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Extra-articular Metacarpal Fractures: Closed Reduction and Percutaneous Pinning Versus Open Reduction and Internal Fixation

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Background: There is no consensus on the optimal operative treatment of isolated closed metacarpal fractures as every technique is associated with advantages and shortcomings. This retrospective study aims to compare the outcomes of single metacarpal, extra-articular fractures treated with closed reduction and percutaneous pinning (CRPP) versus open reduction and internal fixation (ORIF).

Methods: The charts of all patients who underwent surgical repair of closed metacarpal fractures at our institutions from 2009 to 2016 were reviewed. 70 patients met the inclusion criteria, 44 had undergone CRPP and 26 ORIF with plate or lag screws. Subgroup analyses of all patients stratified by both fracture pattern and fracture location were performed. Additionally, subgroup analyses of outcomes based on the time from injury to surgery were conducted. Clinical outcomes included immobilization time, total active motion, stiffness, complication and reoperation rates, as well as occupational therapy referral rates and duration. Functional outcomes were determined using the Quick-DASH (Disabilities of the Arm, Shoulder and Hand) score via telephone questionnaire administered retrospectively.

Results: Overall, there was no significant difference in functional outcome parameters including total active motion (CRPP 91% of normal vs. ORIF 87% of normal), stiffness, therapy referrals, and complications between treatment groups. Patients treated with CRPP, regardless of fracture pattern or location, were operated on earlier than those treated with ORIF (avg. 7 days vs. 15 days). The immobilization time for patients treated with ORIF was significantly less than those treated with CRPP (19.7 vs. 30.7 days; p=0.001). This difference in the immobilization time also reflected the outcomes of the subgroup analyses based on the post-injury time of surgery. When transverse shaft fractures were examined independently as a subgroup, ORIF resulted in improved post-operative range of motion vs. CRPP (100% normal vs. 91% normal). The mean DASH score for each group was satisfactory and the difference was not statistically significant (16.3 for the CRPP and 18.7 for the ORIF group, p=0.805).

Conclusion: Both CRPP and ORIF are viable techniques with good clinical outcomes and low complication rates. ORIF of closed metacarpal fractures allowed for earlier mobilization when compared with CRPP without compromising fracture stability, clinical or functional short-term outcomes. *(Plast Reconstr Surg Glob Open 2019;7:e2261; doi: 10.1097/GOX.0000000000002261; Published online 21 May 2019.)*

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INTRODUCTION

Metacarpal fractures are common injuries, accounting for approximately 36% of all hand and wrist fractures, occurring at an incidence rate of 13.6 fractures per 100,000 person-years.[1–3] It has been estimated that metacarpal and phalangeal fractures contribute to approximately 40% of emergency room and urgent care facility visits.[4,5]

Multiple factors are taken into consideration when deciding between the different treatment options available to achieve the goals of returning to normal lifestyle, work activities and ultimately restoring hand function.

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These factors include the patient's physical examination, mechanism of injury, injury-to-treatment time, fracture pattern, individual comorbidities, and physical demand. There is a high degree of sophistication involved in every step of the treatment decision process. In addition, advancements in our understanding of hand biomechanics and improvements in plating technology have expanded the options available for the treatment of metacarpal fractures.

There is no consensus, evidenced-based opinion regarding the optimal treatment for many types of metacarpal fractures. Often, the choice of surgical technique and approach largely depends upon surgeon preference and comfort. However, there are significant factors associated with each technique that warrant consideration in situations where one technique would clearly be advantageous.

Percutaneous pinning with Kirschner wires (K-wires) is a widely used surgical option for extra-articular metacarpal fractures. It is less invasive, versatile, and often quicker as compared with other techniques. On the other hand, wire fixation is not truly rigid, leading to the need for prolonged immobilization and potential postoperative stiffness.[5]

Open reduction and internal fixation (ORIF) with plates or lag screws provides a rigid and biomechanically stable fixation, ideally allowing for early mobilization.[5,6] However, the disadvantages associated with ORIF using plate or lag screw fixation are well known and described in the literature. They largely result from the invasive nature of the technique and include adhesions, scarring, infection, stiffness, and the potential need for hardware removal.[7] Fractures that require an incision to obtain an anatomical reduction either due to a delayed presentation or fracture comminution potentially favor placement of internal hardware to allow early motion and possibly mitigate the risks of increased scarring and stiffness.

This study was designed to retrospectively compare the clinical outcomes of both percutaneous pinning with K-wires and ORIF with miniplates or lag screws in the treatment of isolated, closed, single-digit extra-articular metacarpal fractures. The working hypothesis was that ORIF using plates or lag screws allows for earlier mobilization without compromising the stability of the fixation leading to less stiffness, higher patient satisfaction, and better clinical outcomes.

METHODS

Institutional Review Board approval was obtained for this study. A retrospective chart review was performed of all patients who underwent surgery for isolated closed metacarpal fractures from January 2009 to December 2016. Patients who underwent closed reduction and percutaneous pinning (CRPP) and ORIF with plating or lag screws were selected and analyzed. The choice of fixation was made at the discretion of the operating surgeon and was based on factors such as fracture pattern, time from injury, and surgeon preference.

The analysis was limited to patients greater than 16 years old with single-digit, closed, isolated, extra-articular metacarpal fractures. Patients were required to have a minimum of 2 postoperative clinic visits and either a discharge plan or referral to hand therapy with subsequent re-evaluation. Patients were initially seen within 1–2 weeks after surgery, again at 4–6 weeks, and then at 3–6 months postoperatively. Patients were discharged when maximum medical improvement was reached, which was determined clinically and related to return of motion, return to work, and activities of daily living. Patients with multiple fractures or fractures in multiple digits, other traumatic injuries, or intra-articular fractures were excluded from the study.

All the patients underwent surgery by a group of board-certified plastic surgeons, the majority of whom have additional hand fellowship training. Preoperatively, radiographs of the digit or hand were reviewed, and a clinical examination was performed either in the clinic or the emergency room. Postoperative immobilization was achieved via either a volar, ulnar gutter, or thumb spica splint in the intrinsic plus position.

Patient demographic characteristics were compared between the 2 groups, including, age, sex, body mass index, comorbidities, including history of diabetes and smoking, occupation, the time from injury to surgery and mechanism of injury. Injury characteristics were also compared, including the metacarpal injured, injury location (base, shaft or neck) and fracture pattern (transverse, spiral/oblique, or comminuted).

Operative outcomes were assessed via retrospective chart review and included follow-up times, postoperative visits, immobilization time, total active motion (TAM—normal range 290–310), stiffness, incidence of complications and reoperations, occupational therapy referral rates, and duration of occupational therapy. Postoperative management was individualized according to each patient's clinical progress and the standard protocol of each hand surgeon.

Removal of the splint and K-wires was decided based on the postoperative clinical progress, with evidence of clinical healing as determined by the absence of tenderness at the fracture site and postoperative x-rays. Referral to hand therapy was based on clinical indications such as degree of stiffness at the time of hardware removal for pin fixation and on average 2 weeks after plate or screw fixation. Those patients not referred to hand therapy were given a home exercise program and were followed until subsequent discharge from the clinic.

Functional outcomes were self-reported using the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) via telephone interview, which was conducted during the data collection process of the study. The QuickDASH is a validated, self-report questionnaire that measures symptoms and function in patients with disorders of the upper extremity. Multiple articles on the development and validation of the 11-question QuickDASH questionnaire exist in the literature.[8–10] Patients who were unable to be contacted or refused to participate were not included in these calculations.

All implants were made by Synthes (Paoli, PA) and Osteomed (Glendale, CA). In the CRPP group, 0.035-, 0.045-, and 0.054-inch K-wires were used, up to 3 wires

Table 1. CRPP Versus ORIF: Comparison of All Metacarpal Fractures

	CRPP	ORIF	*P*
No. patients	44	26	
Demographics			
Age, y‡	37.9±17.8	36.8±16.1	0.786
Body mass index‡	25.3±4.2	27.5±5.3	0.082
Male, % (n)	63.6 (28)	80.8 (21)	0.131
Diabetes, % (n)	6.8 (3)	11.5 (3)	0.664
Smoking, % (n)	27.3 (12)	30.8 (8)	0.754
Metacarpal, % (n)			
First	6.8 (3)	3.8 (1)	1.000
Second	2.3 (1)	11.5 (3)	0.141
Third	9.1 (4)	23.1 (6)	0.158
Fourth	15.9 (7)	26.9 (7)	0.266
Fifth	65.9 (29)	34.6 (9)	0.011*
Fracture site, % (n)			
Base	13.6 (6)	7.7 (2)	0.701
Shaft	75.0 (33)	88.0 (23)	0.174
Neck	11.4 (5)	3.8 (1)	0.401
Fracture type, % (n)			
Transverse	56.8 (25)	23.1 (6)	0.006*
Spiral/oblique	29.5 (13)	53.8 (14)	0.044*
Comminuted	13.6 (6)	23.1 (6)	0.341
Mechanism of injury, % (n)			
Fighting	25.0 (11)	26.9 (7)	0.859
Falls	31.8 (14)	23.1 (6)	0.434
Sports	6.8 (3)	11.5 (3)	0.664
MVA	18.2 (8)	19.2 (5)	1.000
Other	18.2 (8)	19.2 (5)	1.000
Employment, % (n)			
Unemployed	0.0	3.8 (1)	0.190
Manual	20.4 (9)	15.4 (26)	0.754
Nonmanual	50.0 (22)	38.5 (10)	0.349
Unknown	29.5 (13)	42.3 (11)	0.277
Outcomes			
Follow-up, mo‡	2.8±2.3	5.1±7.5	0.141
Injury to repair, d‡	7.4±4.0	15.0±10.0	0.001*
Postop visits‡	3.9±1.7	3.7±2.9	0.759
Immobilization, d‡	30.7±5.3	19.7±14.8	0.001*
Hand therapy, % (n)	68.2 (30)	53.8 (14)	0.230
TAM‡	243.9±41.9	230.4±60.4	0.321
TAM, % of normal‡	90.8±14.8	86.7±20.6	0.375
Stiffness % (n)	34.1 (15)	50.0 (13)	0.189
Complications % (n)	2.3 (1)	7.7 (2)	0.551
DASH score	16.3	18.7	0.805

‡Values expressed the mean ± SD. *Value statistically significant. MVA, motor vehicle accident.

Table 2. CRPP Versus ORIF: Comparison of All Shaft Metacarpal Fractures

	CRPP	ORIF	*P*
No. patients	33	23	
Demographics			
Age, y‡	37.1±18.6	37.4±16.2	0.947
Body mass index‡	25.3±4.1	27.2±5.3	0.168
Male, % (n)	63.6 (21)	78.3 (18)	0.242
Diabetes, % (n)	6.1 (2)	8.7 (2)	1.000
Smoking, % (n)	21.2 (7)	30.4 (7)	0.433
Metacarpal, % (n)			
First	6.1 (2)	4.3 (1)	1.000
Second	3.0 (1)	8.7 (2)	0.562
Third	12.1 (4)	26.1 (6)	0.288
Fourth	18.2 (6)	26.1 (6)	0.522
Fifth	60.6 (20)	34.8 (8)	0.057
Fracture Type, % (n)			
Transverse	51.5 (17)	17.4 (4)	0.009*
Spiral/oblique	33.3 (11)	60.7 (14)	0.041*
Comminuted	15.2 (5)	21.7 (5)	0.725
Mechanism of injury, % (n)			
Fighting	24.2 (8)	21.7 (5)	0.827
Falls	27.3 (9)	26.1 (6)	0.921
Sports	9.1 (3)	13.0 (3)	0.681
MVA	18.2 (6)	17.4 (4)	1.000
Other	21.2 (7)	21.7 (5)	1.000
Employment, % (n)			
Unemployed	0.0	26.1 (1)	0.411
Manual	21.2 (7)	17.4 (4)	1.000
Nonmanual	45.4 (15)	39.1 (9)	0.638
Unknown	33.3 (11)	39.1 (9)	0.656
Outcomes			
Follow-Up, mo‡	2.9±2.4	4.2±6.8	0.383
Injury to repair, d‡	7.4±4.2	14.2±9.7	0.004*
Postop visits‡	4.1±1.6	3.6±2.8	0.448
Immobilization, d‡	30.9±5.8	20.0±15.6	0.004*
Hand therapy, % (n)	75.8 (25)	52.2 (12)	0.067
TAM‡	249.0±40.0	234.3±58.5	0.302
TAM, % of normal‡	92.2±14.8	86.8±21.6	0.303
Stiffness % (n)	30.3 (10)	47.8 (11)	0.183
Complications % (n)	3.0 (1)	8.7 (2)	0.562

‡Values expressed the mean ± SD.

per metacarpal as dictated by the fracture pattern and surgeon preference. Most commonly, crossed intramedullary K-wires were placed percutaneously in either a retrograde or anterograde fashion according to surgeon preference. In the ORIF group, linear plates (1.5, 2.0, or 2.3 mm), T-shaped shaped (1.5 mm or 2.0 m), or Y-shaped (2.0 mm) stainless steel and titanium plates were utilized. In patients who received lag screws (1.5 or 2.0 mm), at least 2 screws per fracture site were placed.

The statistical analysis was performed using a Chi-square test to compare nominal means of continuous patient demographic characteristics and outcome characteristics. A 2-tailed Fisher's exact test was used to compare nominal patient demographic and injury characteristics and outcome characteristics. Subgroup analyses of shaft fractures, oblique/spiral fractures, and transverse fractures were performed. Additionally, subgroup analyses based on the time from injury to treatment were conducted. Early treatment was defined as surgery less than 7 days from the time of the injury. Surgery performed 7 or more days from the time of the injury was considered late treatment. A *P* value of less than 0.05 was considered significant.

RESULTS

A total of 238 patients were treated for metacarpal injuries at our affiliated institutions in Long Island, NY, from January 2009 to December 2016, of whom 70 met our inclusion criteria for the study. Forty-four patients underwent CRPP and 26 were treated with ORIF (Table 1). Fifty-five percent of the study patients were treated at Nassau University Medical Center, an academic tertiary care county hospital. The remaining patients were treated at other university-affiliated medical centers and local community hospitals in the area by the same group of attending surgeons.

Of the 26 patients who had ORIF, plate fixation was performed in 18 (69.2%), and lag screws were utilized in 8 (30.8%). Shaft fractures constituted the majority of fractures in each treatment group (75% and 88%, respectively). In the subgroup analysis of shaft fractures, 33 patients underwent CRPP and 23 patients ORIF (Table 2). Tables 3–5 present the subgroup analyses comparing the

Table 3. CRPP Versus ORIF: Comparison of Transverse Shaft Fractures

	CRPP	ORIF	*P*
No. patients	17	4	
Demographics			
Age, y‡	37.3±21.2	23.9±4.5	0.028*
Body mass index‡	26.3±3.8	24.6±2.5	0.305
Male, % (n)	70.6 (12)	100.0 (4)	0.532
Diabetes, % (n)	5.9 (1)	0.0 (0)	1.000
Smoking, % (n)	29.4 (5)	25.0 (1)	1.000
Metacarpal, % (n)			
First	11.8 (2)	0	1.000
Second	5.9 (1)	25.0 (1)	0.352
Third	0	0	N/A
Fourth	0	0	N/A
Fifth	82.3 (14)	75.0 (3)	1.000
Mechanism of injury, % (n)			
Fighting	29.4 (5)	75.0 (3)	0.253
Falls	23.5 (4)	25.0 (1)	1.000
Sports	11.8 (2)	0	1.000
MVA	23.5 (4)	0	0.546
Other	11.8 (2)	0	1.000
Employment, % (n)			
Unemployed	0	0	N/A
Manual	11.8 (2)	50.0 (2)	0.148
Nonmanual	58.8 (10)	0	0.090
Unknown	29.4 (5)	50.0 (2)	0.574
Outcomes			
Follow-up, mo‡	3.4±3.1	3.4±3.4	0.980
Injury to repair, d‡	7.2±4.7	13.8±6.9	0.151
Postop visits‡	3.7±1.9	3.8±2.4	0.974
Immobilization, d‡	30.6±7.2	14.2±11.2	0.055
Hand therapy, % (n)	70.6 (12)	75.0 (3)	1.000
TAM‡	246.3±40.8	270.0±0.0	0.029*
TAM, % of normal‡	91.2±15.1	100.0±0.0	0.029*
Stiffness % (n)	35.3 (6)	0	0.281
Complications % (n)	5.9 (1)	25.0 (1)	0.352

‡Values expressed the mean ± SD.

Table 4. CRPP Versus ORIF: Comparison of All Transverse Fractures

	CRPP	ORIF	*P*
No. patients	25	6	
Demographics			
Age, y‡	39.8±19.8	23.3±4.4	0.001*
Body mass index‡	26.3±4.3	25.1±2.3	0.362
Male, % (n)	68.0 (25)	100.0 (6)	0.298
Diabetes, % (n)	8.0 (2)	0	1.000
Smoking, % (n)	36.0 (9)	16.7 (1)	0.634
Metacarpal No., % (n)			
First	12.0 (3)	0	1.000
Second	4.0 (1)	33.3 (2)	0.088
Third	0	0	N/A
Fourth	0	0	N/A
Fifth	84.0 (21)	66.7 (4)	0.567
Fracture site, % (n)			
Base	12.0 (3)	16.7 (1)	1.000
Shaft	68.0 (17)	66.7 (4)	1.000
Neck	20.0 (5)	16.7 (1)	1.000
Mechanism of injury, % (n)			
Fighting	28.0 (7)	83.3 (6)	0.022*
Falls	32.0 (8)	16.7 (1)	0.642
Sports	8.0 (2)	0	1.000
MVA	20.0 (5)	0	0.553
Other	12.0 (3)	0	1.000
Employment, % (n)			
Unemployed	0	0	N/A
Manual	16.0 (4)	33.3 (2)	0.567
Nonmanual	60.0 (15)	0	0.018*
Unknown	84.0 (6)	66.7 (4)	0.067
Outcomes			
Follow-up, mo‡	2.9±2.7	7.0±8.5	0.301
Injury to repair, d‡	7.4±4.2	17.2±10.2	0.068
Postop visits‡	3.5±1.7	3.2±2.0	0.738
Immobilization, d‡	30.4±6.2	13.8±8.7	0.004*
Hand therapy, % (n)	64.0 (16)	66.7 (4)	1.000
TAM‡	240.5±40.7	261.7±20.4	0.088
TAM, % of normal‡	89.1±15.1	96.9±7.6	0.088
Stiffness % (n)	40.0 (10)	16.7 (1)	0.383
Complications % (n)	4.0 (1)	16.7 (1)	0.355

‡Values expressed the mean ± SD.

2 techniques with respect to transverse shaft fractures, all transverse fractures and spiral or oblique fractures.

Overall, patients who underwent ORIF were operated at a later stage than those who had CRPP, an average of 15.0 days from the time of injury, versus 7.4 days for CRPP ($P = 0.001$) (Table 1). This was also the case in the subgroup analyses of metacarpal shaft ($P = 0.004$, Table 2) and spiral/oblique fractures ($P = 0.028$, Table 5).

There were no statistically significant differences in the remaining demographics, mechanism of injury, and employment status between the 2 groups (Table 1). When comparing all fractures, CRPP was employed at a significantly higher rate than ORIF for fifth metacarpal and transverse fractures ($P = 0.011$ and 0.06, respectively), whereas ORIF was more commonly utilized in oblique and spiral fractures ($P = 0.044$). Focusing on metacarpal shaft fractures only (Table 2), CRPP was more commonly utilized for transverse fractures, whereas ORIF was more common for spiral/oblique fractures ($P = 0.009$ and 0.041, respectively).

Clinical Outcomes

There was no statistically significant difference in outpatient follow-up, total clinic visits, and hand therapy referral rates between the 2 groups (Table 1). In terms of immobilization, ORIF resulted in earlier splint removal and earlier referral to occupational therapy as compared with CRPP (19.7 and 30.7 days, respectively, $P = 0.001$). Similar results were found in the subgroup analyses of shaft fractures (20.0 and 30.9 days, respectively, $P = 0.004$, Table 2), transverse fractures (30.3 and 13.8 days, respectively, $P = 0.004$, Table 4), and spiral/oblique fractures (31.1 and 17.6 days, respectively, $P = 0.001$, Table 5).

Overall, comparison of TAM—actual or % of normal—revealed no statistically significant difference between the 2 techniques (Table 1). The only exception was in patients with transverse shaft fractures, where ORIF resulted in improved TAM outcomes over CRPP with similar percentage of patients requiring postoperative hand therapy (Table 3).

The outcomes of the subgroup analyses of early (less than 7 days since the injury) and late (7 or more days) postinjury treatment are presented in Tables 6–8. There were no statistically significant differences in the outcomes between early and late treatment within each group (Table 6). However, there was a trend toward shorter follow-up, less postoperative visits, enhanced TAM and less immobilization time with early ORIF when compared with ORIF performed 7 or more days following the injury (Table 6).

When comparing all fractures treated in the early postinjury period, ORIF resulted in significantly fewer postoperative visits (2.6 versus 3.8, $P = 0.030$) and less immobilization time (12.8 versus 30.1 days, $P < 0.001$) than

Table 5. CRPP versus ORIF: Comparison of Spiral/Oblique Fractures

	CRPP	ORIF	*P*
No. patients	13	14	
Demographics			
Age, y‡	31.9±7.8	42.7±16.7	0.043*
Body mass index‡	23.3±2.8	26.7±5.1	0.043*
Male, % (n)	53.8 (7)	64.3 (9)	0.581
Diabetes, % (n)	0	14.3 (2)	0.481
Smoking, % (n)	15.4 (2)	21.4 (3)	1.000
Metacarpal, % (n)			
First	0	0	N/A
Second	0	7.1 (1)	1.000
Third	23.1 (3)	35.7 (5)	0.678
Fourth	38.5 (5)	28.6 (4)	0.695
Fifth	38.5 (5)	28.6 (4)	0.695
Fracture Site, % (n)			
Base	15.4 (2)	0	0.222
Shaft	84.6 (11)	100.0 (14)	0.222
Neck	0	0	N/A
Mechanism of injury, % (n)			
Fighting	23.1 (3)	7.1 (1)	0.326
Falls	38.5 (5)	28.6 (4)	0.695
Sports	7.7 (1)	14.3 (2)	1.000
MVA	7.7 (1)	28.6 (4)	0.326
Other	23.1 (3)	21.4 (3)	1.000
Employment, % (n)			
Unemployed	0.0	0	N/A
Manual	23.1 (3)	7.1 (1)	0.326
Nonmanual	30.8 (4)	64.3 (9)	0.082
Unknown	46.2 (6)	28.6 (4)	0.440
Outcomes			
Follow-up, mo‡	2.7±2.0	3.8±6.4	0.579
Injury to repair, d‡	7.1±3.9	15.0±11.5	0.028*
Postop visits‡	4.6±1.4	3.6±3.2	0.314
Immobilization, d‡	31.1±4.4	17.6±12.0	0.001*
Hand therapy, % (n)	76.9 (10)	50.0 (7)	0.236
TAM‡	240.4±51.6	220.9±68.9	0.413
TAM, % of normal‡	90.5±16.9	81.8±21.5	0.305
Stiffness % (n)	30.8 (4)	57.1 (8)	0.168
Complications % (n)	0	0	N/A

‡Values expressed the mean ± SD.

CRPP (Table 7). In the late postinjury period, ORIF allowed for less immobilization than CRPP (22.2 versus 31.3 days, $P = 0.030$) with a trend toward fewer patients being referred to hand therapy following ORIF (Table 7).

Focusing on shaft metacarpal fractures, ORIF results in significantly fewer postoperative visits (2.6 versus 4.2, $P = 0.012$) and less immobilization (23.1 versus 31.4 days, $P < 0.001$) than CRPP when performed in the early postinjury period (Table 8). Similarly, there is a trend toward less immobilization with ORIF in the late postinjury period too, although this did not reach statistical significance (23.1 versus 31.4, $P = 0.088$).

Postoperative stiffness impairing daily activities, work duties, or both was a complaint for 15 (34.1 %) patients in the CRPP group and 13 (50.0 %) patients in the ORIF group ($P = 0.189$) (Table 1). Among the patients with metacarpal shaft fractures, stiffness was a complaint in 10 patients following CRPP (30.3 %) and 11 patients following ORIF (47.8 %), which was not statistically significant ($P = 0.183$) (Table 2). Of those, one required operative treatment in the form of capsulotomy and extensor tenolysis approximately 5 months following CRPP of a fifth metacarpal shaft fracture. This was the only complication in the CRPP cohort.

In the ORIF group, there were 2 complications. One patient required hardware removal, tenolysis of the extensor pollicis longus and transfer of the extensor indicis proprius to the extensor pollicis longus approximately 6 months following ORIF of his comminuted first metacarpal shaft fracture. The second patient demonstrated clinical and radiographic signs of nonunion following ORIF using lag screws for a comminuted third metacarpal fracture and underwent revision plate fixation and bone grafting following removal of lag screws.

There were no complaints about hand or scar cosmesis, postoperative superficial or deep infections, angulation, shortening, malrotation, scissoring, or delayed union in either cohort.

We were able to contact 17 (38.6%) patients in the CRPP group and 6 (23.1 percent) patients in the ORIF group to administer the telephone QuickDASH questionnaire. The mean score for each group was satisfactory, and the difference was not statistically significant (16.3 for the CRPP and 18.7 for the ORIF group, $P = 0.805$). This is within 1 SD of the normal population (QuickDash 10) and indicates a mild degree of disability only.

DISCUSSION

We compared the outcomes of ORIF with closed reduction and percutaneous pinning in the management of isolated, closed metacarpal fractures. No single surgical technique has been proven superior to others when treating closed metacarpal fractures; furthermore, most studies available in the literature lack consistency with regard to endpoints, surgical techniques, and measures of clinical outcomes. Our results showed similar clinical outcomes for both techniques including TAM (except for the transverse shaft fracture population, Table 3), postoperative stiffness, patients referred to hand therapy, and QuickDASH scores.

To increase the power and statistical significance of the study, we pooled the data of all digits and extra-articular closed fracture patterns. Although certain fracture patterns like fifth metacarpal neck fractures are known to have unique characteristics, the issues that differentiate open surgery from percutaneous pinning are consistent regardless of fracture type. We then performed multiple subgroup analyses to compare and focus on more homogeneous fracture patterns. Although the numbers in this cohort were low, ORIF demonstrated significantly reduced time of immobilization and earlier postoperative motion despite most patient presenting at a later time from injury to repair. This is in line with our original hypothesis favoring ORIF for early mobilization and increased stability of fixation.

In this series, there were pretreatment delays in both cohorts, which we attribute to the fact that the vast majority of patients were treated within the County Hospital System. This presented significant challenges such as limited operating room time, lack of health insurance, poor compliance, language barrier, and hesitation to consent to surgery to avoid loss of income from time off of work. Furthermore, patients treated with ORIF were operated

Table 6. Outcomes of CRPP and ORIF in Early versus Late Treatment of All Metacarpal Fractures

	CRPP		*P*	ORIF		*P*
Total no. patients	44			26		
Injury to repair	Early	Late		Early	Late	
No. patients	21	23		7	19	
Demographics						
Age, y‡	41.1±18.7	35.0±16.8	0.260	48.4±19.3	32.5±12.8	0.078
Body mass index‡	25.3±4.2	25.3±4.4	0.953	25.6±5.6	28.2±5.2	0.301
Male, % (n)	71.4 (15)	56.5 (13)	0.305	57.1 (4)	89.5 (17)	0.101
Diabetes, % (n)	9.5 (2)	4.3 (1)	0.599	14.3 (1)	10.5 (2)	1.000
Smoking, % (n)	2.4 (5)	30.4 (7)	0.622	28.6 (2)	31.6 (6)	1.000
Injury to repair, d‡	4.2±1.9	10.3±2.9	<0.001*	4.1±2.3	19.0±8.6	<0.001*
Metacarpal, % (n)						
First	4.8 (1)	8.7 (2)	1.000	0	5.3 (1)	1.000
Second	0	4.3 (1)	1.000	0	15.8 (3)	0.540
Third	9.5 (2)	8.7 (2)	1.000	28.6 (2)	21.0 (4)	1.000
Fourth	4.8 (1)	26.1 (6)	0.097	28.6 (2)	26.3 (5)	1.000
Fifth	80.9 (17)	52.2 (12)	0.044*	42.9 (3)	31.6 (6)	0.661
Fracture site, % (n)						
Base	14.3 (3)	13.0 (3)	1.000	0	10.5 (2)	1.000
Shaft	76.2 (16)	73.9 (17)	0.862	100.0 (7)	84.2 (16)	0.540
Neck	9.5 (2)	13.0 (3)	1.000	0	5.3 (1)	1.000
Fracture type, % (n)						
Transverse	57.1 (12)	56.5 (13)	0.967	14.3 (1)	26.3 (5)	1.000
Spiral/oblique	33.3 (7)	26.1 (6)	0.599	71.4 (5)	47.4 (9)	0.391
Comminuted	9.5 (2)	17.4 (4)	0.666	14.3 (1)	26.3 (5)	1.000
Mechanism of injury, % (n)						
Fighting	28.6 (6)	21.7 (5)	0.601	14.3 (1)	31.6 (6)	0.629
Falls	28.6 (6)	34.8 (8)	0.659	28.6 (2)	21.0 (4)	1.000
Sports	0	13.0 (3)	0.086	14.3 (1)	10.5 (2)	1.000
MVA	19.0 (4)	17.4 (4)	1.000	28.6 (2)	15.8 (3)	0.588
Other	23.8 (5)	13.0 (3)	0.448	14.3 (1)	21.0 (4)	1.000
Employment, % (n)						
Unemployed	0	0	N/A	0	5.3 (1)	1.000
Manual	19.0 (4)	21.7 (5)	1.000	14.3 (1)	15.8 (3)	1.000
Nonmanual	42.8 (9)	56.5 (13)	0.365	28.6 (3)	36.8 (7)	1.000
Unknown	38.1 (8)	21.7 (5)	0.235	28.6 (3)	42.1 (8)	1.000
Outcomes						
Follow-up, mo‡	2.4±1.9	3.2±2.6	0.311	2.2±2.3	6.2±8.4	0.075
Postop visits‡	3.8±1.7	3.9±1.7	0.775	2.6±1.0	4.1±3.3	0.082
Immobilization, d‡	30.1±4.3	31.3±6.1	0.449	12.8±8.4	22.2±16.1	0.067
Hand therapy, % (n)	57.1 (12)	78.3 (18)	0.133	57.1 (4)	52.6 (10)	1.000
TAM‡	243.7±43.0	244.0±41.9	0.980	256.5±24.7	220.8±67.1	0.059
TAM, % of normal‡	91.2±14.3	90.4±15.5	0.858	95.0±9.1	83.5±22.9	0.081
Stiffness % (n)	33.3 (7)	34.8 (8)	1.000	28.6 (3)	52.6 (10)	1.000
Complications % (n)	4.8 (1)	0	0.477	0	10.5 (2)	1.000

Time to fixation: early was defined as less than 7 d since the injury.
Time to fixation: late was defined as 7 or more days since the injury.
‡Values expressed the mean ± SD.

on an average of 7 days later than patients treated with percutaneous pinning. Logically, a delay in presentation and treatment may steer one toward open surgery if enough time has passed to allow for callus formation making closed reduction difficult or impossible. However, we were not able to determine from the records whether the decision to open was made intraoperatively or preoperatively based on other criteria such as fracture patterns or patient preference.

The specific technique of percutaneous pinning is another inconsistent variable between prior studies in the literature. Most commonly, we favored the use of retrograde crossed K-wires for the treatment in our series. The literature has focused on the use of intramedullary "bouquet" wiring or transverse pinning; however, these techniques seem to be less popular and not reflective of what is done in many practices.[5] In addition, there has been disagreement on the outcomes associated with different techniques with some studies showing a preference for intramedullary wiring and others showing equivalent results.[11]

Fifth metacarpal fractures were treated statistically more often using percutaneous pinning (P = 0.026). This finding is consistent with the literature demonstrating better outcomes with pinning versus plating of fifth metacarpal neck fractures specifically.[2,11] Fractures treated with percutaneous pinning were immobilized an average of nearly 2 weeks longer than those treated with plate or screw fixation. However, in this series, prolonged immobilization did not contribute to changes in ultimate TAM, stiffness, need for therapy, or need for revision surgery. All patients regardless of operative technique achieve outcomes that were considered good or excellent based on prior studies.

Although there have been reports of similar functional and clinical outcomes of ORIF with plates or lag screws compared with CRPP in various types and patterns of metacarpal fractures, many surgeons are skeptical of this.[11–13] This stems from the invasive nature of open fixation, in

Table 7. Outcomes of CRPP and ORIF in the Early and Late Treatment of All Metacarpal Fractures

	CRPP		ORIF		*P*	
					Early vs early	Late vs late
Total no. patients	44		26			
Injury to repair	Early	Late	Early	Late		
No. patients	21	23	7	19		
Demographics						
Age, y‡	41.1±18.7	35.0±16.8	48.4±19.3	32.5±12.8	0.404	0.590
Body mass index‡	25.3±4.2	25.3±4.4	25.6±5.6	28.2±5.2	0.869	0.061
Male, % (n)	71.4 (15)	56.5 (13)	57.1 (4)	89.5 (17)	0.646	0.037*
Diabetes, % (n)	9.5 (2)	4.3 (1)	14.3 (1)	10.5 (2)	1.000	0.581
Smoking, % (n)	23.8 (5)	30.4 (7)	28.6 (2)	31.6 (6)	1.000	1.000
Injury to repair, d‡	4.2±1.9	10.3±2.9	4.1±2.3	19.0±8.6	0.961	<0.001*
Metacarpal, % (n)						
First	4.8 (1)	8.7 (2)	0	5.3 (1)	1.000	1.000
Second	0	4.3 (1)	0	15.8 (3)	n/a	0.313
Third	9.5 (2)	8.7 (2)	28.6 (2)	21.0 (4)	0.253	0.384
Fourth	4.8 (1)	26.1 (6)	28.6 (2)	26.3 (5)	0.145	1.000
Fifth	80.9 (17)	52.2 (12)	2.8 (3)	31.6 (6)	0.142	0.221
Fracture site, % (n)						
Base	14.3 (3)	13.0 (3)	0	10.5 (2)	0.551	0.433
Shaft	76.2 (16)	73.9 (17)	100.0 (7)	84.2 (16)	0.291	0.113
Neck	9.5 (2)	13.0 (3)	0	5.3 (1)	1.000	0.433
Fracture type, % (n)						
Transverse	57.1 (12)	56.5 (13)	14.3 (1)	26.3 (5)	0.084	0.757
Spiral/oblique	33.3 (7)	26.1 (6)	71.4 (5)	47.4 (9)	0.103	1.000
Comminuted	9.5 (2)	17.4 (4)	14.3 (1)	26.3 (5)	1.000	0.707
Mechanism of injury, % (n)						
Fighting	28.6 (6)	21.7 (5)	14.3 (1)	31.6 (6)	0.639	0.504
Falls	28.6 (6)	34.8 (8)	28.6 (2)	21.0 (4)	1.000	0.495
Sports	0	13.0 (3)	14.3 (1)	10.5 (2)	0.250	1.000
MVA	19.0 (4)	17.4 (4)	28.6 (2)	15.8 (3)	0.622	1.000
Other	23.8 (5)	13.0 (3)	14.3 (1)	21.0 (4)	1.000	0.682
Employment, % (n)						
Unemployed	0	0	0	5.3 (1)	n/a	0.452
Manual	19.0 (4)	21.7 (5)	3.8 (1)	15.8 (3)	1.000	0.709
Nonmanual	42.8 (9)	56.5 (13)	11.5 (3)	36.8 (7)	1.000	0.204
Unknown	38.1 (8)	21.7 (5)	11.5 (3)	42.1 (8)	1.000	0.192
Outcomes						
Follow-up, mo‡	2.4±1.9	3.2±2.6	2.2±2.3	6.2±8.4	0.817	0.151
Postop visits‡	3.8±1.7	3.9±1.7	2.6±1.0	4.1±3.3	0.030*	0.860
Immobilization, d‡	30.1±4.3	31.3±6.1	12.8±8.4	22.2±16.1	<0.001*	0.030*
Hand therapy, % (n)	57.1 (12)	78.3 (18)	15.4 (4)	52.6 (10)	1.000	0.079
TAM‡	243.7±43.0	244.0±41.9	256.5±24.7	220.8±67.1	0.346	0.199
TAM, % of normal‡	91.2±14.3	90.4±15.5	95.0±9.1	83.5±22.9	0.426	0.276
Stiffness % (n)	33.3 (7)	34.8 (8)	11.5 (3)	52.6 (10)	0.674	0.245
Complications % (n)	4.8 (1)	0	0	10.5 (2)	1.000	0.199

Time to fixation: early was defined as less than 7 d since the injury.
Time to fixation: late was defined as 7 or more days since the injury.
‡Values expressed the mean ± SD.

particular the placement of hardware in close proximity to the extensor mechanism, the extensive dissection, and overall technical demands associated with ORIF.[5,14] Earlier publications have suggested that ORIF techniques are associated with higher rates of reoperation, impaired mobility, fracture healing limitations, and complications related to functional impairment.[2,15–17] This is not consistent with our findings. Both groups had very few and similar complication and reoperation rates, both lower than the data published in the literature. There was also a trend toward more patients in the CRPP group requiring postoperative hand therapy (70% versus 50%), although this was not statistically significant ($P = 0.201$).

Interestingly, a recent meta-analysis conducted by Melamed et al.[18] comparing CRPP with K-wires to ORIF with plate and screws for the treatment of unstable metacarpal fractures, focusing on functional outcomes, found statistically significant improved TAM scores with CRPP on their weighted mean analysis of the 3 studies that reported TAM scores. The authors did not find a difference in DASH scores or other functional outcome variables. The meta-analysis included only 5 studies and the authors discussed the limitations and heterogeneity of the data, which may limit the conclusions in the article. No studies in the meta-analysis looked at key variables such as the time lapse between injury and time of surgery, time of immobilization, or postoperative referral to hand therapy. In our study, there were no differences in TAM—actual or % of normal—between the 2 techniques. This important difference could be due to our study being underpowered. On the other hand, it might be attributed to higher degree of consistency in our cohort in terms of surgical technique, implant type, and postoperative care which may have led to the equivalent results in both cohorts.

We have shown that ORIF of closed metacarpal fractures allows for earlier mobilization when compared with CRPP. This reflects the stable fixation that plating and lag screw placement provides, potentially enhancing fracture

Table 8. Outcomes of CRPP and ORIF in the Early and Late Treatment of Metacarpal Shaft Fractures

	CRPP		ORIF		*P*	
					Early vs early	Late vs late
Total no. patients	33		23			
Injury to repair	Early	Late	Early	Late		
No. patients	16	17	7	16		
Demographics						
Age, y‡	42.4±20.1	32.0±15.9	48.4±19.3	32.6±12.4	0.514	0.913
Body mass index‡	25.8±4.6	24.9±3.6	25.6±5.6	27.8±5.3	0.949	0.072
Male, % (n)	68.8 (11)	58.8 (10)	57.1 (4)	87.5 (14)	0.657	0.118
Diabetes, % (n)	6.2 (1)	5.9 (1)	14.3 (1)	6.2 (1)	0.526	1.000
Smoking, % (n)	18.8 (3)	23.5 (4)	28.6 (2)	31.2 (5)	0.621	0.708
Injury to repair, d‡	4.1±2.1	10.5±3.2	4.1±2.3	18.6±8.3	0.938	0.002*
Metacarpal, % (n)						
First	6.2 (1)	5.9 (1)	0	6.2 (1)	1.000	1.000
Second	0	5.9 (1)	0	12.5 (2)	N/A	0.601
Third	12.5 (2)	11.8 (2)	28.6 (2)	25.0 (4)	0.557	0.398
Fourth	6.2 (1)	29.4 (5)	28.6 (2)	25.0 (4)	0.209	1.000
Fifth	75.0 (12)	47.1 (8)	42.8 (3)	31.2 (5)	0.182	0.282
Fracture type, % (n)						
Transverse	56.2 (9)	47.1 (8)	14.3 (1)	18.8 (3)	0.089	0.085
Spiral/oblique	37.5 (6)	29.4 (5)	71.4 (5)	56.2 (9)	0.193	0.119
Comminuted	6.2 (1)	23.5 (4)	14.3 (1)	25.0 (4)	0.526	1.000
Mechanism of injury, % (n)						
Fighting	25.0 (4)	23.5 (4)	14.3 (1)	25.0 (4)	1.000	1.000
Falls	31.2 (5)	23.5 (4)	28.6 (2)	25.0 (4)	1.000	1.000
Sports	0	17.6 (3)	14.3 (1)	12.5 (2)	0.304	1.000
MVA	18.8 (3)	17.6 (3)	28.6 (2)	12.5 (2)	0.621	1.000
Other	25.0 (4)	17.6 (3)	14.3 (1)	25.0 (4)	1.000	0.688
Employment, % (n)						
Unemployed	0	0	0	6.2 (1)	N/A	0.485
Manual	25.0 (4)	17.6 (3)	14.3 (1)	18.8 (3)	1.000	1.000
Nonmanual	37.5 (6)	59.2 (9)	42.9 (3)	37.5 (6)	1.000	0.373
Unknown	37.5 (6)	29.4 (5)	42.9 (3)	37.5 (6)	1.000	0.622
Outcomes						
Follow-up, mo‡	2.8±2.1	3.1±2.7	2.2±2.3	5.1±8.0	0.590	0.340
Postop visits‡	4.2±1.8	3.9±1.5	2.6±1.0	4.0±3.2	0.012*	0.947
Immobilization, d‡	30.3±4.8	31.4±6.8	12.9±8.4	23.1±17.2	<0.001*	0.088
Hand therapy, % (n)	75.0 (12)	76.5 (13)	57.1 (4)	50.0 (8)	0.626	0.114
TAM‡	253.1±38.9	245.0±41.8	256.5±24.7	224.5±66.6	0.805	0.303
TAM, % of normal‡	93.8±14.4	90.7±15.5	94.9±9.1	83.2±24.7	0.805	0.304
Stiffness % (n)	25.0 (4)	35.3 (6)	42.9 (3)	50.0 (8)	0.626	0.393
Complications % (n)	0	0	0	12.5 (2)	1.000	0.227

Time to fixation: early was defined as less than 7 d since the injury.
Time to fixation: late was defined as 7 or more days since the injury.
‡Values expressed the mean ± SD.

healing. Spiral or oblique fractures demonstrated a trend toward ORIF, perhaps due to the favorable orientation of the fracture for the placement of internal hardware like lag screws. Earlier mobilization following ORIF may offer a significant advantage in terms of return to work, return to independent activities of daily living, and patient satisfaction versus CRPP.[19–21]

Based on our data, it has become our practice to favor CRPP in the cases of acute metacarpal base fractures, neck fractures, and comminuted fractures. We recommend the use of ORIF in the cases of transverse shaft fractures, delayed presentation, spiral/oblique fractures, and in the cases where early mobilization is especially advantageous to the patient.

This study is associated with several limitations. First, it is retrospective in nature with inherent response bias. Second, standardization of surgical decision-making and technique, and postoperative management was not performed. Most of the patients were treated in a county hospital clinic setting with barriers to compliance including language, insurance, and socioeconomic status. Third, average follow-up for was only 3 months for the CRPP cohort and 5 months for the ORIF cohort. Although relatively short, it should be long enough to capture most postsurgical complications including infections and those related to scarring and motion loss. Longer follow-up may capture some delayed complications such as tendon ruptures or osteomyelitis, but these numbers are expected to be low. Finally, despite our efforts, the response rate to the telephone QuickDASH questionnaire was poor for both cohorts, and this limits our ability to analyze the patient's subjective functional outcome. Although we did not analyze cost, CRPP has lower equipment costs, shorter duration of therapy, and less overall postoperative care as compared with ORIF which could be considered an advantage to the medical system as a whole.

Despite these limitations, this is one of the few studies in the literature that focuses on the common clinical scenario of closed, isolated, extra-articular metacarpal fractures and compares the 2 most commonly used operative techniques with this sample size. In addition, we have

been able to perform subgroup analyses based on fracture location and fracture patter that may help guide surgical decision-making in many common clinical scenarios. Given that postoperative outcomes were similar in both groups, and that both groups had favorable results, we recommend using ORIF in the cases of delayed presentation or when early mobilization and return to activities are advantageous for the patient.

CONCLUSIONS

Both percutaneous pinning and ORIF are effective techniques for the treatment of closed, extra-articular metacarpal fractures. Both techniques result in good functional outcomes with low morbidity. ORIF of closed metacarpal fractures has resulted in improved postoperative range of motion for transverse shaft fractures and allowed for faster mobilization in all fracture types without compromising fracture stability, clinical or functional short-term outcomes.

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