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Original Research

Forearm Fracture Fixation with Locking Plates: Does Size Matter?

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Purpose: Forearm shaft fractures of the radius and/or ulna are typically repaired with plates and screws, with 3.5 mm nonlocking screws being generally recommended. However, smaller plates and screws, either nonlocking or locking, can also be applied. The purpose of this study was to retrospectively review whether fracture healing rates and related complications are affected by plate size and type.
Methods: Patient demographic and descriptive data were retrospectively collected for all patients with a forearm shaft fracture treated with repair of the radial shaft and/or ulna shaft between 2017 and 2021 at a multiprovider and multilocation single institution. Inclusion criteria involved use of a locking plate with a minimum radiographic follow-up of 60 days and/or until fracture union was confirmed.
Results: A total of 110 patients met inclusion criteria. There were 45 (40.9%) females and 65 (59.1%) males included with the mean age at time of injury being 47 years (± 22). There were 34 (30.1%) isolated radius fractures, 50 (45.5%) isolated ulna fractures, and 26 (23.6%) both bone forearm fractures. Screw sizes consisted of 3.5 mm (small fragment) screws in 57 (52%) cases, whereas 2.7 mm/2.5 mm/2.4 mm (mini fragment) screws were used in 53 (48%) cases. Fracture union was confirmed in 108 (98%) cases. Among the two nonunion cases, one case (50%) involved a small fragment, and one case (50%) involved a mini fragment plate.
Conclusions: This study confirms that fracture union is high following any size plate fixation of radius and/or ulna fractures. Moreover, smaller screw sizes did not affect fracture union rates. Choice of plate type and screw diameter should be based on patient characteristics and surgeon preference and need not be limited to only 3.5 mm plate and screws.
Type of Study/Level of Evidence: Prognosis IIb.

Restoring anatomic alignment with rigid plate fixation is the recommended treatment of most adult diaphyseal forearm fractures to restore pronosupination and optimize recovery.[1] Currently, this treatment paradigm has espoused the use of 3.5 mm screws and associated plates, often referred to as "small fragment" plates and screws, to achieve this goal.[2–4] More recently, with the advent of locking plate and screws as well as anatomically contoured plates, there has been an increased trend in the use of smaller "mini fragment" plates and screws, including 2.7/2.5/2.4 mm screw constructs, for adult diaphyseal forearm fractures. Potential advantages include a smaller surgical footprint, greater screw density in less area, and better fit for smaller adult patients.

Clinical studies have demonstrated that the use of mini fragment (2.7 mm or smaller) fixation of olecranon fractures is safe and efficacious, as biomechanical testing has shown that these smaller plates had similar construct stability to larger plates.[5] Similarly, Kotain et al[6] found good to excellent postoperative radiologic outcomes in the majority of distal radius fractures repaired with 2.7 mm screws. Still, there is a paucity of research concerning the use of mini fragment plates and screws in the fixation of adult forearm fractures. The objective of this study was to compare fixation of adult diaphyseal forearm fractures using small fragment (3.5 mm) plates with mini fragment (2.4 mm, 2.5 mm, and 2.7 mm) plates with respect to implant failure and union characteristics.

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Figure 1. **A** Case of an ulna shaft fracture repaired with a small fragment 3.5 mm plate and screws. **B** Case of an ulna shaft fracture repaired with a mini fragment 2.7 mm plate and screws.

Materials and Methods

After institutional review board approval was obtained, a retrospective study was conducted at a large single institution of consecutive adult patients who underwent primary fixation of radius and ulna fractures from 2017 to 2021 using Current Procedural Terminology codes 25515 and/or 25545 (corresponding to radial shaft fracture and ulna shaft fracture fixation, respectively) as well as International Classification of Diseases codes of S52.0, S52.1, S52.2, and S52.3 (corresponding to fractures of the upper end of the ulna, upper end of the radius, shaft of the ulna and shaft of the radius, respectively). The treatment of interest was the size of the plate used for forearm fixation. All forearm fractures in this study were fixed with small fragment (3.5 mm) or mini fragment (2.4 mm, 2.5 mm, 2.7 mm) plate-screw constructs (Fig. 1). The types of plates included were limited contact dynamic compression (LC-DCP) plates and reconstruction (RECON) plates, both locking. The plates that were used were obtained from various companies, including Acumed, Biomet, Globus, Skeletal Dynamics, Stryker, and Synthes.

The surgical technique employed utilized standard AO principles encompassing adequate fracture exposure, fracture site debridement of hematoma and interposed soft tissue, and direct fracture reduction and internal fixation. Whenever possible without significant comminution, AO compression plating principles were applied to achieve absolute stability. In cases with greater comminution where absolute stability was not possible, relative stability with locking screw utilization was used instead.

The primary outcome of interest was fracture union versus nonunion. Whether a fracture progressed to union was analyzed by x-ray by the research team and verified by a single hand surgery fellowship-trained orthopedic surgeon. Secondary outcomes included patient characteristics, fracture location, plate type, plate size, screw type, and union characteristics. Inclusion criteria were a minimum radiographic follow-up of 60 days and/or until fracture union was confirmed. Exclusion criteria included patients less than 16 years of age, greater than 90 years of age, and fractures that were not primarily repaired (ie, revisions, nonunion corrections).

Results

Demographics

A total of 110 diaphyseal forearm fractures in 110 patents met the inclusion criteria (Table 1). The average number of days until the last follow-up x-ray was 140 days (standard deviation ± 22 days). There were 45 (40.9%) females and 65 (59.1%) males included in this study. The mean age at the time of injury was 47 (± 22) years. There were 34 (30.1%) isolated radius fractures, 50 (45.5%) isolated ulna fractures, and 26 (23.6%) fractures of both bones of the forearm. There were 14 (12.7%) proximal third, 61 (55.5%) mid-shaft, and 35 (31.8%) distal third fractures.

Table 1
Characteristics of Patients (N = 110)

	Small Fragment System (3.5) (N = 57), N (%)	Mini Fragment System (2.7/2.5/2.4) (N = 53), N (%)
Gender		
Female	20 (35.1%)	25 (47.2%)
Male	37 (64.9%)	28 (52.8%)
Age (y); (mean ± SD)	47 ± 22	47 ± 22
BMI	27.0 ± 5.34	27.0 ± 5.36
Fracture Type		
Radius	27 (47.4%)	7 (13.2%)
Ulna	20 (35.1%)	30 (56.6%)
Both	10 (17.5%)	16 (30.2%)
Fracture Location		
Proximal	12 (21%)	2 (3.8%)
Mid	40 (70.2%)	21 (39.6%)
Distal Third	5 (8.8%)	30 (56.6%)
Plate Type		
LC-DCP	51 (89.5%)	42 (79.2%)
RECON	6 (10.5%)	11 (20.8%)
Company		
Acumed	1 (1.8%)	1 (1.9%)
Biomet	-	1 (1.9%)
Globus	-	2 (3.8%)
Skeletal Dynamics	2 (3.4%)	6 (11.3%)
Stryker	6 (10.5%)	1 (1.9%)
Synthes	47 (82.5%)	42 (79.2%)
Unknown	1 (1.8%)	-
Reoperation	1 (1.8%)	-
Other Complications		
Nonunion	1 (1.8%)	1 (1.9%)
Mean Days from Surgery to 1st Follow-up X-ray (Average)	15.7 days ± 10.1	15.4 days ± 9.82
Mean Days from Surgery to Last Follow-up X-ray (Average)	140 days ± 127.93	140.8 days ± 128.1

BMI, body mass index.

Primary outcome (union)

Fracture union was confirmed in 108 cases (98.1%), whereas there were two (1.9%) nonunion cases. Among the two nonunion cases, one involved the ulna (50%), and one involved the radius (50%) (Table 2). Of the nonunion cases, one involved a small fragment construct (for a radius fracture), whereas the other had a mini fragment construct (for an ulna fracture). Of the two cases of nonunion, the case with the ulna nonunion was a pinhole open fracture that had initially been treated with early surgical incision and debridement and was eventually lost to follow-up. The radial nonunion patient was offered a bone stimulator but elected not to obtain it due to costs; this patient was also eventually lost to follow-up.

Secondary outcomes

The types of plates applied included LC-DCP plates in (84.6%) cases and RECON plates in 17 (15.4%) cases. Screw sizes consisted of 3.5 mm screws in 57 cases (51.8%) and 2.7/2.5/2.4 mm screws in 53 cases (48.2%).

Discussion

Small fragment 3.5 mm plate and screw constructs have been accepted as the gold standard for the treatment of most forearm fractures.[7] Anderson et al[2] published a paper in 1975 showing the benefits of the AO compression plating technique in treating diaphyseal forearm fractures. They noted roughly 97% union in all fractures, results that have been duplicated in multiple studies.[2] Interestingly, there is a dearth of literature comparing the outcomes of using small fragment 3.5 mm plate-screw constructs to smaller, mini fragment constructs. Furthermore, there is minimal evidence that supports or rejects the usage of mini fragment plate-screw constructs for obtaining and maintaining forearm fracture reduction.

Table 2
Fixation Outcomes: All Small Fragment System (3.5 mm) Versus Mini Fragment System (2.7 mm/2.5 mm/2.4 mm) Union Rate

	Small Fragment System, N (%)	Mini Fragment System, N (%)
Union	56 (98.2%)	52 (98.1%)
Nonunion	1 (1.8%)	1 (1.9%)

Mini fragment plate fixation is designed to minimize subcutaneous plate prominence without sacrificing stability, thus decreasing the rate of symptomatic implants and potentially the need for implant removal. These plates also afford greater screw density in a smaller area than their small fragment counterparts. Mini fragment plates have also been found to be a viable alternative in clavicle, distal radius, talar neck, and tibial plafond fractures.[8–11] These plates have been noted to allow for better customized fitting of implants to bone and creating a lower profile construct compared with precontoured plates.[12]

In this retrospective study, we found high union rates with a low incidence of nonunion with open reduction and internal fixation of forearm fractures with plates and screws, regardless of which plating systems were used. There was one only one nonunion case in both the small fragment and mini fragment groups. The complication rates between both groups were also low, and there was no difference in nonunion rates between groups. Furthermore, no significant difference in the fracture location, bone involved, days to until union, or days until follow-up were identified between the two groups. This suggests equivalent outcomes regardless of the plate size used for fixation of forearm fractures.

Based on the findings of this study, there is now evidence in favor of using smaller plate sizes individualized to the anatomy of each patient, particularly smaller patients, adolescents, and elderly patients. In addition, the study reinforces the use of the AO technique to achieve fracture union, irrespective of plate size, where absolute stability with dynamic compression is possible and relative stability with locking screws in cases where compression is not a feasible alternative. Fortunately, current small and mini fragment plate technology and market availability currently provides surgeons both of these options.

This study is not without limitations. We analyzed fractures that underwent primary fixation only and thus cannot comment on whether smaller plate-screw sizes would yield similar union rates in instances of revisions or cases of nonunion. Additionally, we were only able to analyze 110 patients with forearm fractures, which is a relatively small sample size. A larger sample size would be needed for more reliable results. Formal outcome scores were not recorded. However, this study represents the largest study to date comparing small fragment and mini fragment fixation on consecutive diaphyseal forearm fracture patients.

In conclusion, this study confirms that fracture union is high following all types of primary plate fixation of radius and/or ulna fractures. Moreover, smaller screw sizes did not affect union rates. Mini fragment plates appear to be a safe alternative to the standard small fragment plates in the treatment of acute diaphyseal forearm fractures. We concluded that the choice of plate type and screw diameter should be based on patient characteristics and surgeon preference and need not be limited to only 3.5 mm plates and screws.

Conflicts of Interest

A.M.I. is a design surgeon with royalties for Globus Medical (Adubon, PA, USA) as well as previously a consultant for Depuy Synthes (West Chester, PA, USA) and Acumed (Hillsboro, OR, USA)

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