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Hand

A Comparison of Outcomes following Plate versus Pin Fixation of Metacarpal Shaft and Neck Fractures

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Background: The aim of this study is to compare clinical and radiographic outcomes of open reduction and internal fixation versus closed reduction and percutaneous pinning of metacarpal fractures in relation to anatomic and surgical variables.

Methods: Electronic medical records at two institutions were reviewed for patients who underwent surgical intervention for metacarpal fractures. Data were collected from those who underwent reduction and internal fixation with either plates or Kirschner wires (K-wires). Inclusion criteria included minimum postoperative follow-up of 60 days and age 18 years or older. Exclusion criteria included insufficient radiographic data, previously attempted closed reduction with immobilization, pathologic fracture mechanism, history of previous trauma or surgery to the affected bone, and fixation technique other than plate or K-wire.

Results: We reviewed data for patients treated over a 22-year time period. Ultimately, 81 metacarpal shaft and neck fractures in 60 patients met inclusion criteria. Among all metacarpal fractures, complications were present in 39 (48.1%) cases. There were no significant associations between complication prevalence and hardware type. Revision surgery was required in 11 (13.6%) patients; there were no significant associations between revision procedures and hardware type. Postoperatively, all patients with imaging data had radiograph follow-up to assess union status. There was no significant association between time to union and hardware type.

Conclusions: Outcomes showed no significant difference between plate and pin fixation for metacarpal shaft and neck fractures. These findings suggest that surgeons may have flexibility to decide on the type of operative intervention while considering patient-specific factors, such as the need for early mobilization. *(Plast Reconstr Surg Glob Open 2023; 11:e4741; doi: 10.1097/GOX.0000000000004741; Published online 10 January 2023.)*

INTRODUCTION

Metacarpal fractures are among the most common injuries of the hand, comprising between 18% and 42% of all hand and forearm fractures.[1–4] While common, there is no established consensus regarding the most effective operative intervention.[5–10] Some studies have shown that open reduction and internal fixation (ORIF) with plates limits immobilization time, provides earlier recovery of powerful hand function, and improves stability compared with other techniques.[7,10–13] Similarly, literature has supported the mechanical superiority of plate constructs compared with other techniques, particularly when positioned dorsally over the metacarpal bone.[14,15] In contrast, minimally invasive techniques, such as pin fixation with Kirschner wires (K-wires), may provide improved range of motion and functionality postoperatively in addition to reducing operative time and invasiveness.[9,12]

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Although outcomes of metacarpal fracture fixation have been well described, there is a lack of decisive evidence defining the relative benefits and drawbacks for either approach. Although studies have characterized specific outcomes, such as range of motion, grip strength, and time to mobilization, there is a paucity of evidence available regarding specific hardware characteristics and radiographic outcomes.[5,6,10]

This study aims to characterize the relationships between hardware features and postoperative outcomes, considering both clinical functionality and radiographic status. This retrospective study compares the outcomes of ORIF ("plate fixation") and closed reduction and percutaneous pinning (CRPP; "pin fixation") of metacarpal neck and shaft fractures with a focus on radiographic outcomes and complications related to the fracture characteristics and surgical technique.

Takeaways

Question: Does open reduction and internal fixation (ORIF) or closed reduction and percutaneous pinning (CRPP) of metacarpal fractures have better radiographic and clinical outcomes?

Findings: Comparison of 141 metacarpal fractures meeting inclusion criteria revealed no significant clinical or radiographic advantage to either technique.

Meaning: Surgeons have the freedom to choose between ORIF and CRPP of metacarpal fractures based on patient-specific considerations.

MATERIALS AND METHODS

Patient Cohort

Following institutional review board approval, electronic medical records (EMRs) at two institutions were retrospectively reviewed. Data were collected from EMRs of patients with traumatic metacarpal fractures who underwent reduction and internal fixation with either K-wires or plates by a total of nine surgeons between institutions. Inclusion criteria consisted of minimum follow-up of 60 days and age greater than or equal to 18 years. Cases were excluded from the cohort for insufficient radiograph data, previously attempted closed reduction with immobilization, fracture location other than metacarpal, fracture mechanism other than trauma, history of previous trauma or surgery to the affected bone, and operative technique other than plate or pin fixation. Data regarding patient demographics, operation and implant details, complications, and reoperations were collected. Revision procedures were defined as any occurrence of reoperation to reduce complications from the original fixation. Clinical outcomes regarding function and pain were collected from EMRs as available. Radiographic outcomes were determined by author (M.R.) review of patient radiographs. Radiographic healing of a fracture was defined as evidence of bridging of the fracture by callus and/or obliteration of the fracture line on radiographic imaging. Data were compiled in a custom Research Electronic Data Capture database. Research Electronic Data Capture is a HIPAA-compliant database that can be used for multi-institutional clinical data management.[16] Study flow is presented in a CONSORT flow diagram.[17]

Statistical Analysis

We present descriptive statistics as n (%) or, depending on data normality, mean [standard deviation (SD)] or median (25th–75th percentile). We specified a significance threshold of $\alpha = 0.05$. To compare outcomes, we used χ^2 tests, Fisher exact tests, or Wilcoxon rank sum tests as appropriate. We used Dunn-Bonferroni corrections for multiple comparisons as appropriate ($\alpha_{corrected} = \alpha/\text{number of comparisons}$) when determining statistical significance. Statistical analyses were conducted using R (R Code Team, Vienna, Austria).[18]

RESULTS

We reviewed data for 252 individual metacarpal shaft fractures treated between April 1, 1998, and September 16, 2020. Of these, 138 (54.8%) fractures met inclusion criteria and were included in subsequent analyses (Fig. 1). Two sites contributed 113 (81.9%) and 25 (18.1%) of included metacarpal fracture cases.

Fracture locations included the metacarpal shaft in 67 (48.6%), base in 43 (31.2%), neck in 14 (10.1%), head in four (2.9%), multiple sites in four (2.9%), and at another location in the metacarpal in six (4.3%) individual metacarpals. As the goal of this study was to compare outcomes for plate versus pin fixation, we excluded cases of metacarpal base fracture [42 (97.7%) treated with pin fixation], metacarpal head fractures due to a small sample size, and multiple or other metacarpal fracture sites due to heterogeneity of their presentations and fixation techniques. Thus, we ultimately include 81 metacarpal shaft and neck fractures in 60 patients (Fig. 1). These fractures occurred in 60 patients: 46 (76.7%) patients fractured one metacarpal, nine (15.0%) fractured two metacarpals, three (5.0%) fractured three metacarpals, and two (3.3%) fractured four metacarpals.

Demographic and clinical characteristics are presented in Table 1. There were no significant differences in median age by fracture location ($P = 0.345$) or hardware type ($P = 0.182$).

Fixation technique characteristics are presented in Supplemental Digital Content 1. [**See table, Supplemental Digital Content 1**, which displays fracture and fixation characteristics. Data are presented as n (% of patients in column). Statistics are reported as χ^2 (df) or odds ratios as appropriate for prevalence ≥5 cases. *P* values are reported for χ^2 or Fisher exact tests as appropriate, **http://links.lww.com/PRSGO/C333**].

There were no significant associations between hardware type and fracture location ($\chi^2 = 2.633$; df = 1; $P = 0.105$), sex and hardware type ($\chi^2 = 1.943$; df = 1; $P = 0.163$), or sex and fracture location ($\chi^2 = 2.090$; df = 1; $P = 0.148$). Fracture characteristics, including radiographic

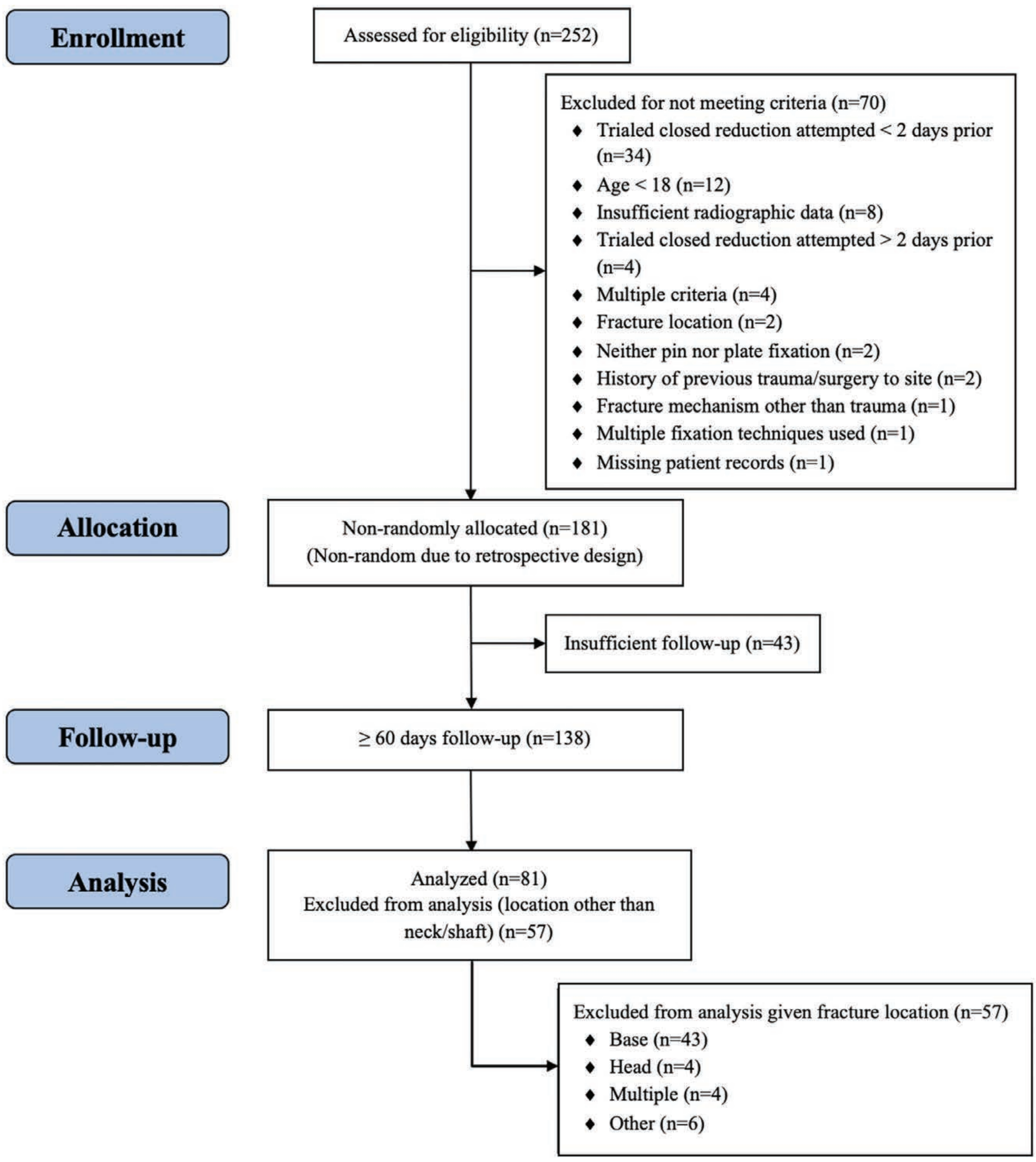

Fig. 1. CONSORT flowchart diagram.[17]

assessments, are displayed in Supplemental Digital Content 2. [**See table, Supplemental Digital Content 2**, which displays fracture and fixation characteristics. Data are presented as n (% of fractures in column), **http://links.lww.com/PRSGO/C334**].

Complication data are demonstrated in Supplemental Digital Content 3. [**See table, Supplemental Digital Content 3**, which displays complications for the entire cohort and the cohort stratified by the metacarpal fixation method. Data are presented as n (% of patients in column), median (25th–75th percentile), and mean (SD) as appropriate. Statistics are reported as χ^2 (df) or odds ratios as appropriate for prevalence ≥5 cases. *P* values are reported for χ^2, Fisher exact, or Wilcoxon rank sum tests as appropriate, **http://links.lww.com/PRSGO/C335**]. Complications were present in 21 (45.7%) single and six

Table 1. Demographic and Clinical Data for the Entire Cohort and the Cohort Stratified by Metacarpal Fixation Method

Variable	Entire Cohort	Plate Fixation Subgroup	Pin Fixation Subgroup
n, metacarpals	81 (100)	42 (51.9)	39 (48.1)
Demographics, by patient (n = 60)			
Age at surgery (y)	37.5 (29.8–49.5)	39.5 (29.8–52.0)	35.0 (28.8–47.5)
Female sex	21 (35.0)	14 (43.8%)	7 (25.0%)
Comorbidities			
Diabetes mellitus	2 (3.3)	1 (3.1)	1 (3.6)
Immunosuppressed status	2 (3.3)	2 (6.3)	0 (0.0)
Inflammatory arthropathy	1 (1.7)	1 (3.1)	0 (0.0)
Osteoporosis	1 (1.7)	1 (3.1)	0 (0.0)
Smoking status			
Never	31 (51.7)	18 (56.3)	13 (46.4)
Past	9 (15.0)	6 (18.8)	3 (10.7)
Current	19 (31.7)	8 (25.0)	11 (39.3)
Missing	1 (1.7)	0 (0.0)	1 (3.6)

Data are presented as n (% of patients in column), mean (SD), or median (25th–75th percentile).

(42.9%) multiple simultaneous metacarpal injuries; there were no significant associations between complication prevalence and single versus multiple simultaneous injuries (χ^2 = 0.373; df = 2; *P* = 0.830). Complications were present in 11 (35.5%) patients with no smoking history, four (44.4%) with a past smoking history, and 12 (63.2%) patients currently smoking. There were no statistically significant associations between complication prevalence and smoking status (χ^2 = 5.156; df = 6; *P* = 0.524) or current versus noncurrent smoking status (χ^2 = 3.363; df = 2; *P* = 0.186). No patients experienced compartment syndrome, complex regional pain syndrome, infection, nerve injury, tendon rupture, or vascular injury.

Revision surgery was required in 11 (13.6%) patients. There were no significant associations between revision procedures and hardware type (χ^2 = 1.018; df = 1; *P* = 0.313). Briefly, the 11 revision procedures involved five cases of tenolysis to address limited range of motion (four ORIFs and one CRPP), three hardware removals due to hardware irritation (three ORIFs), two-digit widget applications to address severe contracture (two CRPPs), two repeated fixations with bone graft due to nonunion/malunion (two CRPPs), and one case of repeated fixation due to hardware failure (one ORIF).

Postoperatively, all patients underwent radiograph follow-up to assess union status. Postoperative time to healing and radiographic data are shown in Supplemental Digital Content 4. [**See table, Supplemental Digital Content 4**, which displays radiographic healing and feature data for the entire cohort and the cohort stratified by metacarpal fixation method. Data are presented as n (% of patients in column). Radiographic evidence data are presented for the number of entire cohort (n = 81) and percent age of total fixation group in columns. Statistics are reported as χ^2 (df) or odds ratios as appropriate for prevalence ≥5 cases. *P* values are reported for χ^2, Fisher exact, or Wilcoxon rank sum tests as appropriate, **http://links.lww.com/PRSGO/C336**].

DISCUSSION

Metacarpal fractures are one of the most common injuries to the upper extremity.[2,4] While these fractures may be treated nonoperatively, those with significant instability or deformity require surgical intervention.[19] The two examined techniques of this study, ORIF and CRPP, are widely used but there is limited evidence suggesting the superiority of one technique over the other.[10] Studies have demonstrated that ORIF has increased rates of complications—extensor lag, hardware irritation, and tendon rupture—compared with other fixation methods postoperatively.[20] This differs from the current study, which does not suggest significant differences in overall complication rates between ORIF and CRPP, nor a significant difference in extensor lag and hardware irritation rates. Tendon rupture was not an observed complication in either cohort of this study. CRPP has been shown to have its own set of limitations, with pin-site infection and loss of reduction being two commonly reported complications in the postoperative course.[21,22] This study demonstrated no significant difference in complications related to fracture union between groups. Of note, the four patients with extensor tendon adhesions had undergone CRPP. However, given the inadequate sample size, statistical conclusions cannot be made.

The outcomes from the current study did not suggest a significant advantage of either technique when considering time to radiographic union, supporting previous work in this area.[10,23] In the current study, complications postoperatively were common, with 48.1% of patients experiencing at least one complication. Although less prevalent than with phalangeal fracture fixation, complications after metacarpal fixation are still common.[24,25] A recent meta-analysis of comparative studies examining pin versus plate fixation of metacarpal fractures demonstrated complications occurring in 40 out of 249 pooled subjects (16%).[24] However, unlike the current study, many of the studies described by this meta-analysis did not report minor complaints, such as stiffness, which may have contributed to the discrepancy in overall complication rates. Furthermore, use of a more comprehensive definition of complications may more accurately reflect the clinical course of patients, and given recent literature suggesting common rates of stiffness postoperatively, we elected to characterize outcomes in this manner.[25] Other commonly reported postoperative complaints in our cohort, such as contractures and extensor lag, were not described in most studies captured by the meta-analysis.[24,26] In the current cohort of metacarpal fixation patients, approximately half (51.3%) of our reported complications were symptoms of stiffness. Stiffness has been associated with factors external to intraoperative technique, such as immobilization time and postoperative therapy regimen.[27] There were no significant differences in complications between fixation groups.

The single documented case of hardware failure occurred with a 1.5-mm plate. Given the isolated incidence of this complication, it is difficult to make any conclusions regarding relative likelihoods of hardware failure. It is reasonable to ascertain that larger 2.0-mm plates are less likely to fail given the biomechanical study by Prevel et al[28] showing increased construct stability with larger plate sizes. Unfortunately, 2.0-mm plates will be higher profile and more vulnerable to hardware-related complications including the need for removal.

There was a relative lack of consistently recorded patient-reported and objective, clinical measurements found during review of the EMR. Patient-reported outcomes—such as Michigan Hand Outcomes Questionnaire scores[29] and Disabilities of Arm, Shoulder, and Hand scores, among others[30]—and objective measurements—such as range of motion measurements or grip strength—were thus excluded from final analysis. We acknowledge this as a limitation of the study, as radiographic and clinical outcomes are not always consistent measures of patient function. However, it is worth noting that this study captures patient concerns, such as stiffness, which have not been reliably reported in the previous literature. Thus, despite an omission of commonly reported outcomes, this study adds to the literature examining objective clinical variables.

Regarding radiographic outcomes, there was no significant difference in time to union between fixation groups in the current study. This differs from a recent study by Dreyfuss et al,[6] who reported a significantly longer time to radiographic union with plate fixation versus pin fixation (59 versus 50 days). However, it is important to consider the clinical relevance of this statistical conclusion. Given the variability in radiographic follow-up, the current study reports time to radiographic union in brackets of time instead of individual days. While less precise, these time categories are aligned more closely with common postoperative follow-up intervals. Neither fixation group showed significant differences in the prevalence of radiographic complications postoperatively.

There is not a widely accepted standard of care when fixing metacarpal fractures with hardware. The outcomes from the current study did not suggest significant advantage of either technique over the other. These findings suggest that surgeons have the flexibility to decide on the type of operative intervention they are more comfortable with while considering patient-specific factors. A highly powered, prospective study would be a valuable addition to the existing literature to better elucidate the differences between these two fixation techniques.

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