



Original article

Complications after surgical treatment of distal clavicle fractures

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ABSTRACT

Introduction: Distal clavicle fractures have low rates of union when treated with conservative measures. Operative treatment is generally recommended for Neer type II and V. Multiple fixation methods exist with no clear gold standard. The goal of the current study is to assess the outcomes and complications of distal clavicle fractures treated with one of three fixation methods: standard clavicular plate, hook plate or suture fixation about the coracoid.

Methods: This is a retrospective cohort study of surgically-treated unstable Neer type II and V distal clavicle fractures in adults. These operations were performed by multiple surgeons within a single healthcare system between January 2010 and September 2012. Patients were divided into three cohorts: pre-contoured clavicular locking plates, hook plates, and suture-only fixation methods. Univariate and multivariate modeling analyses were performed.

Results: A total of 74 distal clavicle fractures comprised the final cohort. Fifty-eight (77%) of these fractures were Neer type II; the remaining 16 (21.6%) were Neer type V. Median follow-up time was 12 months (range 10–28). BMI, smoking status, diabetes, and ASA class were similar among all cohorts. Twenty-one patients were treated with suture fixation alone (28.3%), 37 with a contoured clavicular plate (50%) and 16 with hook plate fixation (21.6%). Twenty-one patients (28.4%) experienced complications, including two hardware failures requiring revision surgery. A total of 10/16 (62.5%) patients with hook plates required hardware removal for irritation, compared to 6/37 (16.2%) with a contoured clavicular plate (OR = 8.61, *p* value = 0.001), and none with sutures alone. A total of 3/21 patients (14.2%) treated with suture fixation methods were diagnosed with adhesive capsulitis post-operatively; no patients in the plate fixation groups received this diagnosis. The Neer V group had a higher proportion of any complications (37.5%) compared to Neer II (25.9%), and a higher rate of stiffness (12.5% v. 1.7% in Neer II).

Conclusion: This study compared the outcomes of three different fixation methods for unstable distal clavicle fractures. The overall union rate with any method of operative intervention was very high (98.6%), consistent with previous studies. Hook plates had a much higher re-operation rate, mostly owing to a higher incidence of hardware removal, an expected outcome owing to the prominence of these plates in the subacromial space. Contoured clavicular plates were associated with a lower incidence of irritation and hardware removal than hook plates, although one patient in this group experienced loss of fracture fixation and went on to asymptomatic radiographic non-union. Suture-only fixation methods had the lowest rate of re-operation, with only one of 21 procedures resulting in failure and requiring revision. However, there was a significantly higher rate of adhesive capsulitis in the suture fixation cohort, perhaps due to the tethering effect of the clavicle to the coracoid or violation of the rotator interval. While this study supports that most distal clavicle fracture fixation methods can achieve stable union, there is a highly variable complication profile associated with each fixation method. The routine use of hook plate fixation cannot be recommended.

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1. Introduction

Distal clavicle fractures as described by Neer in 1963 present a clinical challenge. The proximal pull of the trapezius coupled with the downward force imparted to the distal fragment by the weight of the arm result in fracture displacement. There is a 20–30%

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rate of non-union or delayed union with non-operative treatment [1–4]. Operative fixation for unstable Neer Type II and V fractures is recommended due to improved union rates.

Neutralization of the deforming forces is complicated by the relatively small volume of bone in the distal fragment for surgical fixation. A multitude of treatment options have been described in the literature with no “gold standard” procedure [5]. Described surgical options have included: tension band wiring, intramedullary Knowles pin, transacromial K-wires, subcoracoid lasso, endobutton or “tightrope” suture fixation, hook plating, coracoclavicular screw placement, and pre-contoured clavicular locking plates [5–13]. While most fixation methods result in a high rate of union, they have very different outcome profiles in terms of type and rate of complications, as well as the need for revision surgery [5,14].

Distal clavicle fractures are uncommon, comprising only 28% of all clavicle fractures [15]. This scarcity results in studies often limited by small sets of patients. Additionally, the relative heterogeneity of patient populations and study designs [5,14] has made most meta-analyses difficult to interpret in terms of optimal treatment options. Most available studies are retrospective case series reporting outcome measures on a single fixation type [14]. There have been few head-to-head comparisons of different fracture fixation methods in a single study [10–12]. Our study aims to leverage the data from a large hospital group to compare hook plate fixation to both standard pre-contoured clavicular plate and suture-only reconstruction techniques to elucidate union rates as well as requirement for re-operation between these methods.

2. Materials and methods

A retrospective cohort study was conducted after institutional review board (IRB) approval. Patients were identified using ICD-9 and CPT codes for distal clavicle fracture and internal fixation of clavicle fracture, respectively from institutional databases and the electronic medical record of an integrated healthcare system.

Patient demographics, comorbidities, and procedure details of interest were decided a priori and extracted from the operative reports and electronic medical record by the authors.

Inclusion criteria were all operatively-treated distal clavicle fractures between January 2010 and September 2012, inclusive, by providers within an integrated healthcare system. Pathologic fractures, non-unions, and infections were excluded.

The study participants were limited to unstable Neer type II and V distal clavicle fractures as identified on radiographs interpreted by a trained orthopedic surgeon. Patients were divided into three cohorts based on their fixation method: pre-contoured clavicular plates, hook plates, or fixation methods utilizing only heavy sutures from the coracoid to the clavicle. The primary outcome studied was need for revision surgery due to loss of fracture fixation. Secondary outcomes included post-operative infection or wound complication, symptomatic hardware removal, and a post-operative diagnosis of adhesive capsulitis.

Differences in patient demographics and clinical characteristics by fixation type were examined. The average differences for continuous variables were assessed by comparing means via *t*-tests when data were normally distributed, and Wilcoxon rank-sum tests to compare medians for non-normally distributed data. Differences in proportions for categorical variables were assessed with use of Pearson chi-square tests, or Fisher's exact test when expected cell frequencies were < 10. Chi-square or Fisher's exact tests were used to examine associations between fixation type and each outcome (fixation failure, infection, or elective implant removal). A univariate analysis was performed to examine associations between predictor variables and the primary and secondary outcomes.

Missing data on gender (1% of patients), smoking status (4% of patients), BMI (3% of patients), and American Society of Anesthesiology (ASA) class (13% of patients) were excluded from univariate analyses case-wise. As the baseline and surgical characteristics appeared to be neither related to fixation type nor complications (see Tables 1 and 2), multivariate modeling was not conducted. In the resulting analyses of post-operative complications, no adjustments were made for gender, ethnicity, age, presence of diabetes mellitus, smoking status, BMI, or ASA class. The unadjusted odds ratios were reported, with 95% confidence intervals for each outcome. Statistical significance was determined using a type I error probability threshold of < 5% (i.e. $p < 0.05$).

3. Results

Seventy-four distal clavicle fractures comprised the final cohort, consisting of 72.6% males with median age of 33.1 years (ranging from 11.7 to 78.6 years). Fifty-eight (77%) of these fractures were Neer type II, 16 (21.7%) were Neer type V, and 1 (1.3%) was a Neer type III and excluded from subsequent analyses. The median follow-up time was 11 months. Among the 74 patients with Neer types II and V, 21 patients were treated with suture fixation alone (28.3%), 37 were treated with a contoured clavicular plate (50%), and 16 were treated with hook plate fixation (21.6%).

In terms of patient demographics, there were no statistical differences between groups in terms of ASA class, gender, diabetes status, smoking status, age or body mass index (BMI). The only demographic factor that was different between groups was that Hispanic patients tended to have hook plates at a higher proportion to Caucasians or others ($p = 0.05$) (Table 1).

Overall, 21 individuals (28.4%) had post-operative complications. These complications included two hardware failures requiring revision surgery, one each in the pre-contoured clavicular plate cohort, and another in the suture fixation cohort. The rate of failure between the groups was not statistically significant ($p = 0.60$) (Table 2). Ten of sixteen patients (62.5%) patients with hook plates required hardware removal for irritation, compared to six of thirty-seven (16.2%) of those with pre-contoured clavicular plates (OR = 8.61, p value < 0.001), and zero patients treated with sutures around the coracoid.

Three of twenty-one patients (14.2%) treated with suture fixation methods were diagnosed with adhesive capsulitis post-operatively; zero patients in the two plate fixation groups received this diagnosis ($p = 0.02$). All three of these cases were treated successfully with physical therapy, and none required further operative procedures (Table 3).

In terms of fracture type, the Neer type V cohort had a higher proportion of any complications (37.5%) compared to the Neer type II cohort (25.9%), though this was not statistically significant ($p = 0.36$). The increase in adhesive capsulitis after Neer type V was significantly higher than after type II fractures ($p = 0.05$). (Table 4).

4. Discussion

In 1963, Neer described an uncommon pattern of clavicular fracture in which the proximal segment of the clavicle becomes unstable as a result of bony discontinuity of the coracoclavicular ligaments from the rest of the clavicle [1]. He classified distal clavicle fractures into five types, and noted the inherent instability in two of those fracture types. Neer type II fractures occur either just medial to (Type IIa) or at the level of the coracoclavicular ligaments (Type IIb) and produce an unstable medial segment. Neer Type V fractures include comminution of the fracture, with a free inferior segment connected to the coracoclavicular ligaments, but not in continuity with the rest of the clavicle. Neer noted increased difficulty

Table 1
Baseline covariates by hardware type for distal fractures.

	Clavicle Plate (n = 37)	Hook plate (n = 16)	Sutures Only (n = 21)	Total (n = 74)	p value
<i>Gender</i>					0.5032
M	27 (73%)	10 (62.5%)	16 (80%)	53 (72.6%)	
F	10 (27%)	6 (37.5%)	4 (20%)	20 (27.4%)	
Missing	0 (.)	0 (.)	1 (.)	1	
<i>Race/Ethnicity</i>					0.0522
White	20 (54.1%)	8 (50%)	14 (66.7%)	42 (56.8%)	
Hispanic	11 (29.7%)	8 (50%)	2 (9.5%)	21 (28.4%)	
Other	6 (16.2%)	0 (0%)	5 (23.8%)	11 (14.9%)	
<i>Smoking status</i>					0.5416
Current	6 (16.2%)	1 (6.3%)	5 (23.8%)	12 (16.2%)	
Former	29 (78.4%)	14 (87.5%)	16 (76.2%)	59 (79.7%)	
Never	2 (5.4%)	1 (6.3%)	0 (0%)	3 (4.1%)	
Unknown					
<i>Diabetes</i>					0.8315
0	35 (94.6%)	15 (93.8%)	19 (90.5%)	69 (93.2%)	
1	2 (5.4%)	1 (6.3%)	2 (9.5%)	5 (6.8%)	
<i>ASA Class</i>					0.5175
Missing	5 (.)	2 (.)	3 (.)	10	
1	10 (31.3%)	6 (42.9%)	7 (38.9%)	23 (35.9%)	
2	20 (62.5%)	8 (57.1%)	8 (44.4%)	36 (56.3%)	
3	2 (6.3%)	0 (0%)	2 (11.1%)	4 (6.3%)	
4	0 (0%)	0 (0%)	1 (5.6%)	1 (1.6%)	
<i>Age at surgery</i>					0.0164
N	33 (89.2%)	13 (81.3%)	12 (57.1%)	58 (78.4%)	
Mean (SD)	4 (10.8%)	3 (18.8%)	9 (42.9%)	16 (21.6%)	
Median					0.1168
Q1, Q3	37	16	21	74	
Range	36.2 (15.94)	31.7 (16.03)	43.8 (19.57)	37.4 (17.39)	
	32.5	25.3	48.1	33.1	
<i>BMI</i>					0.4304
N	22.5, 50.0	18.3, 46.2	25.6, 57.0	21.3, 51.7	
Mean (SD)	(12.6–64.2)	(11.7–62.6)	(17.2–78.6)	(11.7–78.6)	
Median					
Q1, Q3	36	16	20	72	
Range	25.1 (4.47)	23.2 (2.44)	24.4 (3.51)	24.5 (3.87)	

Table 2
Outcomes by hardware type for distal fractures.

	Clavicle plate (n = 37)	Hook plate (n = 16)	Sutures Only (n = 21)	Total (n = 74)	p value
<i>Any complications</i>					0.0029
0	30 (81.1%)	6 (37.5%)	17 (81%)	53 (71.6%)	
1	7 (18.9%)	10 (62.5%)	4 (19%)	21 (28.4%)	
<i>Infection</i>					.
0	37 (100%)	16 (100%)	21 (100%)	74 (100%)	
<i>Stiffness</i>					0.0193
0	37 (100%)	16 (100%)	18 (85.7%)	71 (95.9%)	
1	0 (0%)	0 (0%)	3 (14.3%)	3 (4.1%)	
<i>HWR</i>					<0.0001
0	31 (83.8%)	6 (37.5%)	21 (100%)	58 (78.4%)	
1	6 (16.2%)	10 (62.5%)	0 (0%)	16 (21.6%)	
<i>Arthroscopy</i>					0.6024
0	36 (97.3%)	16 (100%)	21 (100%)	73 (98.6%)	
1	1 (2.7%)	0 (0%)	0 (0%)	1 (1.4%)	

in achieving union of these two fracture types, and thus recommended operative treatment for the unstable variants. (Fig. 1).

Non-operative treatment has been recommended as a potential treatment option by some authors. This recommendation is typically based on studies that revealed acceptable functional outcomes despite a high non-union rate (up to 33%) in non-operatively treated patients [2–4,13,14]. Oh et al. also based their recommendation on a high rate of complications in the operatively-treated group (22.2%) averaged over all surgical fixation methods [14]. It is worth noting, however, that most of the complications in this study were seen in the hook plate and K-wire tension band groups, two fixation methods shown to consistently result in high levels

of impingement, hardware irritation or migration in the literature [10,11,16,17].

Most authors align with Neer’s original recommendation and advocate surgical fixation of unstable distal clavicle fractures to achieve a higher rate of union. Across multiple studies and meta-analyses, a union rate of >90% is consistently achieved with operative treatment [5–8,14,18–22]. However, there is a paucity of comparative data in orthopedic literature comparing different operative treatment methods for unstable (Neer type II and V) distal clavicle fractures. Neer originally advocated transacromial K-wire fixation for unstable fractures, noting high rates of union and a low complication rate. However, the appropriateness of this treatment

Table 3
Outcomes by Neer Type.

	Neer Type II (n = 58)	Neer Type V (n = 16)	Total (n = 74)	p value
<i>Any complications</i>				0.3606
0	43 (74.1%)	10 (62.5%)	53 (71.6%)	
1	15 (25.9%)	6 (37.5%)	21 (28.4%)	
<i>Infection</i>				0.0530
0	58 (100%)	16 (100%)	74 (100%)	
<i>Stiffness</i>				0.7108
0	57 (98.3%)	14 (87.5%)	71 (95.9%)	
1	1 (1.7%)	2 (12.5%)	3 (4.1%)	
<i>HWR</i>				0.5969
0	46 (79.3%)	12 (75%)	58 (78.4%)	
1	12 (20.7%)	4 (25%)	16 (21.6%)	
<i>Arthroscopy</i>				0.4514
0	57 (98.3%)	16 (100%)	73 (98.6%)	
1	1 (1.7%)	0 (0%)	1 (1.4%)	
<i>Failure</i>				
0	56 (96.6%)	16 (100%)	72 (97.3%)	
1	2 (3.4%)	0 (0%)	2 (2.7%)	

Table 4
Any complications by baseline covariates.

	No Complications (n = 53)	Any Complications (n = 21)	Total (n = 74)	p value
<i>Gender</i>				0.4699
Missing	1 (.%)	0 (.%)	1	
F	13 (25%)	7 (33.3%)	20 (27.4%)	
M	39 (75%)	14 (66.7%)	53 (72.6%)	
<i>Race/Ethnicity</i>				0.5258
Hispanic	16 (30.2%)	5 (23.8%)	21 (28.4%)	
Other	9 (17%)	2 (9.5%)	11 (14.9%)	
White	28 (52.8%)	14 (66.7%)	42 (56.8%)	
<i>Smoking status</i>				0.1471
Current	7 (13.2%)	5 (23.8%)	12 (16.2%)	
Former	45 (84.9%)	14 (66.7%)	59 (79.7%)	
Never	1 (1.9%)	2 (9.5%)	3 (4.1%)	
Unknown				0.5506
<i>Diabetes</i>				0.8407
0	50 (94.3%)	19 (90.5%)	69 (93.2%)	
1	3 (5.7%)	2 (9.5%)	5 (6.8%)	
<i>ASA Class</i>				0.3606
Missing	8 (.%)	2 (.%)	10	
1	17 (37.8%)	6 (31.6%)	23 (35.9%)	
2	24 (53.3%)	12 (63.2%)	36 (56.3%)	
3	3 (6.7%)	1 (5.3%)	4 (6.3%)	
4	1 (2.2%)	0 (0%)	1 (1.6%)	
<i>Age at surgery</i>				0.7146
N	43 (81.1%)	15 (71.4%)	58 (78.4%)	
Mean (SD)	10 (18.9%)	6 (28.6%)	16 (21.6%)	
Median				0.4620
Q1, Q3	53	21	74	
Range	37.0 (17.54)	38.3 (17.40)	37.4 (17.39)	
	33.6	32.3	33.1	
<i>BMI</i>				
N	19.8, 51.0	21.9, 51.7	21.3, 51.7	
Mean (SD)	(12.6–78.6)	(11.7–73.6)	(11.7–78.6)	
Median				0.4620
Q1, Q3	52	20	72	
Range	24.8 (4.16)	23.7 (2.94)	24.5 (3.87)	
Median	24.0	23.1	23.8	
Q1, Q3	21.7, 27.0	21.7, 26.0	21.7, 26.6	
Range	(17.7–34.5)	(18.6–29.4)	(17.7–34.5)	

is now debated, as recent studies demonstrate a high complication rate due to pin migration, fixation failure, and infection causing many orthopedic surgeons to abandon this method [18,23].

Several treatment modalities for unstable distal clavicle fractures have been described, including intramedullary fixation[6], subcoracoid suture lasso[7], endo-button or suture anchor fixation [8,9], hook plating [16,17,19], coracoclavicular screw placement[20], locking t-plates combined with Suture

augmentation[21], and pre-contoured clavicular plates[24,25]. (Fig. 2, Fig. 3, Fig. 4) Endoscopic techniques have also been described [26,27].

This series retrospectively analyzed 74 distal clavicle fractures treated via either hook plate, pre-contoured clavicular plate, or suture fixation methods. Historically, all three treatment methods have displayed high union rates but with varying incidence of complications. A recent meta-analysis of 350 operatively-treated

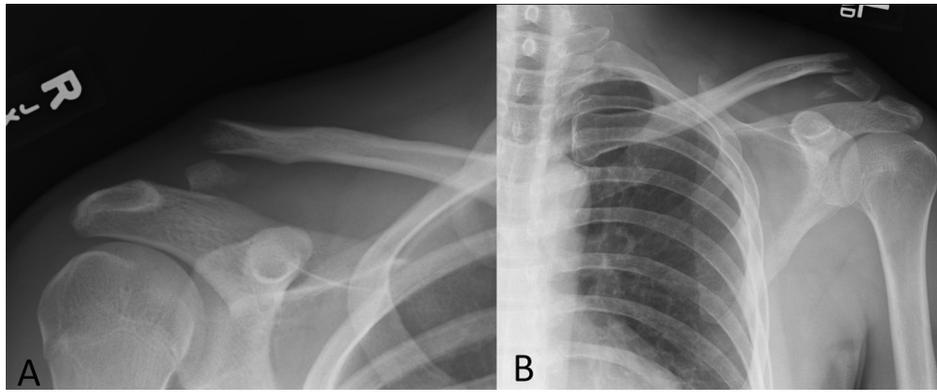


Fig. 1. Neer (A) Type II and (B) Type V distal clavicle fractures.

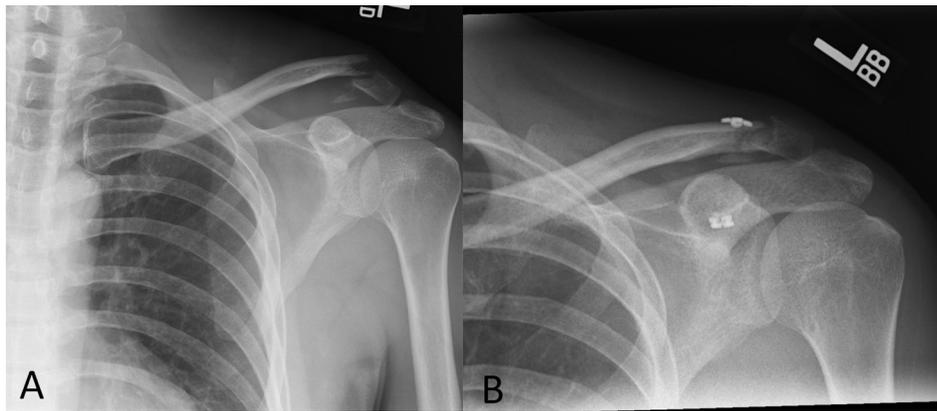


Fig. 2. Neer Type V distal clavicle fracture, treated with endo-button and suture fixation.

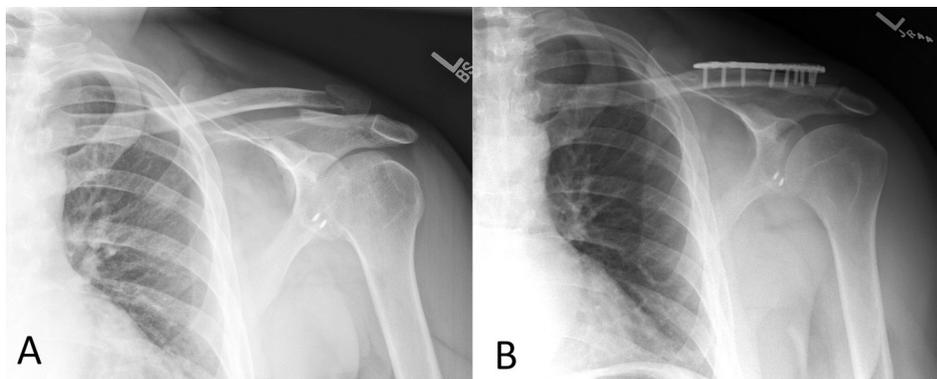


Fig. 3. Neer Type V distal clavicle fracture, treated with a pre-contoured clavicular locking plate.

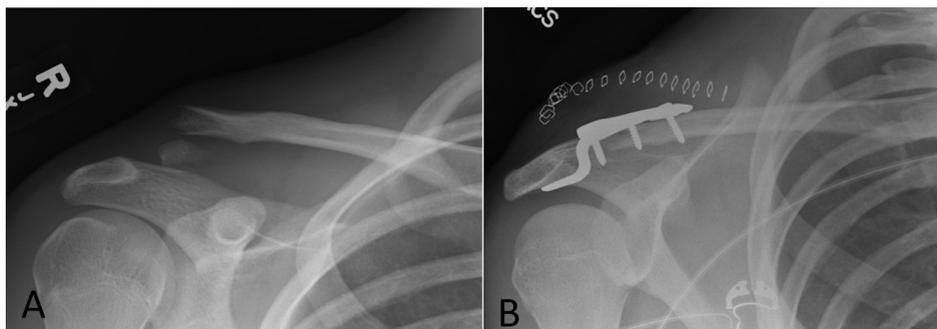


Fig. 4. Neer Type II distal clavicle fracture, treated with hook plate fixation.

patients reported a 98% union rate across 4 different treatment modalities and revealed a much higher risk of complications for hook plate fixation as compared to suture-only methods of fixation [5]. A high union rate (98.6%) was corroborated in our case series. One patient in the pre-contoured plate group exhibited hardware failure which required removal; this patient never achieved radiographic union. However, the patient was asymptomatic and required no further procedures at 2-year follow-up.

Despite the high rate of radiographic and clinical union in our series, nearly two-thirds of patients (10/16; 62.5%) treated with hook plates required hardware removal for irritation or impingement symptoms. By comparison, only 6/37 (16.2%) of patients with pre-contoured clavicular plates exhibited irritation requiring removal. No hardware removal was required in the suture fixation group (21 patients), however one fracture fixed with a tightrope method failed and required revision with a pre-contoured plate. This patient went on to union after locking plate fixation. Additionally, three suture-fixed patients suffered from adhesive capsulitis. All three were treated successfully with physical therapy and required no further surgical treatment.

It has been suggested that suture fixation of distal clavicle fractures avoids the need for metal implants, minimizes the need for re-operation, and has equivalent functional outcomes as compared to plate fixation methods [22,26–29]. This study supports the favorable side effect profile of suture fixation methods described in the two large meta-analyses of distal clavicle fixation [5,14]. Only one patient (4.8%) required a re-operation for fixation failure, and the remainder needed no further operations. Interestingly, the incidence of adhesive capsulitis was higher in the suture fixation cohort in our study than in the plate treated cohorts. This finding has not been extensively studied in the literature, and warrants further investigation.

Well-documented complications associated with hook plate fixation include acromial osteolysis, impingement, pain, hardware failure, and plate migration [14,30–32]. While this study showed no hardware failure or acromial fracture with hook plating, hook plates had a high rate of irritation requiring hardware removal. Some authors contend the hook plate should be routinely removed at 4 to 6 months post-operatively to avoid impingement or acromial wear [33]. This necessitates a second operation in all patients, and increases the operative exposure and expense. Alternatively, the use of a pre-contoured clavicular plate achieved a stable union in 97% of patients, with only 15% experiencing hardware irritation requiring removal. While the re-operation rate was higher compared to suture-only fixation methods, plate fixation of the clavicle is familiar to most orthopedic surgeons compared to the relatively newer suture fixation methods, and thus has a lower learning curve—an important consideration in treating this relatively uncommon fracture.

Overall, this case series displayed a high rate of union and low infection rate across all three studied fixation methods. Pre-contoured plate fixation and suture fixation methods had significantly lower re-operation rates compared to hook plate. Trans-osseous sutures had a higher rate of post-operative stiffness, but otherwise had the fewest complications of the three groups. Given the findings of this study, the authors would advise against the routine use of hook plates for primary surgical fixation of unstable distal clavicle fractures.

Disclosure of interest

The authors declare that they have no competing interest.

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Contributions

All co-authors contributed to the collection of data and writing of this article.

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