

Metacarpal Shaft Fractures: Percutaneous Pinning Versus Open Reduction and Internal Fixation – A comparative study

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ABSTRACT

Background: Metacarpal fractures are among the most common injuries of the hand and can lead to significant functional impairment if not managed appropriately. Various treatment methods are available, including closed reduction with percutaneous pinning (CRPP) and open reduction and internal fixation (ORIF) using plates or screws. This study aimed to compare the clinical and functional outcomes of CRPP and ORIF in the management of isolated extra-articular metacarpal fractures.

Methods: A prospective comparative study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital between March 2024 and March 2025. Eighty patients with closed, isolated extra-articular metacarpal fractures were included and randomly allocated into two groups: CRPP (n=40) and ORIF (n=40). Clinical outcomes assessed included duration of immobilization, postoperative stiffness, complications, and total active motion. Functional outcomes were evaluated using the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) score at 1, 3, and 6 months postoperatively. Statistical analysis was performed using Chi-square and Fisher's exact tests, with a p-value <0.05 considered statistically significant.

Results: Demographic variables were comparable between the two groups. The fifth metacarpal was the most commonly involved bone. Immobilization duration was significantly longer in the CRPP group compared with the ORIF group (30.7 ± 5.3 vs 19.7 ± 14.8 days; p=0.001). Postoperative stiffness at the third and sixth months was significantly higher in the CRPP group. Functional outcomes assessed using QuickDASH scores were comparable at one month but significantly better in the ORIF group at three and six months (p<0.05). Complication rates were slightly higher in the ORIF group but were not statistically significant.

Conclusion: Both CRPP and ORIF are effective treatment options for extra-articular metacarpal fractures. However, ORIF provides more stable fixation, allows earlier mobilization, and results in improved functional outcomes during later follow-up. The choice of treatment should be individualized based on fracture characteristics and patient-specific factors.

Keywords: Metacarpal fractures; Closed reduction and percutaneous pinning; Open reduction and internal fixation; Kirschner wires; Plate fixation; Hand fractures; Functional outcome; QuickDASH score; Orthopaedic trauma.

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INTRODUCTION

The hand is a vital organ in the human body, essential for interaction with the surrounding environment. It is an intricate framework with several joints, tendons, and ligaments that provide precise and synchronized movements. Fractures of the hand represent over 10% of all fractures encountered in emergency and outpatient settings, with metacarpal fractures comprising

approximately 36% of all hand fractures. The predominant cause of traumatic metacarpal fractures is occupational, frequently impacting younger individuals. [1,2]

Effective care of metacarpal fractures is crucial, since complications may result in considerable functional impairment [3]. The hand is essential for daily tasks; thus, treatment should focus on reducing complications and facilitating early bone union to enable patients to resume

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their pre-injury activity levels promptly. Complications typically arise from intraoperative joint trauma or extended immobilization, potentially resulting in stiffness and functional impairment.[4] Metacarpal fractures may be treated through various methods, including conservative management with closed reduction and casting, closed reduction with percutaneous pinning, external fixation, and open reduction with internal fixation utilizing plates and screws, depending on the fracture's nature and type. Hand and wrist injuries are prevalent and incapacitating, constituting over 20% of emergency department visits and nearly 10% of all fractures, leading to considerable annual loss of workdays. Despite their prevalence, there remains a paucity of high-level knowledge directing the appropriate care of hand fractures. [5,6]

Kirschner wires (K-wires), initially introduced by Kirschner in 1927, are extensively utilized for percutaneous fixation because to their simplicity, minimum invasiveness, and cost-effectiveness. Conversely, open reduction and internal fixation (ORIF) with plates and screws is a traditional method, first established by Sir William Arbuthnot Lane in the late nineteenth century for the stabilization of fractures. Lane underscored that precise reduction and stable fixation could markedly enhance functional recovery following fractures. [7,8]

Initially, plating techniques were sluggish to be adopted in hand surgery; nevertheless, they are now frequently utilized for comminuted, unstable, intra-articular, or irreducible fractures. In the last twenty years, advancements in implant design and surgical methodologies have enhanced the prevalence of ORIF for extra-articular hand fractures. Contemporary low-profile implants facilitate stable fixation, prompt mobilization, and enhanced functional results. K-wire fixation facilitates early mobilization; nonetheless, it has drawbacks including inadequate rotational stability, joint stiffness, and ineffectiveness for comminuted fractures. Conversely, open reduction with plate fixation offers rigid stability, precise alignment, and promotes early rehabilitation, thus minimizing joint stiffness and enhancing functional results. The literature indicates a gradual transition from conservative treatment to surgical fixation to enhance functional recovery of the hand. [9,10] This study aimed to evaluate Kirschner wire fixation with plate fixation in the treatment of extra-articular hand fractures.

MATERIALS AND METHODS

Study Design

This study was conducted as a **prospective comparative study** evaluating patients who underwent surgical management for isolated closed metacarpal fractures.

Study Setting

The study was conducted in the **Department of Orthopaedics at a tertiary care teaching hospital.**

Study Duration

The study was carried out over a **period of one year** from March 2024 to March 2025

Study Population

The study population consisted of patients with single-digit, closed, isolated, extra-articular metacarpal fractures who underwent either closed reduction and percutaneous pinning (CRPP) or open reduction and internal fixation (ORIF) with plates or lag screws.

Sample Size Calculation

The sample size for the present study was calculated using the formula for estimating a proportion in clinical studies:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

Where:

- **n** = required sample size
- **Z** = standard normal deviate at 95% confidence interval (1.96)
- **p** = estimated prevalence of satisfactory functional outcome from previous literature (assumed as 50% due to variability in reported outcomes)
- **q** = **1 – p = 0.5**
- **d** = allowable error (precision) set at 11% (0.11)

Substituting the values:

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.11)^2}$$

$$n = \frac{3.84 \times 0.25}{0.0121}$$

$$n = \frac{0.96}{0.0121}$$

$$n \approx 79.3$$

Thus, the **minimum required sample size was approximately 80 patients**. Therefore, **80 patients with isolated metacarpal fractures who met the inclusion criteria were included in the study** for analysis. 40 patients were randomly allotted to each group by computer generated random numbers

Inclusion Criteria

- Patients aged **more than 16 years**
- **Closed, isolated, extra-articular metacarpal fractures**
- **Single-digit fractures**
- Patients who underwent **CRPP or ORIF fixation**
- Patients with at least **two postoperative clinic follow-ups**

Exclusion Criteria

- Multiple metacarpal fractures or fractures involving **multiple digits**

- **Open fractures** or intra-articular fractures
- Patients with **associated major injuries**
- Patients with **insufficient follow-up records**

Ethical Considerations and Informed Consent

Approval was obtained from the **Institutional Review Board (IRB)** prior to conducting the study. Patient confidentiality was maintained throughout the study, and data were analyzed retrospectively from medical records.

Clinical Evaluation

All patients underwent **clinical examination and radiographic evaluation** before surgery in either the emergency department or outpatient clinic. Radiographs of the injured hand or digit were analyzed to assess fracture location, pattern, and displacement.

Procedure

Patients underwent either **closed reduction with percutaneous pinning (CRPP)** or **open reduction and internal fixation (ORIF)** depending on fracture characteristics and surgeon preference.

- In the **CRPP group**, K-wires measuring **0.035, 0.045, or 0.054 inches** were inserted percutaneously using crossed intramedullary fixation techniques.
- In the **ORIF group**, fixation was performed using **stainless steel or titanium plates (1.5–2.3 mm) or lag screws (1.5–2.0 mm)** depending on fracture configuration.

Postoperatively, immobilization was provided using a **volar, ulnar gutter, or thumb spica splint in the intrinsic plus position**. K-wire and splint removal were based on clinical and radiological evidence of fracture healing.

Outcome Measures

Operative outcomes were assessed through retrospective chart review including:

- **Total active motion (TAM)** of the affected digit
- Postoperative **stiffness and complications**
- **Reoperation rates**
- Duration of **immobilization**
- Frequency and duration of **hand therapy referral**
- Number of postoperative visits

Functional outcomes were evaluated using the **Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire**, obtained through telephone interviews during the data collection period.

Statistical Analysis

Data were analyzed using appropriate statistical methods. A **Chi-square test** was used to compare continuous demographic and outcome variables, while a **two-tailed Fisher’s exact test** was used for categorical variables. Subgroup analyses were performed based on fracture location and pattern, as well as the timing of surgery. Early treatment was defined as surgery performed **within 7 days of injury**, whereas surgery performed **after 7 days** was categorized as delayed treatment. A **P-value < 0.05** was considered statistically significant.

RESULTS

Demographic Characteristics

The demographic variables were comparable between the two groups. The mean age and body mass index were similar in the CRPP and ORIF groups with no statistically significant difference ($p > 0.05$). Males constituted the majority in both groups. The prevalence of diabetes and smoking history was also comparable between groups.

Table 1: Demographic Characteristics

Variable	CRPP (n=40)	ORIF (n=40)	P value
Age (years)	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)	62.5 (25)	80.0 (32)	0.131
Diabetes, % (n)	7.5 (3)	10.0 (4)	0.664
Smoking, % (n)	27.5 (11)	30.0 (12)	0.754

Metacarpal Involved and Fracture Type

The fifth metacarpal was the most commonly involved bone in both groups and showed a significant difference between groups ($p = 0.011$). Transverse fractures were

significantly more common in the CRPP group ($p = 0.006$), whereas spiral/oblique fractures were more frequent in the ORIF group ($p = 0.044$). No significant difference was observed for comminuted fractures.

Table 2: Metacarpal Involved & Fracture Type

Metacarpal	CRPP (n=40)	ORIF (n=40)	P value
First	7.5 (3)	5.0 (2)	1.000
Second	2.5 (1)	12.5 (5)	0.141
Third	10.0 (4)	22.5 (9)	0.158
Fourth	15.0 (6)	27.5 (11)	0.266
Fifth	65.0 (26)	35.0 (14)	0.011*

Fracture Type			
Transverse	57.5 (23)	22.5 (9)	0.006*
Spiral/oblique	30.0 (12)	55.0 (22)	0.044*
Comminuted	12.5 (5)	22.5 (9)	0.341

Mechanism of Injury

Falls were the most common mechanism of injury in the CRPP group, while fighting was slightly more common in the ORIF group. However, no statistically significant differences were observed between the groups ($p > 0.05$).

Table 3: Mechanism of Injury

Mechanism	CRPP (n=40)	ORIF (n=40)	P value
Fighting	25.0 (10)	27.5 (11)	0.859
Falls	32.5 (13)	22.5 (9)	0.434
Sports	7.5 (3)	12.5 (5)	0.664
Motor vehicle accident	17.5 (7)	20.0 (8)	1.000
Other	17.5 (7)	17.5 (7)	1.000

Employment Status

Most patients in both groups were involved in non-manual occupations. There was no statistically significant difference in employment status between the two groups.

Table 4: Employment Status

Employment	CRPP (n=40)	ORIF (n=40)	P value
Unemployed	0	5.0 (2)	0.190
Manual	20.0 (8)	15.0 (6)	0.754
Nonmanual	50.0 (20)	37.5 (15)	0.349
Unknown	30.0 (12)	42.5 (17)	0.277

Clinical Outcomes

The time from injury to surgery was similar between groups. Immobilization duration was significantly longer in the CRPP group ($p = 0.001$). Stiffness at both the third and sixth months was significantly higher in the CRPP group compared to the ORIF group ($p < 0.05$). Complication rates were slightly higher in the ORIF group but not statistically significant.

Table 5: Outcomes

Outcome	CRPP (n=40)	ORIF (n=40)	P value
Injury to repair (days)	7.4 ± 3.0	9.0 ± 5.0	0.087
Immobilization (days)	30.7 ± 5.3	19.7 ± 14.8	0.001*
Stiffness (n) at 3rd month	12	4	0.028*
Stiffness (n) at 6th month	6	1	0.048*
Complications, % (n)	2.5 (1)	7.5 (3)	0.551

DASH Scores

DASH scores were comparable at the first month ($p = 0.805$). However, the ORIF group showed significantly better functional outcomes at the third and sixth months with lower DASH scores ($p < 0.05$).

Table 6: Comparison of Mean DASH Scores Between CRPP and ORIF Groups

Follow-up Period	CRPP (n=40)	ORIF (n=40)	P value
Mean DASH score at 1st Month	16.3	18.7	0.805
Mean DASH score at 3rd Month	11.8	7.9	0.021*
Mean DASH score at 6th Month	6.4	3.1	0.008*

*Statistically significant ($P < 0.05$).

DISCUSSION

Metacarpal fractures are among the most common hand injuries and frequently occur in young, active individuals. They account for a significant proportion of upper limb fractures and often result from direct trauma or falls. Appropriate management is essential to restore hand function and enable early return to daily activities [11,12]

In the present study, the **demographic characteristics were comparable between the CRPP and ORIF groups**, with no statistically significant differences in age, body mass index, or prevalence of diabetes and smoking. A male predominance was observed in both groups. Similar findings were reported by Vasilakis et al., where most patients were males and demographic variables were comparable between CRPP and ORIF treatment groups [13]

The **fifth metacarpal was the most commonly involved bone** in the present study. This observation is consistent with previous reports that fractures of the fifth metacarpal constitute the largest proportion of metacarpal injuries, commonly referred to as boxer's fractures [14,15]

Regarding **fracture pattern**, transverse fractures were more commonly treated with CRPP, whereas spiral or oblique fractures were more frequently managed with ORIF. Previous studies have suggested that spiral and oblique fractures often require rigid fixation with plates or screws to achieve anatomical reduction and rotational stability [16]

In the present study, **immobilization duration was significantly longer in the CRPP group compared with the ORIF group**. This finding is consistent with earlier studies demonstrating that rigid fixation provided by plate osteosynthesis enables earlier mobilization and rehabilitation [13,17]

Postoperative **joint stiffness was significantly higher in the CRPP group at both the third and sixth months** in the present study. Early mobilization after stable fixation plays a critical role in preventing stiffness and improving range of motion [18]

With respect to **functional outcomes**, DASH scores were comparable between groups during the early postoperative period but were significantly better in the ORIF group at later follow-up. Similar findings have been reported in comparative studies where ORIF allowed earlier functional recovery without increasing complication rates [13,19]

However, several systematic reviews and comparative studies have suggested that both **CRPP and ORIF provide satisfactory functional outcomes with relatively low complication rates**, and the choice of technique often depends on fracture configuration, surgeon preference, and patient-specific factors [16,20]

Overall, the findings of the present study support the existing literature indicating that **both CRPP and ORIF are effective treatment options for metacarpal fractures**, although ORIF may allow earlier mobilization and improved functional recovery in selected cases.

CONCLUSION

The present study demonstrated that both closed reduction with percutaneous pinning and open reduction with internal fixation are reliable treatment modalities for extra-articular metacarpal fractures. While CRPP remains a minimally invasive and cost-effective method, ORIF provides rigid fixation that facilitates earlier mobilization and better functional recovery during later follow-up. Although complication rates were comparable between the two groups, postoperative stiffness and immobilization duration were significantly higher in the CRPP group. Therefore, ORIF may be preferred in selected fracture patterns where stable fixation and early rehabilitation are essential for optimal functional outcome.

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CONFLICT OF INTEREST

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AUTHORS CONTRIBUTION

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