Performance of Military Tasks After Clavicle Plating

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ABSTRACT Management of displaced midshaft clavicle fractures in the military, a largely shoulder-bearing population, is controversial. We aimed to report the military-relevant functional outcomes after plate fixation. We performed a nested cross-sectional analysis of active duty service members enrolled in an ongoing multicenter, randomized trial on clavicle plating. For this analysis, we included subjects with ≥6 months follow-up. Outcome measures included radiographic appearance, physical examination, a military-specific questionnaire, and validated shoulder surveys. Mean follow-up for 28 clavicle fractures was 13 months. Union rate by 12 weeks was 93% (26/28). There was one case of soft tissue irritation requiring hardware removal. At latest follow-up, 75% of patients were satisfied; 68% had mild/no pain; 79% had full range of motion; 75% could perform push-ups; and 21% have deployed. For the majority of active duty personnel, rapid healing, return to military-specific tasks, and satisfaction with outcome are possible after plate fixation of clavicle fractures. However, approximately 25% report some functional limitations at 1 year.

INTRODUCTION

Clavicle fractures are commonly sustained by active duty service members during military training, combat, and recreational activities. In the general population, these fractures account for up to 5% of adult fractures and 35% of shoulder girdle injuries.[1–3] Given the nature and demands of the military profession, it is not surprising that for servicemen and women, the incidence is higher than that of the general population. The functional outcomes and complications from management of these injuries in military subjects are of particular importance since their duties place specific and significant demands on the clavicle, such as performing push-ups, firing a rifle, and wearing shoulder-borne gear/equipment.

For displaced midshaft clavicle fractures, there is an ongoing trend in the civilian literature toward operative fixation with increasing recognition of the limitations of nonoperative management, as demonstrated by higher nonunion rates and poorer patient-oriented outcomes.[4,5] Dramatic pain relief after surgical stabilization may facilitate early mobilization and early return to activities, which are major benefits for active individuals.

A variety of methods for operative treatment of midshaft clavicle fractures have been described, including open reduction and plating,[6–8] intramedullary fixation,[9–11] and external fixation.[12] Plate osteosynthesis is the most commonly utilized treatment; advantages include rigid stabilization, cortical compression, and rotational control of the fracture.[13] This fixation method, however, has a known association with soft tissue irritation related to hardware prominence that sometimes necessitates removal.[6,7,14] On the other hand, malunion and fracture callous associated with nonoperative treatment are not uncommon and can lead to similar symptoms seen with prominence from plating.

The military is a unique population whose members require the frequent and repetitive use of shoulder-bearing equipment (i.e., load-bearing equipment, individual body armor, rucksack, etc.). These added demands raise concern for a theoretically higher risk of function-limiting hardware prominence in active duty service members. For this reason, management of displaced clavicle fractures in the military remains controversial. The potential for symptomatic hardware to limit the mission capabilities of our service members has created debate as to the optimal fixation for displaced clavicle fractures. To date, no published studies have looked specifically at satisfaction and ability to perform military tasks after clavicle plating in our uniquely shoulder-bearing population.

The purpose of this study was to determine the early patient-derived and military-specific outcomes of plate fixation of displaced midshaft clavicle fractures in an active duty population.

MATERIALS AND METHODS

Study Design

In March 2007, a multicenter, prospective randomized controlled trial (PRCT) of midshaft clavicle fractures undergoing open reduction and internal fixation was initiated at Brooke Army Medical Center and William Beaumont Army Medical Center to compare the rate of soft tissue irritation associated

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with superior versus anterior-inferior plate position. While this PRCT is ongoing, we performed this substudy of military performance. It is a nested cross-sectional descriptive analysis of outcomes of all study subjects enrolled in the parent study with at least 6-month follow-up. The same patient selection criteria, surgical protocol, and outcome measures used for the larger PRCT were used for this study. Approval from the institutional review board was obtained at both participating study sites, and informed consent was obtained from all study participants.

Patient Selection

Inclusion criteria were: (1) active duty or activated Reserve or National Guard service member, (2) presence of a completely displaced midshaft fracture of the clavicle (no cortical contact between the main proximal and distal fragments [Fig. 1]), and (3) no medical contraindication to general anesthesia.

Exclusion criteria were: (1) age less than 18 years or greater than 65 years, (2) fracture in the proximal or distal third of the clavicle not amenable to plating, (3) pathologic fracture, (4) associated head injury (Glasgow Coma Scale score of <15 at 21 days after injury), (5) an inability to comply with follow-up, and (6) a medical contraindication to surgery and/or anesthesia. For this descriptive study, we excluded patients with less than 6-month follow-up and those with nonacute clavicle fractures (i.e., nonunions, malunions).

Treatment Protocol

All patients underwent surgical fixation of their clavicle fracture following a standard protocol as described below. Surgery was performed by four orthopedic staff surgeons, two at each institution.

All operations were performed with the patient in the supine position with arms tucked and the bed in reverse Trendelenburg position (Fig. 2). A transverse skin incision was made and the supraclavicular nerves were preserved as much as possible. Careful soft tissue handling was used with approximately 2 mm of periosteal excision only at the fracture site; no intentional periosteal stripping was performed. Direct reduction was then performed and held with clamps, k-wires, or interfragmentary screws (Fig. 3).

FIGURE 1. Radiograph of completely displaced midshaft clavicle fracture.

Precontoured 3.5-mm clavicle-locking plates (Peri Loc; Smith and Nephew, Memphis, TN) were used for fixation in all patients. The plates were placed in either the superior or anterior-inferior position. A minimum of three screws were placed in the main proximal and distal fragments. The clavipectoral fascia was then closed over the bone and implant with interrupted number-0 absorbable braided suture as a distinct layer, followed by closure of the subcutaneous layer and skin. No drains were used.

Post-operative rehabilitation consisted of immediate unrestricted range of motion without supervised physical therapy. Patients wore a sling for comfort no longer than 3 days and were encouraged to immediately use the arm in daily activities as tolerated. All patients were restricted from weight-training

FIGURE 2. Standard preoperative setup for clavicle plate fixation.

FIGURE 3. Intraoperative photo during clavicle fracture fixation using a precontoured plate.

activities for at least 12 weeks or until they demonstrated signs of clinical and radiographic healing, if healing was not seen by 12 weeks.

Outcome Measures

Patients were evaluated using both objective and subjective measures at 2, 6, and 12 weeks and 6, 12, and 24 months. Objective measures included radiographs, physical examination, and complication rate. Radiographic union was defined as complete cortical bridging between proximal and distal fragments (Fig. 4). Range of motion was assessed on physical examination. For complication rate, we focused specifically on the incidence of hardware removal as a result of hardware prominence/soft tissue irritation. For this study, we did not record other complications including infection or nerve injury.

Our subjective outcome measurement tools included a self-administered military-specific questionnaire and two validated functional shoulder surveys. The military-specific questionnaire addressed the patient's ability to perform basic military tasks and wear his/her uniform, including shoulder-borne equipment over the surgical site. We derived each patient's "deployment potential" by using their own responses to questions that assessed ability to perform the five specific military "Functional Activities" listed in Section 5 of the Army Physical Profile (i.e., ability to carry and fire weapon, move with fighting load 2 miles, wear all chemical defense equipment, construct individual firing position, and perform 3–5 second rushes).[15]

The two validated functional shoulder surveys used were the Constant–Murley Shoulder score and the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. The Constant–Murley Shoulder score is a 100-point functional shoulder assessment tool that incorporates four components (subjective: pain and function; objective: range of motion and strength), where a higher total score reflects a better score.[16] The DASH questionnaire consists of 30 items designed to measure function and symptoms in patients with disorders of the upper limb, where a lower score represents a better outcome.[17]

Data Collection and Analysis

The outcome measures were administered and reviewed by research assistants not involved in the care of the patients to ensure an unbiased assessment. For this nested cross-sectional analysis, data was collected from 28 patients at their latest follow-up (6, 12, or 24 months). There were 11 patients with 6-month follow-up data, 9 patients with 12-month follow-up data, and 8 patients with 24-month follow-up data. After pooling the data from the latest follow-up visits across all patients, descriptive statistics (averages and standard deviations) were calculated using Microsoft Office Excel (Microsoft, Redmond, WA).

RESULTS

Twenty-eight patients (27 male, 1 female) who underwent clavicle plate fixation met our inclusion criteria, and all were available for follow-up at an average interval of 13 months (range, 9–24 months). Mean age was 28 years (range, 19–37 years). There was a similar distribution in the number of superior (15) and anterior-inferior (13) plates used.

Twenty-six patients (93%) achieved clinical and radiographic union at 12 weeks. The 2 remaining patients eventually went on to heal by their 6-month follow-up visit. There was one complication of symptomatic hardware, requiring removal after fracture healing. This patient continued to have pain, despite hardware removal. He eventually elected to undergo the Medical Evaluation Board process and has since been medically separated from the service.

At latest follow-up, full active range of motion was demonstrated by 79% (22/28) of patients. Full active range of motion was defined as achieving maximum points (40) for the range of motion domain on the Constant score sheet, which assess forward flexion, abduction, and internal and external rotation at the shoulder.[16] Although we are unable to comment on patient strength level in this study with limited long-term follow-up, it should be noted that compliance with post-operative weight-training restrictions was variable, as the patients were predominantly young men and many returned to more aggressive recreational and occupational activities earlier than recommended (before 12-weeks post-op). One patient with concomitant bilateral lower extremity injuries was allowed immediate weight bearing on the operative extremity to assist with mobilization; he had no associated complications from this treatment course.

Figure 5 shows the military-specific outcomes in our cohort after clavicle plate fixation at latest follow-up. Of the 4 patients who fire from their operated shoulder, 3 (75%) have returned to firing. Of the 4 airborne-qualified patients, 2 (50%) have reported ability to wear their parachute gear.

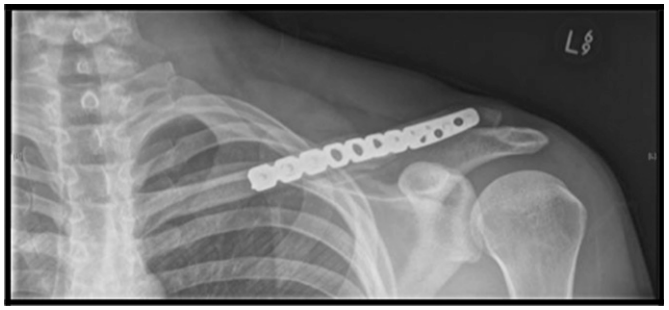

FIGURE 4. Radiograph of a healed clavicle fracture after plate fixation.

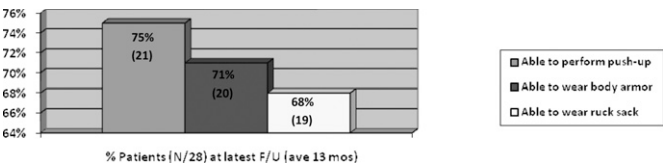

FIGURE 5. Military-specific functional outcomes after clavicle plating.

At the time of this analysis, 21% (6/28) of our cohort had deployed since surgery (earliest at 12 weeks). Using the 5 "Functional Activities" from Section 5 of the Army Physical Profile described earlier,[15] we found that at latest follow-up, 64% (18/28) of our military subjects met all 5 criteria for deployment. The breakdown of each Functional Activity is illustrated in Figure 6. Of those who did not yet meet all 5 criteria, the most common reported limiting task was movement with a standard 48-lb fighting load.

At latest follow-up, the mean DASH score was 9.6 points (range, 1–43; SD ±12), compared with a published normative value for the general population of 10.1 points (0 = no disability and 100 = complete disability).[18] The mean Constant score was 84 (range, 35–97; SD ±40) out of a maximum of 100 points, compared with a published normative value of 92 points for the general population.[19] Overall satisfaction with the shoulder was reported by 75% (21/28) of patients; 68% (19/28) of patients reported mild or no pain; 11 had no pain.

DISCUSSION

Although studies in the general population have shown clinically superior performance with plate fixation of displaced midshaft clavicle fractures versus nonoperative management,[4,5,7,20] little is known about the outcomes and complications of this treatment method in active duty military subjects. The military is unique, in that it requires the regular use of shoulder-borne equipment by service members. Not surprisingly, some surgeons remain skeptical of clavicle plating as a result of the potential effects of hardware prominence and soft tissue irritation on ability to return to duty and perform military-specific tasks. Although this management preference seems intuitive, it is based on opinion and anecdotal evidence. To date, there are no published studies on the optimal treatment of clavicle fractures in our shoulder-bearing military population.

On the basis of our series, open reduction and plating of clavicle fractures does not necessarily limit active duty service members from returning to shoulder-bearing military tasks, nor does it seem to hinder future deployment. However, while satisfaction rate (75%) and achievement of full range of motion are fairly high (79%), at an average of 13-months follow-up, there still remains an important percentage of patients who remain limited in terms of ability to wear their military protective body armor (29%), perform push-ups (25%), and perform all five "Functional Activities" required for deployment (36%).

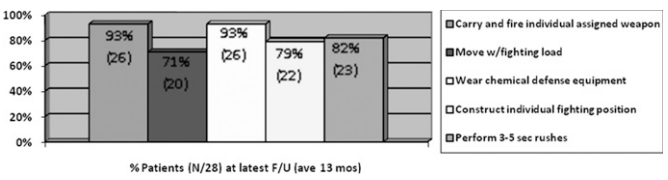

FIGURE 6. "Deployment potential" after clavicle plating.

Our results support recent findings in the civilian literature that demonstrate excellent union rates and early return to function following plate fixation of displaced midshaft clavicle fractures.[4,5,7] In a recent 2007 multicenter, randomized trial comparing nonoperative treatment with primary plate fixation, the authors revealed an 89% (58/65) union rate and a mean time to radiographic union of 28.4 weeks in the nonoperative group.[5] Similarly, in a 2005 meta-analysis that looked at treatment of displaced diaphyseal clavicle fractures, the rate of nonunion after nonoperative treatment was found to be 15.1%, compared to 2.2% after plate fixation.[4] In our series of plated clavicles, the union rate at 12 weeks was 93% (26/28) and all 28 clavicles were healed by 24 weeks, which is consistent with a better and faster nonunion rate when compared to the above-mentioned historical controls of nonoperative management.

To our knowledge, our series is the only one to date that utilizes prospectively collected and validated patient-oriented functional outcome scores as well as an evaluation of military-specific tasks after any treatment of a clavicle fracture, malunion, or nonunion. The only other report in the literature that looked at outcomes after clavicle plating, specifically in military subjects was a limited case series of 5 servicemen with closed symptomatic clavicular nonunions who underwent plate fixation. The authors reported a 100% return to duty rate with pain-free shoulder girdles within 6 months. There was one case of a prominent plate that required removal.[21] This series highlighted the existence and significance of painful nonunions after nonoperative management of clavicle fractures in military subjects.

Another study looking at clavicle plate fixation in a highly active population revealed a high rate of early union and return to sports activity. In a cohort of 39 semiprofessional athletes, the authors reported a union rate of 90% at 12 weeks and the average time for return to sport was 45 days. This study did not report a rate of implant prominence or hardware removal.[22]

Despite the promising results of clavicle plating, the procedure is not without complications. Most common are wound infection, implant failure, and soft tissue irritation from implant prominence. Hardware removal rates as a result of painful and disabling plate irritation are variable. Shen et al[6] removed 171 of 232 (74%) 3.5-mm recon plates placed on acute clavicle fracture. Similarly, Bradbury et al[23] reported removal of 41% (13/32) of recon plates used for their patients. In addition to the potential risks of a second surgery, implant removal also carries risk of refracture, which has been reported in 4 to 7% of cases.[6,14] Besides hardware removal rates, few studies in the general civilian population comment on patient tolerance of gear or clothing over the operative shoulder. In their series of 58 anterior-inferiorly plated clavicle fractures, Collinge et al[24] reported no problems with backpack use or clothing warn about the operative shoulder.

In our series to date, we have seen one case of soft tissue irritation from implant prominence that required removal. This number may increase as our sample size and follow-up

increase with our ongoing prospective clinical trial. The low rate of soft tissue irritation may be due to the use of precontoured plates. Early reports of surgical treatment with these plates suggest a reduced prevalence and severity of soft tissue irritation from hardware prominence, leading to lower rates of hardware removal after union.[5,25]

Concerns regarding hardware prominence from plate fixation has driven interest in alternative surgical options for clavicle fractures in military subjects, specifically intramedullary fixation.[26] Reported results have been more mixed than those after plate fixation, and therefore it is used less widely.[27–29] A recent prospective study of 57 clavicle fractures found that operative fixation with intramedullary modified Hagie pin fixation did not offer an advantage over nonoperative treatment and was associated with a higher complication rate.[30] Associated complications unique to intramedullary fixation can result in significant morbidity and include implant migration and skin breakdown from hardware irritation; these devices inherently necessitate implant removal.[27,28] Furthermore, there is biomechanical evidence to suggest that plate fixation provides a stronger construct than intramedullary fixation.[31] The inability to statically lock these implants has the potential to lead to significant shortening, especially in the presence of comminution. Rotational control is also difficult to achieve and often mandates restricted post-operative shoulder motion to 90° of forward elevation and abduction for the first 4 weeks.[13] This is an important disadvantage of intramedullary fixation in a highly active patient population such as the active duty military population.

Our study has several limitations that warrant discussion. First, this is an observational cross-sectional study and therefore, prone to the biases inherent in such a study design. Specifically, the pooled data was collected at disparate time points (6–24 months), and without a control group, no causal conclusions can be made. The small sample size and short-term follow-up further limit our study. As our ongoing prospective randomized trial proceeds, we will be able to address these limitations. Second, our military-specific questionnaire is not a validated outcome measure and relies on the patients' subjective report, rather than their demonstration of ability to perform each listed activity. Finally, this study is unable to comment on the reasons why some patients had less than optimal outcomes. It is difficult to speculate on the cause, since we have discovered through other recent projects that return to duty after an orthopedic injury is multifactorial.[32]

In conclusion, for the majority of active duty personnel, rapid healing and satisfaction with outcome is possible after plate fixation of displaced clavicle fractures. Most patients are able to return to military-specific tasks, and we have even seen a small percentage deploy. We are optimistic that with longer follow-up, functional limitations in the remaining 20% of our cohort will improve.

Although we cannot guarantee the best functional outcomes with clavicle plating at this time, our findings do challenge anecdotes that a military population cannot tolerate a plate on the clavicle. Furthermore, they may offer insight to other occupations and recreational enthusiasts that necessitate frequent load bearing on the shoulders (e.g. firemen, law enforcement officers, mail couriers, football players, backpackers).

As we seek to determine the optimal treatment of clavicle fractures in a military population, it is clear that further studies comparing clavicle plating with both nonoperative management and other fixation techniques that closely examine the effect of complications on the ability to return to occupation-specific tasks are warranted.

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