

Original Research Article

The functional outcome of metacarpal fractures fixed with mini plates and screws

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ABSTRACT

Background: Metacarpal fractures are common hand injuries that can significantly impair hand function if inadequately treated. Surgical fixation using mini plates and screws provides stable fixation and permits early mobilization, which may improve functional outcomes. However, evidence regarding procedure-specific functional outcomes remains variable.

Methods: This prospective observational study was conducted in the Department of Orthopaedics at Government Medical College, Kottayam, over a one-year period from 1st January 2025 to 31st January 2026. A total of 47 adult patients with metacarpal fractures requiring surgical intervention were included. All patients underwent open reduction and internal fixation using mini plates and screws. Functional outcome was assessed using the Total Active Flexion (TAF) score at 10 weeks, 3 months, and 6 months postoperatively. Pain was evaluated using the Visual Analogue Scale (VAS), and radiological union was assessed using serial X-rays. Statistical analysis was performed using SPSS version 26, with $p < 0.05$ considered statistically significant.

Results: The mean age of patients was 34.6 ± 9.9 years, with a male predominance (37;78.7%). Metacarpal shaft fractures were the most common injury (37;78.7%). Radiological union was achieved in all patients (47;100%) by 6 weeks. Functional outcomes improved significantly over time, with excellent TAF scores observed in 42 patients (89.4%) at 6 months ($p < 0.01$). Postoperative pain reduced markedly, with 46 patients (97.9%) being pain free at 6 months ($p < 0.01$).

Conclusions: Mini plate and screw fixation of metacarpal fractures provides reliable fracture union, excellent functional outcomes, and significant pain relief, making it an effective treatment option for unstable metacarpal fractures.

Keywords: Metacarpal fractures, Mini plates and screws, Functional outcome, Total active flexion, ORIF

INTRODUCTION

Metacarpal fractures are among the most frequently encountered injuries of the hand and constitute a significant proportion of upper-extremity fractures seen in orthopaedic practice. Owing to the crucial role of the metacarpals in grip strength, dexterity, and overall hand function, inadequately treated fractures can lead to malunion, stiffness, reduced range of motion, and long-

term functional disability, particularly in individuals involved in manual work.¹ Therefore, achieving anatomical alignment and early functional recovery remains the primary goal of management.

Treatment options for metacarpal fractures vary depending on fracture location, displacement, stability, and patient-related factors. Stable and minimally displaced fractures are commonly managed

conservatively; however, unstable fracture patterns such as displaced shaft fractures, comminuted fractures, rotational deformities, and multiple metacarpal injuries often require surgical intervention to restore alignment and function.² Various operative techniques have been described, including percutaneous Kirschner wire fixation, intramedullary fixation, and open reduction with internal fixation (ORIF) using plates and screws.³

ORIF with mini plates and screws provides rigid fixation, precise restoration of length and rotation, and allows for early mobilization of the hand.⁴ Early postoperative movement is particularly important in preventing joint stiffness and tendon adhesions, which are common complications following prolonged immobilization.⁵ Several clinical studies have demonstrated high union rates and favorable functional outcomes with mini-plate fixation, especially in unstable metacarpal fractures.⁶ The stability offered by plate-screw constructs enables patients to resume hand function earlier, potentially reducing time away from work and improving overall quality of life.

Despite these advantages, plate fixation is not without limitations. Concerns such as soft-tissue irritation, hardware prominence, infection risk, and increased surgical exposure have been reported.⁷ Moreover, recent systematic reviews and comparative studies have suggested that alternative fixation methods may yield comparable outcomes in selected fracture patterns, highlighting the lack of consensus regarding the optimal surgical technique.⁸⁻¹⁰ Differences in fracture characteristics, rehabilitation protocols, and outcome assessment tools further complicate direct comparisons across studies. In view of the ongoing debate and the need for procedure-specific outcome data, evaluating the functional results of metacarpal fractures treated with mini plates and screws remains clinically relevant. The objective of study was to assess the functional outcome of metacarpal fractures treated surgically with mini plates and screws.

METHODS

This prospective observational study was conducted in the Department of Orthopaedics at Government Medical College, Kottayam, over a one-year period from 1st January 2025 to 31st January 2026, after obtaining approval from the Institutional Ethics Committee.

Adult patients (≥ 18 years) presenting with metacarpal fractures requiring surgical intervention were consecutively enrolled after obtaining informed written consent. Patients with open fractures, associated phalangeal or carpal fractures, and those with severe osteoporosis were excluded from the study. The sample size was calculated based on a previous study by Zinkasaimuralimahoday, in which 70% of patients demonstrated an excellent functional outcome; using the formula $n = Z^2pq/d^2$ with a 95% confidence level ($Z =$

1.96), relative error (d) taken as 19% of p ($d = 13.3$), and $q = 100 - p$, the calculated sample size was 47 patients.¹¹ All patients underwent open reduction and internal fixation using mini plates and screws under regional or general anaesthesia, following standard surgical principles. A dorsal approach was used with careful protection of extensor tendons and surrounding soft tissues. Fracture reduction was achieved anatomically and stabilized with appropriately sized mini plates and screws. Postoperatively, a below-elbow splint was applied in a functional position. Early mobilization was encouraged, with gentle finger movements initiated once pain permitted, and splints were discontinued after suture removal. Patients were followed up at regular intervals for clinical and radiological assessment.

Functional outcome was assessed using the Total Active Flexion (TAF) score at 10 weeks, 3 months, and 6 months postoperatively. Pain was evaluated using the Visual Analogue Scale (VAS) preoperatively and during follow-up visits.

Radiological union was assessed using serial X-rays. Complications such as infection, implant failure, stiffness, delayed union, and non-union were documented. Data was entered into Microsoft Excel and analysed using SPSS version 26, with categorical variables expressed as frequencies and percentages and continuous variables as mean \pm standard deviation. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 47 patients with metacarpal fractures treated surgically with mini plates and screws were included in the study.

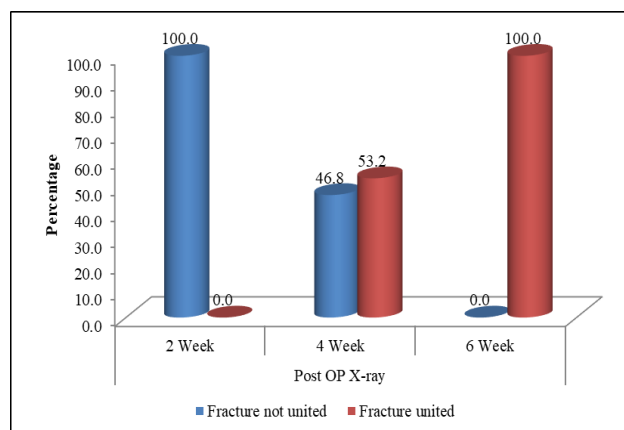


Figure 1: Distribution of radiological union at different postoperative follow-up intervals.

Patients aged less than 30 years constituted 20 (42.6%) of the study population, followed by those aged 30–39 years with 12 (25.5%) patients and 40–49 years with 10 (21.3%) patients, while patients aged 50 years and above accounted for 5 (10.6%). The mean age of the patients

was 34.6±9.9 years. Male patients predominated, with 37 (78.7%) males and 10 (21.3%) females. The right hand was more commonly involved in 37 (78.7%) patients, whereas the left hand was involved in 10 (21.3%) patients (Table 1).

Table 1: Sociodemographic profile of study participants (n=47).

Variable	Category	N (%)
Age (years)	<30	20 (42.6)
	30–39	12 (25.5)
	40–49	10 (21.3)
	≥50	5 (10.6)
Sex	Male	37 (78.7)
	Female	10 (21.3)
Side involved	Right	37 (78.7)
	Left	10 (21.3)

Table 2: Fracture characteristics of the study population (n=47).

Variable	Category	N (%)
Fracture location	Head/neck	4 (8.5)
	Shaft	37 (78.7)
	Base	6 (12.8)
Treatment	Orif with mini plates and screws	47 (100)

With respect to fracture characteristics, metacarpal shaft fractures were the most frequent, occurring in 37(78.7%)

patients, followed by metacarpal base fractures in 6 (12.8%) patients and head or neck fractures in 4 (8.5%) patients. All 47 (100%) patients underwent open reduction and internal fixation using mini plates and screws (Table 2). Radiological evaluation revealed progressive fracture healing during follow-up. At 2 weeks postoperatively, none of the fractures had united, with non-union observed in all 47 (100%) patients. At 4 weeks, radiological union was evident in 25 (53.2%) patients, while 22 (46.8%) patients had not yet achieved union. At 6 weeks, complete radiological union was observed in all 47 (100%) patients (Figure 1). Functional outcome assessed using the Total Active Flexion score showed significant improvement over time.

At 10 weeks, a fair functional outcome was observed in 39 (83.0%) patients, while 8 (17.0%) patients had a poor outcome. At 3 months, a good functional outcome was achieved in 39 (83.0%) patients and a fair outcome in 8 (17.0%) patients. At 6 months, an excellent functional outcome was observed in 42 (89.4%) patients, a good outcome in 4 (8.5%) patients, and a fair outcome in 1 (2.1%) patient, with the improvement being statistically significant ($p<0.01$) (Table 3). Postoperative pain assessment using the VAS demonstrated a marked reduction in pain severity. At 2 weeks, moderate to severe pain was reported by all 47 (100%) patients. At 4 weeks, all 47 (100%) patients reported only mild pain. By 6 months, 46 (97.9%) patients were pain free, while 1 (2.1%) patient reported mild pain, and this reduction in pain was statistically significant ($p<0.01$) (Table 4).

Table 3: Functional outcome based on total active flexion (TAF).

Follow-up period	Poor N (%)	Fair N (%)	Good N (%)	Excellent N (%)	P value
10 weeks	8 (17.0)	39 (83.0)	0 (0)	0 (0)	<0.01*
3 months	0 (0)	8 (17.0)	39 (83.0)	0 (0)	<0.01*
6 months	0 (0)	1 (2.1)	4 (8.5)	42 (89.4)	<0.01*

*Statistically significant.

Table 4: Post-operative pain assessment using visual analogue scale (VAS).

Time point	No pain N (%)	Mild pain N (%)	Moderate–severe pain N (%)	P value
2 weeks	0 (0)	0 (0)	47 (100)	<0.01*
4 weeks	0 (0)	47 (100)	0 (0)	<0.01*
6 months	46 (97.9)	1 (2.1)	0 (0)	<0.01*

*Statistically significant.

DISCUSSION

The present study evaluated the clinical, radiological, and functional outcomes of metacarpal fractures treated with open reduction and internal fixation using mini plates and screws, and the findings were compared with existing literature. In the present study, metacarpal fractures were predominantly observed in younger adults, with the largest proportion of patients being below 30 years of age and a mean age of 34.6±9.9 years. This age distribution

mirrors the findings of previous studies, which have consistently reported a higher incidence of the metacarpal fractures among the young and active individuals due to the occupational and recreational exposure to trauma.¹ A marked male predominance was observed, accounting for 78.7% of cases, which is comparable to reports by Panthi et al, Gupta et al, and Kumar et al.^{2,7,9} The higher involvement of the dominant right hand in the present study is also consistent with earlier observations and is likely related to greater functional use and exposure to

injury.²⁻¹¹ Metacarpal shaft fractures constituted the majority of injuries in this study. Similar fracture patterns have been reported in systematic reviews by Taha et al and Daher et al, which highlighted shaft fractures as the most common subtype requiring operative intervention due to instability, angulation, or rotational deformity.¹⁻⁴ Radiological union was achieved in all patients, with complete union observed by six weeks postoperatively. This 100% union rate is comparable with outcomes reported by Singh et al, Gupta et al, and Zinkasaimuralimahoday and Vishnu Vardhan.^{6,7,11} The absence of delayed union or non-union in the present study supports the biomechanical advantage of plate-screw constructs, which provide rigid fixation and reduce micromotion at the fracture site. Biomechanical evidence from finite-element analysis by Zhang et al further supports the role of plate fixation in maintaining stability and promoting fracture healing.⁵

Functional outcome assessed using the Total Active Flexion score demonstrated a progressive and statistically significant improvement over the follow-up period. At six months, excellent functional outcomes were achieved in 89.4% of patients. These results are superior to those reported by Zinkasaimuralimahoday and Vishnu Vardhan, who documented excellent outcomes in 70% of patients, and are comparable with the outcomes reported by Panthi et al and Gupta et al.^{2,7,11} The favorable functional recovery observed in the present study can be attributed to stable fixation, accurate restoration of alignment, and early initiation of hand rehabilitation. Page and Stern also reported that rigid plate fixation facilitates early mobilization and satisfactory range of motion when meticulous soft-tissue handling is employed.¹²

Postoperative pain assessment using the VAS revealed a significant and progressive reduction in pain. By six months, 97.9% of patients were pain free. Similar findings have been reported by Singh et al and Soni et al, who observed substantial pain relief following plate fixation.^{6,10} Duncan et al emphasized that stable internal fixation plays an important role in minimizing postoperative pain and stiffness, thereby improving overall functional recovery in hand fractures.¹³ The present study was limited by its single-center design, relatively small sample size, lack of a comparative treatment group, and short-term follow-up, which may restrict the generalizability of the findings and preclude assessment of long-term functional outcomes and complications.

CONCLUSION

The present study concludes that surgical fixation of metacarpal fractures with mini plates and screws resulted in complete radiological union in all patients (47;100%) by 6 weeks, excellent functional outcomes in 42 patients (89.4%) at 6 months, and near-complete pain relief in 46 patients (97.9%). Based on these findings, mini plate and

screw fixation is recommended for unstable metacarpal fractures to achieve early mobilization, reliable fracture healing, and optimal restoration of hand function, provided meticulous surgical technique and structured postoperative rehabilitation are employed.

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