Predictors of Persistent Pain After Fixation of Distal Clavicle Fractures in an Active Military Population

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abstract

Patients who undergo open reduction and internal fixation of distal clavicle fractures have a high rate of hardware removal and persistence of symptoms, particularly when attempting to return to high-demand activities. This study evaluated the outcomes of military servicemembers after surgical treatment of distal clavicle fractures. The authors performed a retrospective analysis of active duty servicemembers who underwent open reduction and internal fixation of Neer type II distal clavicle fractures between October 17, 2007, and July 20, 2012, with a minimum of 2-year clinical follow-up. The electronic health record was queried to extract demographic features and clinical outcomes, primarily persistence of pain, removal of hardware, and postoperative return to high-level activity. A total of 48 patients were identified, with mean follow-up of 3.8 years. A total of 44% of patients underwent subsequent hardware removal. All fractures achieved radiographic union, and 35% of patients had persistence of symptoms. Patients who were treated with hook plating had a 3.64-fold higher risk of persistence of pain compared with those treated with conventional plating techniques. A total of 35% of patients successfully returned to full military function and completed a postoperative military deployment. Coracoclavicular reconstruction did not improve outcomes. Persistence of symptoms and requirement for hardware removal were not associated with the rate of postoperative deployment. Achieving excellent functional outcomes with open reduction and internal fixation of distal clavicle fractures remains a challenge. Where possible, conventional plate fixation should be considered over hook plate fixation. However, subsequent hardware removal and continuing shoulder pain do not preclude a return to high-level activity. [*Orthopedics.* 201x; xx(x):xx-xx.]

Accounting for 2.6% to 4% of all fractures, clavicle fractures are among the most common fractures in the United States, with 5.8 clavicle fractures occurring per 10,000 individuals per year.[1-3] Within a military population, the incidence of clavicle fractures increases to 9.1 per 10,000 individuals per year, posing a significant threat to patient function and medical readiness.[4] Larger epidemiologic studies have shown that 69% to 85% of clavicle fractures involve the middle one-third of the clavicle, and distal clavicle fractures may occur in 10% to 28% of cases.[3,5-7] Operative management of midshaft clavicle fractures leads to significant functional limitations in up to 25% of military patients 1 year postopera-

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Table 1

Patient Demographics and Clinical Profile

Variable	Value
Patients, Total No.	48
Age, y	
Mean	30.33
Range	19.98-50.82
Laterality, No.	
Left	25 (52%)
Right	23 (48%)
Sex, male/female, No.	45 (94%)/3 (6%)
Military rank, No.	
Junior enlisted	7 (15%)
Senior enlisted	27 (56%)
Warrant officer/officer	14 (29%)
Branch of military service, No.	
Marines	9 (19%)
Army	16 (33%)
Navy	9 (19%)
Air Force	14 (29%)
Tobacco use, No.	22 (46%)
Mechanism of injury, No.	
Sports	23 (48%)
Motor vehicle	16 (33%)
Fall	8 (17%)
Military trauma	1 (2%)
Open fracture, No.	1 (2%)
Associated procedures, No.	
Coracoclavicular fixation	9 (19%)
Body mass index, kg/m^2, No.	
18.5-24.9	18 (38%)
25-29.9	27 (56%)
≥30	3 (6%)
Occupation, No.	
Combat arms	15 (31%)
Non-combat arms	24 (50%)
Unknown	9 (19%)
Fixation construct, No.	
Hook plate	12 (25%)
Non-hook plate	36 (75%)
Coracoclavicular screw	1 (2%)
Concomitant injuries, No.	
Rib fractures	3 (6%)
Pneumothorax	2 (4%)
Transverse process fractures	1 (2%)
Loss of consciousness	1 (2%)

tively, but the outcomes of distal clavicle fractures have not been elucidated.[8]

Traditionally, distal clavicle fractures have been classified based on the fracture location relative to the coracoclavicular ligaments and acromioclavicular articulation, as described by Neer.[5] However, treatment of these fractures can vary significantly, depending on fracture subtype, coracoclavicular ligament integrity, articular involvement, degree of cephalad displacement, and associated injuries to the superior shoulder suspensory complex.[5,9] Further, distal clavicle fractures are inherently more difficult to address and may have increased surgical site morbidity, largely because of the limited distal clavicle bone stock, associated ligamentous or soft tissue injury, and minimal soft tissue envelope.[9] As a result, multiple techniques have been described with the use of a variety of implants in an attempt to optimize fixation and patient-reported function.[2,3,9-12] The purpose of this study was to characterize the surgical results of open reduction and internal fixation (ORIF) of type II distal clavicle fractures in a military cohort and to identify risk factors associated with suboptimal functional outcomes.

Materials and Methods

Institutional review board approval was obtained for this study to ensure protection of all human subjects. All US military servicemembers undergoing acute primary ORIF for distal one-third clavicle fracture (*International Classification of Diseases, Ninth Edition,* code 810.03) at military treatment facilities between October 17, 2007, and July 20, 2012, were identified from the Military Health Systemic Management Analysis and Reporting Tool database. Inclusion criteria were applied to all active duty military patients who had a confirmed Neer type II clavicle fracture and a minimum of 2-year follow-up. Based on the Neer type II classification, all fractures were considered unstable and met the indications for surgery. Exclusion criteria were nonmilitary beneficiary status; insufficient follow-up (ie, <2 years); miscoding or incorrect classification; and concomitant fracture of the scapula, acromion, and/or coracoid. Data were extracted from the Department of Defense electronic medical record (Armed Forces Health Longitudinal Technology Application [AHLTA], version 3.3) for age, sex, military rank, branch of military service, tobacco use, body mass index, laterality, mechanism of injury, concomitant procedures, associated injuries, and medical comorbidities. Additionally, radiographic and clinical outcomes were derived from the electronic health record, including perioperative complications, fracture union, surgical implant, subsequent implant removal or other secondary surgery, persistence of symptoms, and duration of clinical follow-up. In addition, the Defense Manpower Data Center database was queried to identify military service association, military occupation specialty (ie, military function), postoperative combat deployment, and presence of military separation date and rationale for discharge (eg, medical, administrative, or routine).

Of note, US military servicemembers must adhere to defined standards for medical and physical fitness, such as those stipulated under Army Regulation 40-501 (Headquarters, Department of the Army, Washington, DC). These regulations are specific to each branch of military service, but generally require successful completion of biannual physical fitness testing and periodic combat deployment. Military duty limitations are often reflected in the electronic medical record and/or physical profile system, allowing investigators to more accurately characterize persistence of symptoms and specific restrictions on activity. Conversely, continuing active military service and performance and completion of postoperative combat deployment after clavicle fixation connote a high level of postoperative function and a return to a moderate- to high-demand occupational activity.

Statistical Analysis

Univariate analysis was performed to determine the association between the identified variables and 3 defined end points: persistence of pain, hardware removal, and postoperative return to high-level activity (deployment). Odds ratios with 95% confidence intervals were quantified for further analysis. Significant independent predictors were determined to be those that maintained P<.05, with odds ratios and 95% confidence intervals that excluded 1.0. Calculations were performed with SAS version 9.2 software (SAS Institute Inc, Cary, North Carolina), with the assistance of a biostatistician.

Results

Demographics and Surgical Variables

A total of 48 patients were identified with ORIF for Neer type II distal clavicle fractures at a mean follow-up of 3.8 years (range, 2.0-6.7 years). Demographics and injury characteristics are listed in **Table 1**. The patient group comprised primarily young (mean age, 30.33 years; range, 19.98-50.82 years) men (94%) of enlisted military rank (71%). Sporting activity (48%) and motor vehicle collisions (33%) were the predominant mechanisms of injury. Fixation was achieved with standard distal clavicle plates for 36 patients (75%), whereas 12 patients (25%) were treated with hook plates (**Figure**). Additionally, 19% (n=9) of patients underwent coracoclavicular ligament repair.

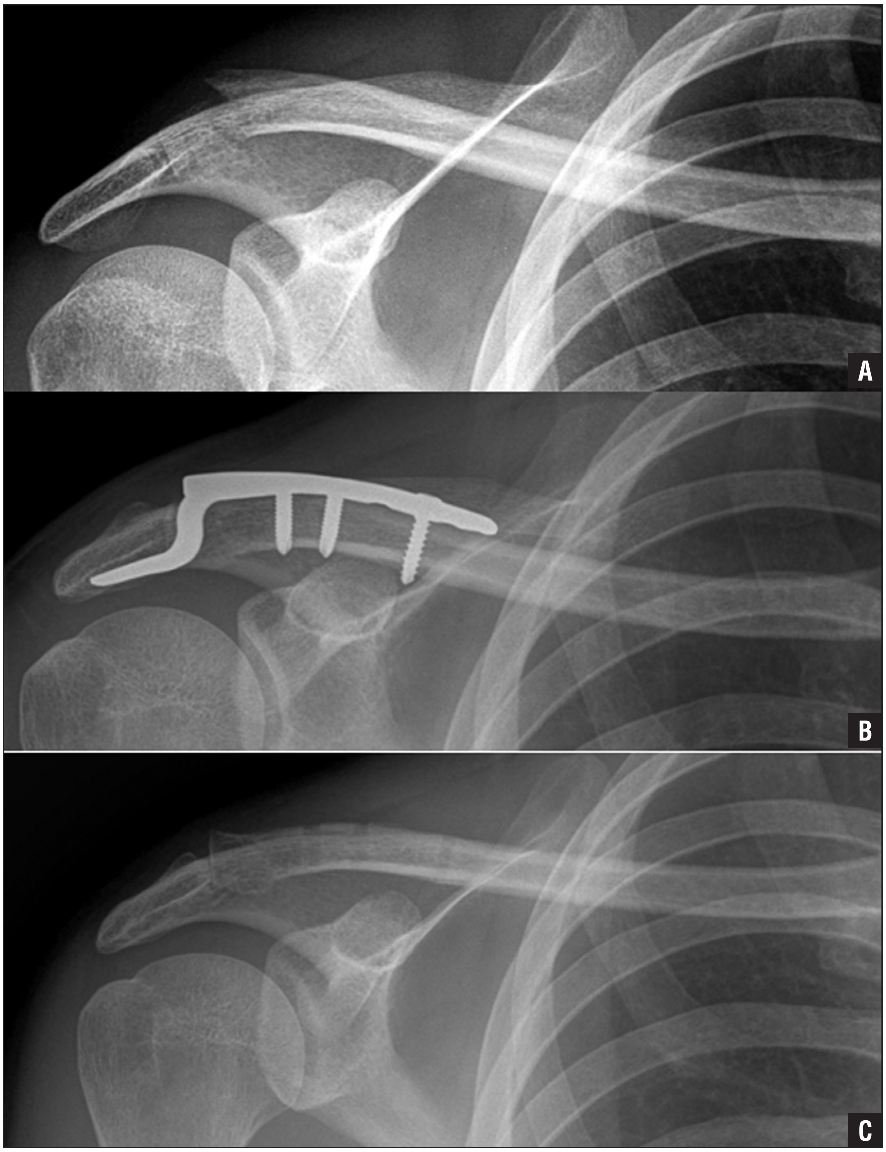

Figure: Anteroposterior radiographs showing distal clavicle fracture injury (A), hook plate fixation with radiographic healing (B), and appearance after hook plate removal (C).

Radiographic and Clinical Outcomes

All fractures (100%) achieved radiographic union, although 2 (4%) were identified as delayed unions. However, both delayed unions achieved union (1 at 9 months postoperatively and 1 at 14 months postoperatively). In addition to the 2 patients who had delayed union, 4 patients had perioperative complications, including 2 (4.2%) with symptomatic heterotopic ossification of the acromioclavicular joint, 1 (2.1%) with inadvertent asymptomatic intra-articular screw placement, and 1 (2.1%) with painful adhesive capsulitis. A total of 44% (n=21) of the study patients required implant removal, including all patients with planned removal of hook plate fixation (n=12; 100%; **Figure**) and 25% (n=9) with standard distal clavicle plates. Hook plates were removed at a mean of 6.1 months postoperatively (range, 3.0-12 months). Stan-

Table 2

Risk Factors for Persistent Symptoms[a]

Risk Factor	Value	Persistent Symptoms	Asymptomatic	Odds Ratio (95% CI)	*P*
Age, y					
Mean±SD	30.3±7.8	30.1±7.5	30.5±8.1	1.00 (0.92-1.07)	.8915
<30, No.	25 (52.1%)	9 (36.0%)	16 (64.0%)	1.05 (0.32-3.45)	.9298
≥30, No.	23 (47.9%)	8 (34.8%)	15 (65.2%)	-	
Sex, No.					
Male	45 (93.8%)	16 (35.6%)	29 (64.4%)	1.10 (0.09-13.14)	.9379
Female	3 (6.2%)	1 (33.3%)	2 (66.7%)		
Body mass index, kg/m^2					
Mean±SD	25.0±7.8	25.7±2.9	24.5±2.3	1.21 (0.95-1.54)	.1236
<30, No.	45 (93.8%)	15 (33.3%)	30 (66.7%)	0.25 (0.02-2.98)	.2731
≥30, No.	3 (6.2%)	2 (66.7%)	1 (33.3%)	-	
Tobacco use, No.					
Yes	22 (45.8%)	6 (27.3%)	16 (72.7%)	0.51 (0.15-1.73)	.2809
No	26 (54.2%)	11 (42.3%)	15 (57.7%)	-	
Servicemember rank, No.					
Junior enlisted (E1-E4)	7 (14.6%)	2 (28.6%)	5 (71.4%)	1.47 (0.18-11.72)	.8659
Senior enlisted (≥E5)	27 (56.2%)	12 (44.4%)	15 (55.6%)	2.93 (0.66-12.95)	.1778
Officer/warrant officer	14 (29.2%)	3 (21.4%)	11 (78.6%)	-	
Branch of service, No.					
Army	16 (33.3%)	6 (37.5%)	10 (62.5%)	0.80 (0.19-3.46)	.7203
Marines	9 (18.8%)	2 (22.2%)	7 (77.8%)	0.38 (0.06-2.53)	.3863
Navy	9 (18.8%)	3 (33.3%)	6 (66.7%)	0.67 (0.12-3.81)	.9906
Air Force	14 (29.2%)	6 (42.9%)	8 (57.1%)	-	
Fracture fixation type, No.					
Hook plate	12 (25.0%)	7 (58.3%)	5 (41.7%)	3.64 (0.93-14.18)	.0626
Non-hook plate	36 (75.0%)	10 (27.8%)	26 (72.2%)	-	
Laterality, No.					
Right	23 (47.9%)	7 (30.4%)	16 (69.6%)	0.66 (0.20-2.17)	.4898
Left	25 (52.1%)	10 (40.0%)	15 (60.0%)	-	
Mechanism of injury, No.					
High energy	42 (87.5%)	16 (38.1%)	26 (61.9%)	3.08 (0.33-28.77)	.3244
Low energy	6 (12.5%)	1 (16.7%)	5 (83.3%)	-	
Open/closed, No.					
Open	1 (2.1%)	0 (0.0%)	1 (100.0%)	0.38 (0.01-65.63)	.7108
Closed	47 (97.9%)	17 (36.2%)	30 (63.8%)	-	
Associated procedures, No.					
Coracoclavicular fixation	9 (18.8%)	3 (33.3%)	6 (66.7%)	0.89 (0.19-4.13)	.8848
No coracoclavicular fixation	39 (81.2%)	14 (35.9%)	25 (64.1%)	-	
Union, No.					
Union	46 (95.8%)	17 (37.0%)	29 (63.0%)	2.96 (0.07-128.08)	.5717

Table 2 (cont'd)

Risk Factors for Persistent Symptoms[a]

Risk Factor	Value	Persistent Symptoms	Asymptomatic	Odds Ratio (95% CI)	*P*
Delayed	2 (4.2%)	0 (0.0%)	2 (100.0%)	-	
Hardware removal, No.					
Yes	21 (43.8%)	10 (47.6%)	11 (52.4%)	2.60 (0.77-8.75)	.1234
No	27 (56.2%)	7 (25.9%)	20 (74.1%)	-	
Postoperative deployment, No.					
Yes	17 (35.4%)	5 (29.4%)	12 (70.6%)	0.66 (0.18-2.35)	.5207
No	31 (64.6%)	12 (38.7%)	19 (61.3%)	-	
Occupation, No.					
Combat arms	15 (31.2%)	5 (33.3%)	10 (66.7%)	0.70 (0.18-2.69)	.6034
Non-combat arms	24 (50.0%)	10 (41.7%)	14 (58.3%)	-	
Unspecified	9 (18.8%)	2 (22.2%)	7 (77.8%)	-	

Abbreviation: CI, confidence interval.
[a]Dashes indicate referent group, for which there is no value.

dard distal clavicle plates were removed for symptomatic prominence or pain at a mean of 15 months postoperatively (range, 2.5-47 months). Of all patients, 35% (n=17) had persistence of symptoms, including those with heterotopic ossification, those with adhesive capsulitis, and 1 with delayed union. Mean follow-up after implant removal, assessing for persistence of pain, was 3.2 years. Postoperatively, 35% (n=17) of the patients successfully completed a combat deployment without incident. Two patients were excluded from continuing in military service because of persistent limitations caused by their injury.

Univariate Analysis

When implant choice was compared, the rate of symptom persistence was higher among those treated with hook plates (58.3%, n=7) than among those with standard plating (27.8%, n=10), even after hardware removal (95% confidence interval, 0.93-14.18; *P*=.0626) (**Table 2**), and this difference approached statistical significance. Additionally, there was a trend toward increased symptom persistence at final follow-up among patients with hardware removal (47.6%) vs those with hardware retention (25.9%), and this difference approached statistical significance (*P*=.1234). When patients treated with and without coracoclavicular ligament repair were compared, no statistical difference was found for persistence of pain (*P*=.8848). However, no significant difference was found for the rate of completion of postoperative deployment with or without hardware removal (47.6% and 25.9%, respectively; *P*=.1234). Increased body mass index was associated with a trend toward inability to complete a combat deployment (odds ratio, 0.77; 95% confidence interval, 0.59-1.01; *P*=.0598) (**Table 3**). Further, the presence of persistent pain was not associated with the rate of postoperative deployment (odds ratio, 0.66; 95% confidence interval, 0.18-2.35; *P*=.5207). The presence of a hook plate was the only variable that was significantly associated with implant removal (**Table 4**).

Discussion

Neer type I and type III fractures are often considered stable and amenable to nonoperative management.[9] However, Neer type II fractures involving coracoclavicular ligaments are often inherently unstable and may require operative reduction and fixation to correct significant medial fragment displacement. However, there is no current gold standard for the treatment of these fractures.[3,12] Although nonsurgical treatment of Neer type II distal clavicle fractures has shown satisfactory outcomes for pain, function, and postinjury strength, there is a corresponding increase in the incidence of symptomatic nonunion, cosmetic deformity, and the need for delayed surgery.[13,14]

A significant consideration with Neer type II fractures is the higher rate of nonunion.[9] Frequently, this has been cited as a primary indication for operative management, and ORIF has a predictably high rate of union. In the current series, all fractures achieved successful radiographic union, with delayed healing occurring in only 4%. This finding is consistent with the findings of other studies that used precontoured or hook plating.[11,15] Lee et al[15] reported that all displaced distal clavicle fractures that were fixed with a locking plate achieved osseous union at a mean of 4.1 months. Similarly, in a meta-analysis

Table 3

Univariate Analysis of Risk Factors Associated With Inability to Return to Combat Military Deployment[a]

Risk Factor	Value	Deployment	No Deployment	Odds Ratio (95% CI)	*P*
Age, y					
Mean±SD	30.3±7.8	30.0±7.2	30.5±8.2	0.99 (0.92-1.07)	.8187
<30, No.	25 (52.1%)	9 (36.0%)	16 (64.0%)	1.05 (0.32-3.45)	.9298
≥30, No.	23 (47.9%)	8 (34.8%)	15 (65.2%)	-	
Sex, No.					
Male	45 (93.8%)	14 (31.1%)	31 (68.9%)	0.09 (0.01-2.05)	.1297
Female	3 (6.2%)	3 (100.0%)	0 (0.0%)	-	
Body mass index, kg/m^2					
Mean±SD	25.0±7.8	24.0±2.7	25.5±2.4	0.77 (0.59-1.01)	.0598
<30, No.	45 (93.8%)	17 (37.8%)	28 (62.2%)	4.27 (0.13-135.80)	.4114
≥30, No.	3 (6.2%)	0 (0.0%)	3 (100.0%)	-	
Tobacco use, No.					
Yes	22 (45.8%)	8 (36.4%)	14 (63.6%)	1.08 (0.33-3.53)	.8996
No	26 (54.2%)	9 (34.6%)	17 (65.4%)	-	
Servicemember rank, No.					
Junior enlisted (E1-E4)	7 (14.6%)	2 (28.6%)	5 (71.4%)	0.40 (0.06-2.80)	.5923
Senior enlisted (≥E5)	27 (56.2%)	8 (29.6%)	19 (70.4%)	0.42 (0.11-1.60)	.5321
Officer/warrant officer	14 (29.2%)	7 (50.0%)	7 (50.0%)	-	
Branch of service, No.					
Army	16 (33.3%)	4 (25.0%)	12 (75.0%)	0.60 (0.12-2.89)	.2783
Marines	9 (18.8%)	3 (33.3%)	6 (66.7%)	0.90 (0.15-5.26)	.7945
Navy	9 (18.8%)	5 (55.6%)	4 (44.4%)	2.25 (0.41-12.44)	.1810
Air Force	14 (29.2%)	5 (35.8%)	9 (64.3%)	-	
Fracture fixation type, No.					
Hook plate	12 (25.0%)	6 (50.0%)	6 (50.0%)	2.27 (0.60-8.64)	.2282
Non-hook plate	36 (75.0%)	11 (30.6%)	25 (69.4%)	-	
Laterality, No.					
Right	23 (47.9%)	9 (39.1%)	14 (60.9%)	1.37 (0.42-4.47)	.6063
Left	25 (52.1%)	8 (32.0%)	17 (68.0%)	-	
Mechanism of injury, No.					
High energy	42 (87.5%)	16 (38.1%)	26 (61.9%)	3.08 (0.33-28.77)	.3244
Low energy	6 (12.5%)	1 (16.7%)	5 (83.3%)	-	
Open/closed, No.					
Open	1 (2.1%)	0 (0.0%)	1 (100.0%)	0.38 (0.01-65.63)	.7108
Closed	47 (97.9%)	17 (36.2%)	30 (63.8%)	-	
Associated procedures, No.					
Coracoclavicular fixation	9 (18.8%)	5 (55.6%)	4 (44.4%)	2.81 (0.64-12.36)	.1710
No coracoclavicular fixation	39 (81.2%)	12 (30.8%)	27 (69.2%)	-	
Union, No.					
Union	46 (95.8%)	16 (34.8%)	30 (65.2%)	0.54 (0.03-9.23)	.6711
Delayed	2 (4.2%)	1 (50.0%)	1 (50.0%)	-	

Table 3 (cont'd)

Univariate Analysis of Risk Factors Associated With Inability to Return to Combat Military Deployment[a]

Risk Factor	Value	Deployment	No Deployment	Odds Ratio (95% CI)	*P*
Hardware removal, No.					
Yes	21 (43.8%)	10 (47.6%)	11 (52.4%)	2.60 (0.77-8.75)	.1234
No	27 (56.2%)	7 (25.9%)	20 (74.1%)	-	
Symptoms, No.					
Yes	17 (35.4%)	5 (29.4%)	12 (70.6%)	0.66 (0.18-2.35)	.5207
No	31 (64.6%)	12 (38.7%)	19 (61.3%)	-	
Occupation, No.					
Combat arms	15 (31.2%)	8 (53.3%)	7 (46.7%)	1.90 (0.52-7.05)	.3344
Non-combat arms	24 (50.0%)	9 (37.5%)	15 (62.5%)	-	
Unspecified	9 (18.8%)	0 (0%)	9 (100.0%)	-	

Abbreviation: CI, confidence interval.
[a]Dashes indicate referent group, for which there is no value.

of 350 patients who underwent ORIF for distal clavicle fractures, 98% of patients achieved union with standard or hook plating and only 1 patient had delayed union.[11]

Although radiographic union is achievable regardless of the method of fixation, clinical outcomes are far more variable and are related to implant selection. Although the current cohort used only standard, precontoured, or hook plate fixation, other constructs may include coracoclavicular ligament stabilization, intramedullary fixation, interfragmentary lag screw fixation, and tension band wiring.[2,16] Stegeman et al[11] showed that hook plate fixation was associated with a significantly higher rate of complications compared with other operative treatments, with rates of major complications as high as 41%.[2] Similarly, hook plate use may contribute to persistent postoperative pain. Lin et al[17] used ultrasonography to identify significant rates of subacromial shoulder impingement and rotator cuff pathology after hook plate treatment, and both of these contributed to continued shoulder pain. Gu et al[18] supported these findings with arthroscopic evaluation of symptomatic patients who were treated with hook plating and reported high corresponding rates of rotator cuff compression caused by prominent subacromial plate position with secondary impingement. Other authors have also reported secondary acromiolysis, or complete transacromial erosion,[19-21] that prompted high rates of symptomatic implant removal.[11,12] Accordingly, the current authors recommend routine removal of hook plates to mitigate secondary surgical site morbidity, with optimal results seen with implant removal before 6 months postoperatively.[22,23]

In contrast to earlier series, the current study showed that pain associated with hook plate fixation may persist well after implant removal. Lin et al[17] stated that symptoms were greatly improved 1 month after hook plate removal. Tan et al[24] reported similar findings among 42 patients with mean 22-month follow-up, indicating that shoulder pain and function were vastly improved after implant removal. In the current series, an astounding 58% of patients who were treated with a hook plate showed continued shoulder symptoms at a mean 3.8 years of follow-up, despite hook plate removal. Although the exact cause of this pain is unknown, a return to higher-demand overhead activities within the military population may exacerbate the persistent deleterious effects of hook plate use.

Because of the instability of the medial fragment in Neer type II fractures, additional techniques have been developed to repair or reconstruct the native coracoclavicular ligaments. Studies have shown that the combined construct of the locking distal clavicle plate and coracoclavicular ligament reconstruction results in decreased fracture displacement compared with treatment with a locking plate alone.[22,25] Other studies have shown that interfragmentary and coracoclavicular suture fixation also have excellent rates of union, low rates of perioperative complications, and high patient satisfaction.[26] Functional outcomes are also reassuring with coracoclavicular ligament repair as part of the treatment of distal clavicle fractures. In a study of young, active male patients, arthroscopic fixation with an adjustable cortical suture button restored all patients to normal range of motion and previous sporting activity by 6 months postoperatively.[27] When the outcomes of those treated with (33%) and without synthetic coracoclavicular ligament repair were analyzed in the current study, no

Table 4

Risk Factors That Affect Implant Removal[a]

Risk Factor	Value	Hardware Removal	No Hardware Removal	Odds Ratio (95% CI)	*P*
Age, y					
Mean±SD	30.3±7.8	30.4±8.3	30.3±7.6	1.00 (0.93-1.08)	.9343
<30, No.	25 (52.1%)	10 (40.0%)	15 (60.0%)	0.73 (0.23-2.28)	.5855
≥30, No.	23 (47.9%)	11 (47.8%)	12 (52.2%)	-	
Sex, No.					
Male	45 (93.8%)	19 (42.2%)	26 (57.8%)	0.37 (0.03-4.33)	.4248
Female	3 (6.2%)	2 (66.7%)	1 (33.3%)	-	
Body mass index, kg/m^2					
Mean±SD	25.0±7.8	25.4±2.9	24.6±2.4	1.12 (0.89-1.40)	.3382
<30, No.	45 (93.8%)	19 (42.2%)	26 (57.8%)	0.37 (0.03-4.33)	.4248
≥30, No.	3 (6.2%)	2 (66.7%)	1 (33.3%)	-	
Tobacco use, No.					
Yes	22 (45.8%)	12 (54.5%)	10 (45.5%)	2.27 (0.71-7.27)	.1686
No	26 (54.2%)	9 (34.6%)	17 (65.4%)	-	
Servicemember rank, No.					
Junior enlisted (E1-E4)	7 (14.6%)	4 (57.1%)	3 (42.9%)	1.78 (0.28-11.12)	.4577
Senior enlisted (≥E5)	27 (56.2%)	11 (40.7%)	16 (59.3%)	0.92 (0.25-3.39)	.5391
Officer/warrant officer	14 (29.2%)	6 (42.9%)	8 (57.1%)	-	
Branch of service, No.					
Army	16 (33.3%)	8 (50.0%)	8 (50.0%)	2.50 (0.55-11.41)	.6243
Marines	9 (18.8%)	4 (44.4%)	5 (55.6%)	2.00 (0.35-11.54)	.9916
Navy	9 (18.8%)	5 (55.6%)	4 (44.4%)	3.13 (0.54-18.04)	.4231
Air Force	14 (29.2%)	4 (28.6%)	10 (71.4%)	-	
Fracture fixation type, No.					
Hook plate	12 (25.0%)	12 (100.0%)	0 (0.0%)	72.36 (3.48-1000.00)	.0057
Non-hook plate	36 (75.0%)	9 (25.0%)	27 (75.0%)	-	
Laterality, No.					
Right	23 (47.9%)	10 (43.5%)	13 (56.5%)	0.98 (0.31-3.07)	.9710
Left	25 (52.1%)	11 (44.0%)	14 (56.0%)	-	
Mechanism of injury, No.					
High energy	42 (87.5%)	21 (50.0%)	21 (50.0%)	13.00 (0.55-308.14)	.1122
Low energy	6 (12.5%)	0 (0.0%)	6 (100.0%)	-	
Open/closed, No.					
Open	1 (2.1%)	1 (100.0%)	0 (0.0%)	13.06 (0.02-1000.00)	.4567
Closed	47 (97.9%)	20 (42.6%)	27 (57.4%)	-	
Associated procedures, No.					
Coracoclavicular fixation	9 (18.8%)	4 (44.4%)	5 (55.6%)	1.04 (0.24-4.46)	.9628
No coracoclavicular fixation	39 (81.2%)	17 (43.6%)	22 (56.4%)	-	
Union, No.					
Union	46 (95.8%)	21 (45.7%)	25 (54.3%)	4.21 (0.10-181.47)	.4538

Table 4 (cont'd)

Risk Factors That Affect Implant Removal[a]

Risk Factor	Value	Hardware Removal	No Hardware Removal	Odds Ratio (95% CI)	*P*
Delayed	2 (4.2%)	0 (0.0%)	2 (100.0%)	-	
Symptoms, No.					
Yes	17 (35.4%)	10 (58.8%)	7 (41.2%)	2.60 (0.77-8.75)	.1234
No	31 (64.6%)	11 (35.5%)	20 (64.5%)	-	
Postoperative deployment, No.					
Yes	17 (35.4%)	10 (58.8%)	7 (41.2%)	2.60 (0.77-8.75)	.1234
No	31 (64.6%)	11 (35.5%)	20 (64.5%)	-	
Occupation, No.					
Combat arms	15 (31.2%)	5 (33.3%)	10 (66.7%)	0.42 (0.11-1.62)	.2086
Non-combat arms	24 (50.0%)	13 (54.2%)	11 (45.8%)	-	
Unspecified	9 (18.8%)	3 (33.3%)	6 (66.7%)	-	

Abbreviation: CI, confidence interval.
[a]Dashes indicate referent group, for which there is no value.

statistical difference was found regarding persistence of pain or hardware removal. As a result, coracoclavicular ligament repair with a synthetic suture button device or formal ligament reconstruction may be a reasonable alternative to hook plate fixation; furthermore, this obviates the need for routine hardware removal and does not increase the risk of adverse outcomes.

Limitations

The current study had certain limitations. By design, this study relied on the accuracy of the electronic medical record, thereby limiting available outcome measures or study variables. Because of the limited number of patients in the database, the study was potentially underpowered, which limited the ability to elucidate differences by specific variables of interest. Additionally, the Neer classification was extrapolated from the electronic medical record and available imaging but could not be confirmed independently on radiographic studies for all of the patients. However, fracture type does not always determine individual surgical indications or implant selection. A study by Bishop et al[28] showed that the decision to operate on distal clavicle fractures was largely determined by the surgeon's assessment of fracture stability rather than the Neer classification or the size of the distal clavicle fracture fragment. Another consideration is that the indications for standard clavicle plates vs hook plates are variable, making direct comparison of treatment groups and outcomes difficult. Additionally, this study did not include a control group with nonoperative treatment. Further prospective randomized implant selection could clarify this potential bias for fixing specific fracture patterns with certain implants. Finally, military duties and demands may preclude external validity because of the highly specific nature of the work.

In terms of strengths, this study accurately captured rates of return to a high level of function within a closed health care network. This is the first study to characterize outcomes with different surgical methods for the management of Neer type II clavicle fractures within an active military population. In general, this demographic endures a significantly higher rate of upper extremity, load-bearing activity compared with the general population, and these demands are heightened during combat deployment. These functional and occupational end points may serve as a proxy for return to high levels of athletic activity among active civilian populations.

Conclusion

The optimal surgical management of unstable distal clavicle fractures remains a challenge. The current findings suggest that standard plate fixation should be considered over hook plating when possible because hook plating is associated with increased risk of persistent painful symptoms, irrespective of routine implant removal. More importantly, this study suggest that secondary hardware removal and persistence of pain were not significant factors in return to high levels of physical activity within the military setting and that other factors may play a larger role than chronic pain in the return to high levels of activity.

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