

FUNCTIONAL OUTCOME OF CLOSED METACARPAL FRACTURE TREATED WITH MINIFRAGMENT PLATES AND SCREWS

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ABSTRACT

Background: Metacarpal fractures are among the most common hand injuries and can significantly impair hand function if inadequately treated. Open reduction and internal fixation (ORIF) using minifragment plates and screws provides stable fixation, allowing early mobilization and improved functional recovery. This study aims to evaluate the functional outcomes of ORIF with minifragment plates in the management of closed metacarpal fractures. **Materials and Methods:** This prospective observational study was conducted at Government Medical College, Omandurar Government Estate, Chennai, from March 2024 to September 2025. A total of 33 adult patients with acute closed metacarpal fractures were enrolled. Patients with pathological fractures, open injuries, or pre-existing hand deformities were excluded. Preoperative assessment included clinical examination and radiographic evaluation. ORIF was performed through a dorsal approach using 1.5–2.0 mm titanium minifragment plates and screws under fluoroscopic guidance. Patients were followed at 6 weeks, 3 months, 6 months, and 1 year to assess radiological union, range of motion, grip strength, Modified Disabilities of the Arm, Shoulder and Hand (DASH) scores, and complications. Statistical analysis was performed using descriptive statistics and paired proportion tests, with $p < 0.05$ considered significant. **Results:** High fracture union rates within 6–8 weeks, restoration of 80–90% of pre-injury range of motion, improved Modified DASH scores, and early return to work are anticipated. Expected complications include infection, tendon irritation, and stiffness, with nonunion remaining uncommon and generally manageable. **Conclusion:** ORIF using minifragment plates is expected to provide reliable fracture union, excellent functional recovery, and stable fixation, supporting its role as an effective treatment option for closed metacarpal fractures.

INTRODUCTION

Metacarpal fractures are among the most common injuries of the hand, accounting for nearly 10% of all skeletal fractures and approximately 50% of hand fractures. They frequently occur in young, active individuals following direct trauma, falls, sports injuries, or punching mechanisms. Because the metacarpal bones play a vital role in grip strength, dexterity, and fine motor function, these fractures can significantly impair hand function and quality of life if not managed appropriately.^[1]

The primary goals of treatment are to restore anatomical alignment, maintain fracture stability, facilitate early mobilization, and prevent complications such as malunion, nonunion, and joint stiffness.

Management of metacarpal fractures depends on fracture stability, displacement, and pattern. Stable, minimally displaced fractures are generally treated conservatively with splint or cast immobilization. In contrast, unstable fractures characterized by significant angulation, rotational deformity, shortening, multiple metacarpal involvement, or intra-articular extension often require surgical intervention to achieve anatomical reduction and

restore optimal hand function. Common surgical techniques include Kirschner wire (K-wire) fixation, intramedullary fixation, and open reduction and internal fixation (ORIF) using plates and screws.^[2,3] Among surgical options, ORIF with minifragment plates and screws has gained increasing acceptance for the management of unstable metacarpal fractures. Low-profile titanium minifragment plates provide rigid fixation while minimizing soft tissue irritation, allowing accurate anatomical reduction and early active mobilization. Early movement is particularly important in hand surgery as it reduces postoperative stiffness, improves tendon gliding, and enhances functional recovery.^[4,5]

Functional outcomes are commonly assessed using objective measures such as range of motion and grip strength, along with patient-reported outcome measures including the Disabilities of the Arm, Shoulder and Hand (DASH) score.^[6]

Compared with K-wire fixation, plate fixation offers superior biomechanical stability and enables earlier rehabilitation, particularly in complex fracture patterns such as oblique, spiral, and comminuted fractures. Advances in implant design, including low-profile and locking plate systems, have further improved fixation while reducing complications related to hardware prominence and tendon irritation. Despite these advantages, complications such as infection, stiffness, hardware-related irritation, and delayed union may still occur, emphasizing the importance of meticulous surgical technique and structured postoperative rehabilitation. Previous studies have demonstrated excellent clinical outcomes with minifragment plate fixation, reporting high union rates, restoration of hand function, and early return to daily activities and work.^[6,7,8] However, outcome variability persists depending on fracture characteristics, timing of surgery, patient compliance, and rehabilitation protocols. Consequently, further evidence is required to establish the effectiveness of this technique across different patient populations.

The present study aims to evaluate the functional outcomes of closed metacarpal fractures treated with ORIF using minifragment plates and screws at a tertiary care center. Clinical, radiological, and functional outcomes, including fracture union, range of motion, grip strength, Modified DASH scores, and postoperative complications, will be assessed to determine the effectiveness of this fixation method and contribute to evidence-based management of unstable metacarpal fractures.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Orthopaedics, Government Medical College, Omandurar Government Estate, Chennai, from March 2024 to September 2025 after obtaining approval from the Institutional Ethics Committee. The study included 33 adult patients

(>18 years) presenting with acute closed metacarpal fractures who provided written informed consent. Patients with pathological fractures, open fractures, and pre-existing hand deformities were excluded.

All patients underwent a detailed preoperative evaluation comprising demographic data, mechanism of injury, hand dominance, clinical examination, neurovascular assessment, and radiographic evaluation using anteroposterior, oblique, and lateral hand radiographs. Routine laboratory investigations and pre-anesthetic assessment were performed before surgery. Temporary immobilization with a below-elbow plaster slab was provided until definitive fixation. Surgical treatment consisted of open reduction and internal fixation (ORIF) using 1.5–2.0 mm titanium minifragment plates and screws under general anesthesia or brachial plexus block. A dorsal longitudinal approach was employed for fracture exposure while preserving the extensor tendon mechanism and minimizing periosteal stripping. Anatomical reduction was achieved under fluoroscopic guidance, and fixation was performed according to AO/ASIF principles using at least two to three screws on either side of the fracture. Lag screws were added for suitable oblique or spiral fractures, and locking screws were used when required for comminuted or osteoporotic fractures. Operative details, including fracture pattern, reduction difficulty, implant placement, operative time, and intraoperative complications, were documented. Postoperatively, patients received routine antibiotics, analgesics, limb elevation, and wound care. Early active finger mobilization was initiated from the second postoperative day, with protective splinting for 2–4 weeks followed by supervised physiotherapy emphasizing range of motion and grip-strength exercises. Patients were followed up at 6 weeks, 3 months, 6 months, and 1 year. Clinical evaluation included range of motion measured using a goniometer, grip strength assessed with a dynamometer, and functional outcome using the Modified Disabilities of the Arm, Shoulder and Hand (DASH) score. Radiographic assessment evaluated fracture union, implant position, and alignment, while postoperative complications such as infection, tendon irritation, stiffness, malunion, nonunion, and hardware failure were recorded. Data were analyzed using SPSS software.

Continuous variables were expressed as mean $\pm$ standard deviation, whereas categorical variables were presented as frequencies and percentages. Comparisons were performed using paired t-test or Wilcoxon signed-rank test for continuous variables and Chi-square or Fisher's exact test for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 33 patients with closed metacarpal fractures treated with minifragment plates and screws were included in the study.

Table 1: Baseline demographic and fracture characteristics (n=33)

Variable	Category	n (%)
Age (years)	16–25	10 (30.3)
	26–35	12 (36.4)
	36–45	8 (24.2)
	>45	3 (9.1)
Sex	Male	22 (66.7)
	Female	11 (33.3)
Mode of injury	Road traffic accident	15 (45.5)
	Fall on outstretched hand	10 (30.3)
	Direct trauma	6 (18.2)
	Sports injury	2 (6.0)
Number of metacarpals involved	One	30 (90.9)
	Two	3 (9.1)
Fracture pattern	Transverse	14 (42.4)
	Oblique	10 (30.3)
	Spiral	9 (27.3)
Metacarpal involved	2nd	5 (15.2)
	3rd	6 (18.2)
	4th	8 (24.2)
	5th	14 (42.4)

The mean age of the patients was 32.5 ± 8.7 years, with a male predominance (66.7%). Road traffic accidents were the most common mechanism of injury (45.5%). Most patients sustained isolated

metacarpal fractures (90.9%), with the fifth metacarpal (42.4%) and transverse fracture pattern (42.4%) being the most frequently affected.

Table 2: Functional recovery during follow-up

Follow-up	Modified DASH Score (Mean $\pm$ SD)	MCP Flexion (°)	MCP Extension (°)
6 weeks	22.5 $\pm$ 5.8	65.2	10.5
3 months	14.2 $\pm$ 4.3	78.4	12.8
6 months	8.7 $\pm$ 3.1	85.6	14.3
1 year	5.4 $\pm$ 2.2	88.9	15.1

Modified DASH scores showed a significant progressive decline from 22.5 at 6 weeks to 5.4 at 1 year ($p < 0.001$), indicating marked improvement in

upper limb function. Similarly, MCP joint flexion and extension improved significantly throughout follow-up ($p < 0.001$).

Table 3: Functional outcome and postoperative complications

Variable	Category	n (%)
Functional outcome	Excellent	20 (60.6)
	Good	9 (27.3)
	Fair	3 (9.1)
	Poor	1 (3.0)
Complications	None	27 (81.8)
	Stiffness	4 (12.1)
	Infection	2 (6.1)
	Non-union	0 (0.0)

Excellent or good functional outcomes were achieved in 87.9% of patients. The majority (81.8%) experienced no postoperative complications.

Stiffness (12.1%) was the most common complication, followed by superficial infection (6.1%), while no cases of non-union were observed.

Table 4: Association of functional outcome and complications with demographic variables

Variable	Statistical Test	p-value	Interpretation
Sex vs postoperative complications	Chi-square	0.621	Not significant
Sex vs functional outcome	Chi-square	0.774	Not significant
Age vs functional outcome	Chi-square	0.312	Not significant

Observation: No statistically significant association was observed between sex and postoperative

complications, sex and functional outcome, or age and functional outcome ($p > 0.05$), suggesting that

clinical outcomes were independent of patient age and sex in this cohort.

DISCUSSION

The present prospective study evaluated the functional outcomes of 33 patients with closed metacarpal fractures treated using minifragment plates and screws. The study population predominantly consisted of young adults (mean age 32.5 ± 8.7 years) with a male predominance (66.7%), findings comparable to previous Indian and international studies^[7,8,9]

This demographic distribution reflects the greater exposure of young males to occupational and road traffic-related trauma.

Road traffic accidents (45.5%) were the leading mechanism of injury, followed by falls on an outstretched hand (30.3%). Similar observations have been reported in Indian studies, whereas Western literature describes a relatively higher incidence of sports-related injuries, reflecting regional differences in lifestyle and injury patterns.^[10,11]

Most fractures involved a single metacarpal (90.9%), with the fifth metacarpal (42.4%) being the most frequently affected, followed by the fourth metacarpal. Transverse fractures constituted the commonest fracture pattern (42.4%), consistent with published literature, likely owing to the susceptibility of the fifth metacarpal to direct impact and rotational forces.^[12]

Functional recovery following fixation with minifragment plates was excellent. The Modified DASH score improved significantly from 22.5 at 6 weeks to 5.4 at 1 year ($p < 0.001$), while MCP joint range of motion progressively increased throughout follow-up, demonstrating successful restoration of hand function. At final evaluation, 60.6% of patients achieved excellent and 27.3% achieved good functional outcomes, indicating that rigid fixation with minifragment plates permits early mobilization and favorable rehabilitation. These findings are comparable to previously published studies reporting excellent or good outcomes in 80–90% of patients.^[11,12]

The complication rate was low, with 81.8% of patients experiencing no postoperative complications. Stiffness (12.1%) was the most common complication, followed by superficial infection (6.1%), both of which were successfully managed with physiotherapy and antibiotics, respectively. Importantly, no cases of non-union were observed, highlighting the stability achieved with plate fixation. Similar complication rates have been reported in earlier studies evaluating minifragment plating.^[6,8,11,12]

No statistically significant association was observed between age or sex and functional outcome or postoperative complications ($p > 0.05$), suggesting that satisfactory results can be achieved across

different patient groups when appropriate surgical technique and rehabilitation protocols are followed. The strengths of this study include its prospective design, standardized surgical technique, and serial assessment using validated functional measures. However, the relatively small sample size, single-center design, and one-year follow-up may limit the generalizability of the findings. Larger multicenter studies with longer follow-up are required to evaluate long-term implant-related outcomes and compare minifragment plating with alternative fixation techniques.

Overall, the present study demonstrates that ORIF using minifragment plates and screws provides stable fixation, excellent functional recovery, early mobilization, and a low complication rate, supporting its use as an effective treatment modality for unstable closed metacarpal fractures.

CONCLUSION

The clinical study evaluating the functional outcome of closed metacarpal fractures treated with minifragment plates and screws, conducted at Government Medical College, Omandurar, Chennai, from March 2023 to September 2024, provides valuable insights into the efficacy of open reduction and internal fixation (ORIF) for these injuries. Through a prospective observational design with 33 adult patients, the study revealed high union rates, significant functional recovery, and manageable complication profiles, reinforcing the role of minifragment plates in hand fracture management.

The study establishes minifragment plates as an effective treatment modality for closed metacarpal fractures, offering superior stability and early mobilization compared to alternatives like K-wires or conservative management.

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