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Four-screw compression plate fixation for diaphyseal humerus fractures

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While many humeral shaft fractures can be successfully treated with nonoperative management, compression plating techniques using at least three or four screws on either side of the fracture are the current gold standard. We hypothesized that a less rigid construct using compression with only two screws on either side of the fracture can provide adequate strength for uneventful fracture union.

This is a retrospective review of all the patients who underwent open reduction and compression plate fixation for acute diaphyseal humerus fractures (ADHFs) at an academic Level-1 urban trauma center between 2018 and 2023. Patients treated with compression plating using only two screws and three or four plate-holes on either side of the fracture (Group 1) were matched one-to-one with patients treated using the conventional number of screws (three or more on either side of the fracture – Group 2). The incidence of nonunion/malunion, infection, and implant failure was compared among the two groups.

There were eleven matched patients in both groups. The nonunion, infection complications, and hardware failure rates were 0% and 9.1% for the control group (Group 2) and four-screw group (Group 1) respectively. This difference was not statistically significant ($p = 1.00$).

Although convention dictates the use of six or more bicortical screws (at least three bicortical screws on each side of the fracture), four-screw bicortical fixation may be a feasible option for ADHFs treated with large fragment compression plating techniques.

Keywords: diaphyseal humerus fractures, compression plate fixation, four-screw.

INTRODUCTION

The incidence of acute diaphyseal humerus fractures (ADHFs) is 13 per 100,000 persons per year and accounts for approximately 3% of all long bone fractures. Functional bracing is the current standard of care and yields good results in most cases[1]. Operative indications for humeral shaft fractures include high-energy fractures, pathologic fractures, and open fractures, as well as patients with polytrauma who may require the use of upper extremities early on due to other concurrent injuries[2]. Other indications for operative fixation include injury characteristics, delayed healing, or patient preference[3,4]. Internal fixation may be performed by using an intramedullary nail or a plate. While humeral shaft plating has been shown to carry an increased risk of iatrogenic radial nerve injury, both methods exhibit similar rates of fracture nonunion, delayed union, and post-operative infection[5].

While the current body of literature and traditional teaching recommend at least three bicortical screws (equivalent to six cortices) both above and below the fracture during plate fixation, it is important to note that this recommendation is largely influenced by tradition rather than strong clinical or biomechanical evidence. To our knowledge, there has only been one retrospective study focused on humeral shaft fractures that has analyzed the effect of the number of screws specifically on aseptic mechanical failure[6]. Previous biomechanical research comparing constructs with two screws versus three or more screws on either side of the fracture failed to show a clear advantage for axial, bending and torsional strength when using more screws[7]. Using additional screws increases the overall length of the plate required, necessitating greater surgical dissection. While this may be desirable for certain fracture patterns and bridge plating techniques where the working length of the plate is increased, this may not be the case for fractures that can be treated using compression plating with a short working length. In this study, we aim to compare the clinical outcomes of compression plate fixation using two versus three or more screws on either side of the fracture.

METHODS

We retrospectively reviewed the charts of patients who underwent open reduction and plate fixation for humeral shaft fractures at a single Academic Level-1 trauma center between 2018 to 2023. Adult skeletally mature patients with Orthopedic Trauma Association (OTA) type 12A and 12B ADHFs fixed with compression plating using two bicortical screws proximal and distal to the fracture were included in the analysis (Group 1). The control group consisted of patients with OTA type 12A and 12B ADHFs fixed with more than two bicortical screws on either side of the fracture**.** The plating constructs employed standard cortical screws, locking screws, or a combination of both, with or without the use of interfragmentary screws. OTA type 12C fractures were excluded from the study. Outcomes collected include nonunion, malunion, infections, and implant failure. Descriptive variables were expressed as mean and median values. A comparison of categorical variables was performed by Fisher's exact test when greater than 20% of the expected counts were less than five. The means were first analyzed for distribution by Shapiro-Wilk Test. Normally distributed data was analyzed by independent samples t-test, while Mann-Whitney U Test analyzed skewed data. A p-value of less than 0.05 was considered significant. Statistical analysis was performed using SPSS version 29.0.1.0.

RESULTS

During the study period, there were twelve patients with humeral shaft fractures treated with open reduction and internal fixation (ORIF) using compression plating and four bicortical screws (two proximal and two distal to the fracture site) that were identified (Figure 1). One patient was involved in a high-speed motor vehicular collision resulting in a mangled upper extremity that underwent both elbow disarticulation and multiple debridements due to extensive soft tissue injury. Persistent drainage from the wound resulted in the early removal of stable, intact hardware. Consequently, this patient was excluded leaving eleven patients comprising Group 1. Group 2 was comprised of eleven patients matched for age and fracture pattern/location treated using compression ORIF with at least three bicortical screws on either side of the fracture. The two groups did not differ significantly with respect to baseline characteristics except for BMI: 30.2 versus 26.0 for Group 1 and Group 2 respectively (Table I). The mean time to surgery was 2.9 days for patients in the four-screw group and 4.7 days for patients treated conventionally (p = 0.748). The mean follow-up time was longer in the four-screw group, 366 +/- 416.1 days,

Figure 1. — Successful treatment using four-screw plate fixation, with or without an interfragmentary screw (left and right, respectively).

Table I. — Baseline characteristics for Four-screw Group & Control Group (>Four screws)

	Group 1 (Four-Screw)	Group 2 (>Four-Screw)	*p value*
Number of patients	11	11	
Age (years)[a]	47.3 +/-21.7	48 +/-21.2	0.937
Sex (M/F)	9M, 2F	8M, 3F	1.000
BMI[a]	30.2 +/-6.0	26.0 +/-5.0	0.043
Smoking Status (Never/Former/Current)	5,3,3	7,2,2	0.692
Patients with diabetes mellitus	2	1	1.000
Closed/Open fracture	8C, 3O	7C, 4O	1.000
Comminutes fractures	2	5	0.361
Plating constructs utilizing interfragmentary screws	8	6	0.659
[a] mean +/- S			

Table II. — Outcomes of both groups of patients

	Group 1 (four-screws)	Group 2 (>four-screws)	*p* value
Nonunion, n, 96	1, 9.09%	0, 0%	1.00
Infectious complication, n, %	1, 9.09%	0, 0%	1.00
Hardware failure, n, %	1, 9.09%	0, 0%	1.00
Malunion	0, 0%	0, 0%	
p values calculated using Fisher's Exact Test			

than in the control group, 174.7 +/- 98.7 days. However, this difference was not statistically significant (p = .606).

We observed no significant differences between nonunion, infection, and hardware failure rates among the two groups (p = 1.00) (Table II). No malunion was observed in either group. In the four-screw group, nonunion was observed in one patient (9.09%) with infectious complications and complete loss of fixation and lysis near the implanted screws. Due to the high-energy nature of his injury, the patient had almost complete loss of his biceps and brachialis. He initially underwent irrigation & debridement (I&D) with open reduction and internal fixation, with repeat I&D three days later due to a large hematoma. Around two months post-operation, imaging showed loss of fixation with lysis around the screws (Figure 2). The patient subsequently underwent hardware removal with the placement of an antibiotic cement spacer and was given systemic antibiotic therapy. Six weeks later, the patient underwent a repeat open reduction and internal fixation with iliac crest bone grafting. The union was uneventful, and the patient could resume his previous level of activity after two years.

DISCUSSION

The results of this study demonstrate no statistically significant differences in fracture nonunion/malunion rate, hardware failure, and post-operative infection between the study and the control groups. Biomechanical studies have shown that techniques such as wider screw spacing can provide adequate stability even with a smaller number of screws[7,8]. Additionally, a previous biomechanical study using the minimally invasive plate osteosynthesis (MIPO) technique for fracture plating determined that two screws per fragment can provide adequate primary stability compared to three screws[9]. In conjunction with the results from our study, we suggest that four-screw fixation is safe, effective,

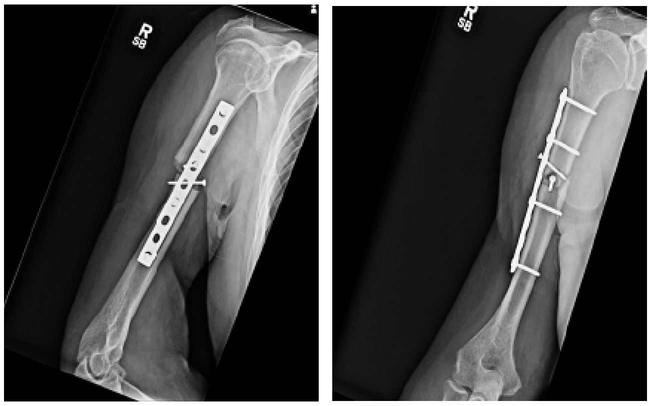

Figure 2. — Loss of reduction and fixation in patient seen with the nonunion.

and non-inferior to conventional plate and screw constructs.

Non-operative management as the standard of care for ADHFs questions the utility of highly rigid plate fixation in the subset needing internal fixation. Notably, the patients in our study all had OTA 12A or 12B fractures. Extensively comminuted injuries deserve special attention because the resulting fragments often cannot be fixed under compression[1]. These fractures need stable fixation on either side of the fracture aimed at secondary fracture healing. However, in carefully selected OTA 12A and 12B fractures, fixation under compression using a plate or an interfragmentary screw is often feasible. These fractures are potentially suitable for fixation with a smaller number of screws. A previous study on diaphyseal fracture of the forearm compared four-screw versus conventional plate fixation and similarly found no significant differences in outcomes between the two groups[10]. Additional advantages of using a shorter plate and fewer screws are the preservation of periosteum, vascularity, and potentially less heat necrosis[11,12].

There has always been a debate between optimizing fixation biomechanics and fracture biology. One of the critical factors in fracture healing is optimal motion between the fragments. This is, in turn, dependent on muscle forces, weight-bearing, and fixation strength[13]. It is well established that very rigid fracture fixation can lead to osteopenia and hypoperfusion of the cortex under the plate[14,15]. As stated previously, the humerus is a well-vascularized bone that often unites with splints and bracing alone and the fractures that are treated operatively may benefit more from the preservation of fracture biology than added mechanical rigidity.

Our study has several limitations. First, we have a small population as this was a single-institution study, increasing the risk of type II error. Second, many of our patients had short follow-up times (mean = 366 days for the four-screw group, 174.73 for the control group), which is not unexpected for an orthopedic trauma population[16]. Nonetheless, the majority of our patients have done well, according to records from their last office follow-up. While our study demonstrates the success of four-screw compression ORIF for humeral shaft fractures, a prospective study with a larger patient population and longer follow-up times would be valuable to fully explore how the number of bicortical screws affects ORIF outcomes, assess its advantage if hardware removal is required, and characterize the specific fracture types suitable to such a technique.

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