation failure and nonunion was recorded.

All patients had multiple attempts at contact for telephone interview. Telephone-interviewed patients were questioned whether they had any subsequent complication or reoperation after the last documented clinical visit, whether they experienced any level of soft-tissue irritation related to their implants, and whether they were considering having their implants removed in the future. Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) scores were determined for all telephone-interviewed patients [13]. Final follow-up was determined according to the last documented clinical visit (for patients with implant removal who were unable to be telephone-contacted) or telephone interview.

Independent t tests were calculated for continuous variables (Excel 2011, Microsoft, Redmond, WA). Significance was set at $p < 0.05$.

Surgical indications and procedures

All patients indicated for ORIF had Neer type-II or type-V distal clavicle fractures. Standard anterosuperior approaches to the distal clavicle were performed in all patients, followed by reduction and fixation depending on the fracture pattern. Implant selection was based on surgeon discretion. Hook plates were all from the same manufacturer (Synthes, West Chester, PA) (Fig. 1). Locking plate selection was variable and included precontoured distal clavicle-specific locking plates (Synthes, West Chester, PA), small fragment locking plates (Synthes, West Chester, PA), and mini-fragment locking plates (Smith & Nephew, Andover, MA) that were used to create a dual-plated construct (Fig. 2). Hook plate removal was routinely recommended after 3 months, or after confirmed radiographic fracture healing. Locking plate removal for implant-related soft-tissue irritation was only performed per patient request.

Results

A total of 43 patients were identified who underwent ORIF for Neer type-II and type-V distal clavicle fractures. Thirteen fractures were treated with hook plates and the other 30 were treated with locking plates. After excluding patients with insufficient follow-up (none of which had a reported complication), 12 patients treated with hook plates and 19 patients treated with locking plates were included in the analysis. For the patients treated with locking plates, 11 received precontoured distal clavicle-specific locking plates, three received small fragment locking plates, and five received dual mini-fragment locking plate constructs. Six of the hook plate patients and 17 of the locking plate patients were successfully contacted for telephone interview and QuickDASH scoring. The remainder of the included patients had undergone implant removal.

Patient and injury characteristics are presenting in Table 1. Age, sex, and body mass index (BMI) were similar between the groups. Seven patients (58%) treated with hook plates were polytraumatized, compared with nine patients (47%) in the locking plate group. The hook plate patients had more Neer type-IIB fracture patterns (50% vs. 42%), and the locking plate patients had more Neer type-V fracture patterns (32% vs. 17%). Time to surgery was similar between the groups. Mean follow-up was 31 months (range 3–80 months) for the hook plate group, and 40 months (range 3–102 months) for the locking plate group.

There were no cases of wound dehiscence, deep or superficial infection, or loss of fixation in either group (Table 2). Radiographic union with maintained reduction was achieved
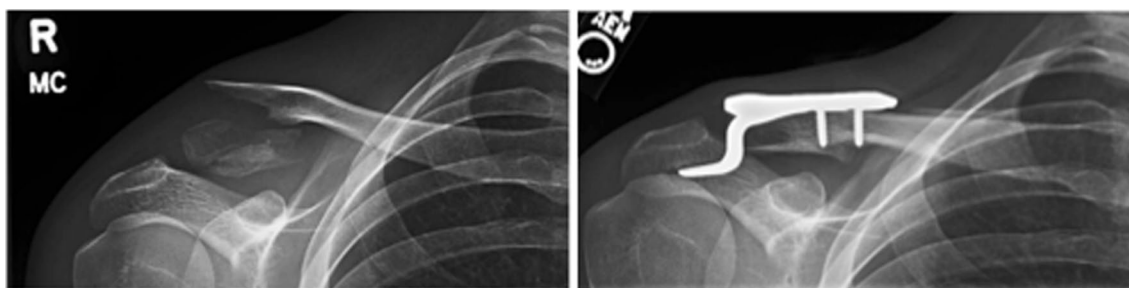

Fig. 1 Radiographs demonstrating an unstable distal clavicle fracture and successful union after treatment with a hook plate
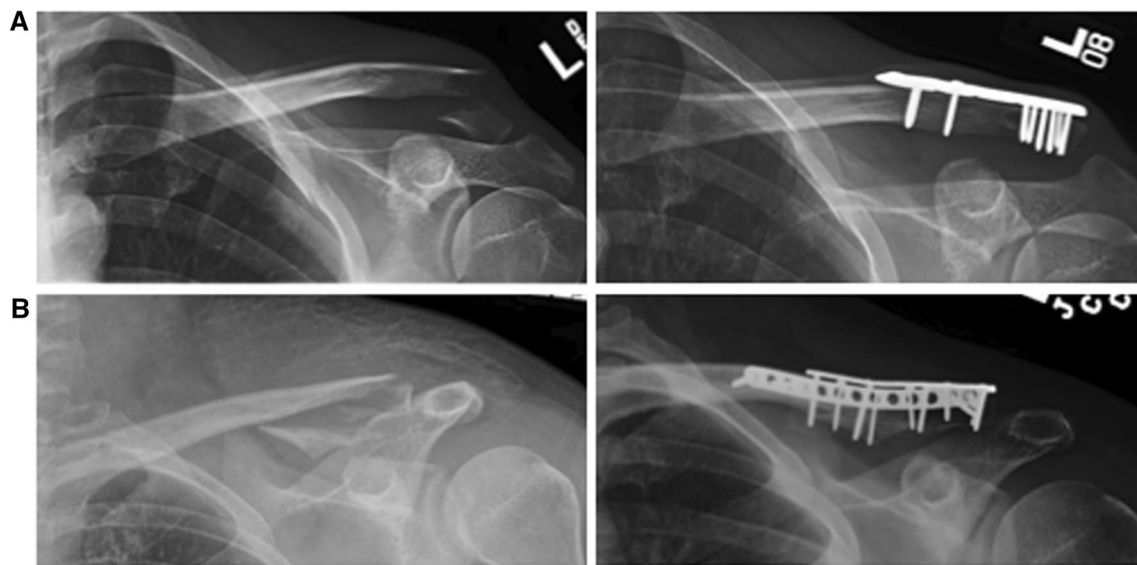
Fig. 2 Radiographs demonstrating a series of unstable distal clavicle fractures and successful union after treatment with **a** precontoured locking plate and **b** dual mini-fragment plates

Table 1 Characteristics of patients treated with hook or locking plate fixation for Neer type-II and type-V distal clavicle fractures

	Hook plate	Locking plate
Total patients, *n*	12	19
Mean age ± SD (range) (years)	40 ± 15 (20–62)	44 ± 13 (24–63)
Male, *n* (%)	10 (83)	15 (79)
Female, *n* (%)	2 (17)	4 (21)
Mean BMI ± SD (range)	23.4 ± 4.6 (17.6–34.7)	23.4 ± 3.5 (17.4–30.8)
Tobacco use, *n* (%)	0 (0)	2 (11)
Multiple injuries, *n* (%)	7 (58)	9 (47)
Neer fracture pattern		
IIA, *n* (%)	4 (33)	5 (26)
IIB, *n* (%)	6 (50)	8 (42)
V, *n* (%)	2 (17)	6 (32)
Time to surgery ± SD (range) (days)	8 ± 7 (1–27)	8 ± 10 (0–44)
Mean FU ± SD (range) (months)	31 ± 31 (3–80)	40 ± 36 (3–102)

SD standard deviation, *BMI* body mass index, *FU* follow-up

in all 12 patients (100%) treated with hook plates, and in all 19 patients (100%) treated with locking plates (Table 2).

All hook plate patients who had their implants removed reported resolution of prior implant-related irritation (mean time to implant removal was 4 months, range 3–7 months, Table 2). Interestingly, the two patients that retained their hook plates denied implant irritation and had no future plans for removal. Ten patients (53%) in the locking plate group reported implant-related irritation, and in five of these patients (26%), symptoms were significant enough to request implant removal (mean time to implant removal was 13 months, range 6–23 months, Table 2). All of these patients reported improvement in their symptoms after removal. Two of the remaining

patients with symptomatic implants were considering future removal (Table 2). The projected final implant removal rate was 37% for locking plates, accounting for future implant removal, and 83% for hook plates (Table 2). QuickDASH scores after hook plate fixation (mean 1.7 ± 1.2) were not statistically different from the scores after locking plate fixation (mean 4.2 ± 3.7, $p = 0.2$) (Table 2).

Table 2 Postoperative complications and outcomes after hook and locking plate fixation for distal clavicle fractures

	Hook plate	Locking plate
Short-term complications		
Wound problem/infection/fixation loss, *n*	0	0
Radiographic union, *n* (%)	12 (100%)	19 (100%)
Implant-related irritation		
Plate irritation, *n* (%)	10 (83)	10 (53)
Actual implant removal, *n* (%)	10 (83)	5 (26)
Mean time to removal ± SD (range), months	4 ± 1 (3–7)	13 ± 6 (6–23)
Considering implant removal, *n* (%)	0 (0)	2 (11)
Projected final implant removal, *n* (%)	10 (83)	7 (37)
Mean QuickDASH ± SD	1.7 ± 1.2	4.2 ± 3.7

SD standard deviation, *QuickDASH* abbreviated Disabilities of Arm, Shoulder and Hand questionnaire

Discussion

Both hook and locking plate fixation for stabilization during ORIF of unstable distal clavicle fractures have high union rates [5, 7, 9, 10]. Hook plates, however, routinely require reoperation for implant removal [4, 7, 8, 10]. Regardless, there is currently no universal consensus on which implant is preferred for treating these difficult fractures, and only one other comparative study has been performed in a North American patient population [10]. The purpose of this study was to evaluate outcomes after hook and locking plate fixation for Neer type-II and type-V distal clavicles fracture in a North American patient population.

This retrospective comparative study found that successful healing of distal clavicle fractures was achieved after using hook or locking plates, regardless of fracture pattern. Implant removal after locking plate fixation was

necessary in only 37% of patients. Of the two hook plate patients with retained implants, although removal was recommended, neither reported implant irritation. Quick-DASH scores for both groups were similarly low, indicated excellent post-intervention functional outcomes. We did not observe any complications, such as acromial fracture or rotator cuff impingement, related to the use of hook plates.

The hook portion of the hook plate is designed to resist inferior displacement of the injured arm, thereby assisting in fracture reduction maintenance. This hook rests in the subacromial space, however, which can lead to impingement of the supraspinatus, as well as focal bony loading of the acromial undersurface [14]. This contributes to rotator cuff irritation and subacromial bony erosion that has been observed by several authors prior to implant removal [3–6, 8, 14]. Motion at the acromioclavicular joint is affected by the spanning hook, which impairs normal scapulothoracic motion while the implant is in place [15]. Furthermore, a 3.6-fold greater risk of persistent shoulder pain has been reported following the use of hook plates, compared with non-spanning plate fixation, for fixation of distal clavicle fractures [16].

A comparison of recent studies comparing hook versus locking plate fixation for treatment of distal clavicle fractures in various regional patient populations is presented in Table 3. All authors reported high union rates in both treatment groups, similar to the findings of the present study. Implant removal varied widely based on the regional population being studied. Symptomatic locking plate removal was higher in the current study compared with the rate reported in the other North American study [10]. However, those authors only reported on a mean follow-up of 11 months from patients that had been treated 7–9 years prior, with no recent follow-up confirming that the patients had not undergone, or desired, implant removal. Our data suggest that some level of implant irritation after locking plate fixation is expected in nearly half of patients

Table 3 List of comparative articles examining hook versus locking plate fixation for treatment of unstable distal clavicle fractures. The fracture union and implant removal rates, with respect to intervention, are presented

Comparative articles	Region	Hook plate			Locking plate		
		Subjects, *n*	Union, *n* (%)	Implant removal, *n* (%)	Subjects, *n*	Union, *n* (%)	Implant removal, *n* (%)
Zhang et al. [7]	China	30	28 (93)	30 (100)	36	35 (97)	12 (33)
Erdle et al. [5]	Germany	19	18 (95)	19 (100)	13	13 (100)	10 (77)
Xiong et al. [9]	China	25	25 (100)	15 (50)	5	5 (100)	0 (0)
Singh et al. [10]	USA	16	16 (100)	10 (63)	37	36 (97)	6 (16)
Current study	USA	12	12 (100)	10 (83)	19	19 (100)	7 (37)

USA United States of America

after locking plate fixation and that a third of patients will ultimately undergo implant removal for significant irritation.

The strengths of this study were that all patients had follow-up to implant removal or telephone contact, and future desire for implant removal was assessed. This is also the first North American study reporting on patient-reported outcome measures after hook versus locking plate fixation, to our knowledge.

The main limitations of this study are its nonrandomized retrospective design, and small patient cohort size. More patients with long-term follow-up are needed to determine a more accurate implant removal rate when using locking plate fixation. The implant selection for locking plate fixation also included precontoured distal clavicle-specific plates, small fragment 3.5-mm plates, and dual mini-fragment plated constructs; all of which have varying profiles of implant prominence. Regardless of the implant selected for locking plate fixation, all fractures went onto union.

Conclusions

Locking and hook plate fixation have comparably high rates of union and excellent patient-reported outcome measures. Implant removal is recommended after hook plate fixation routinely and is only needed in a third of patients who undergo locking plate fixation for implant irritation. Future studies should determine the potential cost-savings from fewer reoperations when utilizing locking versus hook plate fixation for ORIF of these injuries. Patients should be educated on the frequency of implant removal to address irritation, regardless of implant selection.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article contained only de-identified human participant information and was approved by our institutional review board.

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