Original article

Evaluation of early outcomes of surgical fixation in metacarpal and phalangeal fractures

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Abstract

Background: Metacarpal and phalangeal fractures are common injuries of the upper extremity. Surgical treatment allows accurate reduction, stable fixation, and early functional rehabilitation. Various fixation techniques have been applied, including Kirschner wire (K-wire) fixation, intramedullary fixation, external fixation, mini-plate and screw fixation, or combinations thereof.

Objective: Evaluation of early surgical outcomes in metacarpal and phalangeal fractures treat with mini-plates/screws or Kirschner wires.

Materials and Methods: This prospective descriptive study included 33 patients with metacarpal and/or phalangeal fractures indicated for surgical fixation using mini-plates and screws or Kirschner wires at the Department of Orthopedic Trauma and Thoracic Surgery, Hue University of Medicine and Pharmacy Hospital. Clinical, radiographic characteristics and treatment outcomes were assessed at 3 months postoperatively using the ASSH scoring system.

Results: The mean age was 39.16 years; the male-to-female ratio was 2.67:1. At 3 months, radiographic bone union was achieved in 94.7% of cases, while delayed union occurred in 5.3%. According to ASSH criteria, range-of-motion outcomes were excellent in 63.2%, good in 34.2%, and fair in 2.6% of cases. The mean total active motion (TAM) at 3 months postoperatively was 231.27 ± 9.96°.

Conclusion: With a low complication rate and favorable early functional recovery, surgical fixation is an effective treatment for metacarpal and phalangeal fractures, helping to avoid joint stiffness commonly associated with prolonged cast immobilization.

Keywords: *metacarpal fractures, phalangeal fractures, surgical fixation of metacarpal and phalangeal fractures.*

1. INTRODUCTION

Hand injuries are common among upper extremity traumas, occurring in occupational accidents, daily activities, and traffic accidents. Metacarpal fractures account for approximately 18–44% of hand fractures with various fracture patterns [1]. Cast immobilization is fast and inexpensive but has several disadvantages: closed reduction of small bones such as metacarpals and phalanges is technically difficult, prolonged immobilization delays rehabilitation, and complications such as joint stiffness, delayed union, or malalignment may occur, with reported rates of 32–36% [2]. Surgical treatment enables precise reduction, stable fixation, and early rehabilitation. Conventional surgical options include Kirschner wire fixation and mini-plate and screw fixation [3], [4]. K-wire fixation is minimally invasive, technically simple, causes minimal soft-tissue damage, provides sufficient stability, allows early mobilization, and yields good functional outcomes [4]. Mini-plate and screw fixation, developed since the late 1970s, has been increasingly indicated for intra-articular and peri-articular fractures of the metacarpals and phalanges, even in the presence of soft-tissue injuries [5], [6].

We conducted this study with the purpose of evaluating surgical outcomes of metacarpal and phalangeal fractures treated with mini-plates/screws or Kirschner wires.

2. MATERIALS AND METHODS

2.1. Study Population

Patients with metacarpal and phalangeal fractures treated surgically using mini-plates/screws or Kirschner wires at the Department of Orthopedic Trauma and Thoracic Surgery, Hue University of Medicine and Pharmacy Hospital, from May 2024 to July 2025.

2.1.1. Inclusion Criteria

- Closed metacarpal fractures with angulation >10°, phalangeal fractures with angulation >30°, or joint displacement ≥1 mm.

- Open fractures Gustilo grade I or II presenting within 6 hours, or delayed presentations with stabilized soft-tissue wounds.

2.1.2. Exclusion Criteria

- Severe crush injuries with vascular damage, risk of necrosis, or compartment syndrome.

- Complete or near-complete finger amputations.

- Pathological fractures (e.g., malignancy, tuberculosis).

2.2. Study Design

A prospective descriptive longitudinal study evaluating radiographic features and surgical outcomes post operation.

2.3. Surgical Technique

Patients were placed supine with the operated hand on a hand table. After sterilization and draping:

- **K-wire** fixation was indicated for avulsion fractures, open fractures, priority for close fractures, and simple transverse shaft fractures without a third fragment. Closed reduction was performed under fluoroscopic guidance, followed by intramedullary insertion of two 1.0 mm K-wires for phalanges and 1.5 mm K-wires for metacarpals.

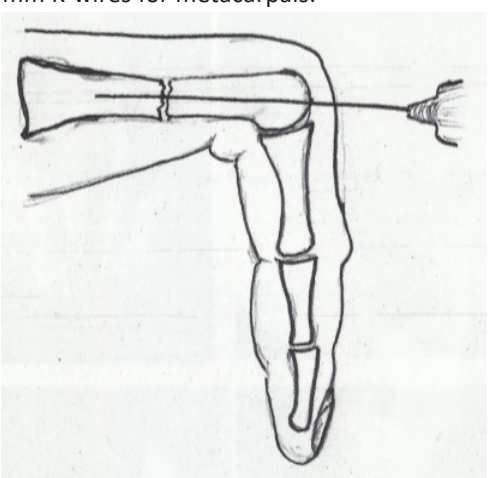

Figure 1. K-wire fixation technique [7]

- Mini-plate and screw fixation was indicated for unstable fractures, comminuted fractures, and intra-articular fractures. Open reduction was performed via dorsal or lateral approaches. Temporary fixation with K-wires was applied when necessary, followed by definitive fixation using appropriate mini-plates with at least two screws on each side of the fracture.

Associated tendon, nerve, or vascular injuries were repaired using standard techniques (Adelaide method for flexor tendons, Kessler method for extensor tendons, epineurial neurorrhaphy, and end-to-end vascular anastomosis under magnification).

Postoperatively, the hand was immobilized in a functional position (the wrist in 20 °- 30 ° extension, MCP joints in 35 °- 45 ° flexion, and fingers in slight flexion, elevated, and early rehabilitation was initiated, typically starting on postoperative day 1.

Rehabilitation exercise guidelines: including passive exercises such as flexion, extension, abduction, adduction, and opposition of the fingers, as well as active hand movements and exercises with assistive devices. The specific start time for each patient depends on their clinical condition. On average, exercises begin on the first day after surgery [8].

2.4. Study Variables

The study variables included general, clinical, and radiographic characteristics. General variables comprised patient age, sex, mechanism of injury, injured hand, and fracture type. Clinical variables included swelling, ecchymosis, pain, pain aggravated by motion, typical deformity at the fracture site, restricted range of motion compared with the contralateral side, and associated soft-tissue injury. Fractures were classified as closed or open, with open fractures graded according to the Gustilo–Anderson classification system (Grade I, II, and III: IIIA, IIIB, IIIC). Associated injuries were also recorded. Concomitant tendon injuries were documented and categorized as flexor tendon rupture, extensor tendon rupture, combined flexor and extensor tendon rupture, or absence of tendon injury.

Radiographic variables included the number of fracture sites, bone involved, fracture location, and fracture pattern.

Outcome Assessment

Wound healing and postoperative fracture alignment were evaluated according to the Larson–Bostman criteria. This assessment was primarily based on radiographic findings.

Table 1. Larson–Bostman Criteria for Evaluation of Fracture Fixation Outcomes [9]

Outcome	Fixation Result	Wound Healing Criteria
Excellent	Anatomical reduction, no displacement, proper axial alignment	Primary wound healing

Good	Angular deformity: < 5° (lateral/anterior) or < 10° (posterior/ medial)	Primary wound healing
Fair	Deformity exceeding the above criteria	Superficial infection, secondary wound healing
Poor	Rotational malalignment or similar deformity	Deep infection, osteomyelitis, persistent drainage

Treatment outcomes at 3 months postoperatively were assessed based on bone union, callus formation, nonunion, muscle atrophy, pain during motion, return-to-work capacity, and range of motion according to the ASSH criteria.

Table 2. ASSH Classification Based on Total Active Motion (TAM) [10]

Outcome	Percentage of Normal Active Range of Motion (TAM %)
Excellent	No difference compared with normal
Good	75 - 99%
Fair	50 - 74%
Poor	< 50%

2.5. Statistical Analysis

Data were analyzed using SPSS software version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean values, and categorical variables were presented as percentages.

3. RESULTS

3.1. General Characteristics of the Study Population

Table 3. General Characteristics of the Study Population (N = 33)

Characteristics	Classification	Number of Patients	Percentage (%)
Age (years)	< 16	3	9.1
	17 - 40	16	48.5
	41 - 60	11	33.1
	> 60	3	9.1
Sex	Male	24	72.7
	Female	9	27.3
Injury mechanism	Traffic accident	15	45.5
	Domestic accident	10	30.3
	Occupational accident	8	24.2
Injured hand	Right	13	39.4
	Left	20	60.6
Fracture type	Closed	14	42.4
	Open	19	57.6

3.2. Clinical Symptoms

3.2.1. Common Clinical Symptoms of Patients

The most common clinical manifestations were pain (100%), swelling (60.6%) with ecchymosis, and restricted range of motion.

3.2.2. Classification of Fractures

Among the 33 fractures, open fractures accounted for 19 cases (57.6%), whereas closed fractures were less frequent, with 14 cases (42.4%). The majority were phalangeal fractures (21 cases, 63.6%), while metacarpal fractures were less common (36.4%).

With in 19 open fractures, Grade I open fractures accounted for 5 cases (26.3%), whereas Grade II open fractures comprised 73.7% of cases.

3.2.3. Associated Tendon Injuries

Among the 33 patients with metacarpal and phalangeal fractures, 2 patients (6.1%) had associated tendon injuries; both cases involved flexor tendon injuries. The remaining 31 patients (93.9%) had fractures without concomitant tendon injury.

3.3. Radiographic Characteristics

3.3.1. Number of Fracture Sites in the Metacarpals and Phalanges

Table 6. Number of Fracture Sites (N = 38)

Fracture Location	Number of Fracture Sites	Percentage (%)
Metacarpal bones	12	31.6
Phalanges	26	68.4
Total	38	100.0

Table 6 presents phalangeal fracture sites accounted for the majority, with 26 fracture sites (68.4%), whereas metacarpal fracture sites were less common, with 12 sites (31.6%).

3.2. Fixation Methods

Table 7. Distribution of fixation methods (N = 33)

Fixation Method	Metacarpal Fractures	Phalangeal Fractures	Total	Percentage (%)
Kirschner wire fixation	8	21	29	87.9
Mini-plate and screw fixation	4	0	4	12.1
Total	12	21	33	100.0

A total of 29 patients (87.9%) underwent internal fixation using Kirschner wires (K-wire fixation). Four patients (12.1%) were treated with plate-and-screw fixation. No patient underwent combined fixation with both K-wires and mini-plates/screws.

3.4. Treatment Outcomes

3.4.1. Immediate Postoperative Outcomes

Table 8. Immediate Postoperative Outcomes (N = 38)

Outcome	Classification	Number	Percentage (%)
Postoperative infection	None	38	100.0
Fixation stability	No displacement	36	94.7
	Minor displacement	2	5.3
	Major displacement	0	0
Length of hospital stay	Mean (days)	6.6	—

All patients (100%) had dry surgical wounds postoperatively, with no recorded cases of infection, bleeding, or K-wire migration. The majority of patients (94.7%) showed no postoperative fracture displacement following internal fixation.

3.4.2. Early Outcomes According Larson-Bostman

Table 9. Early Outcomes According to Larson–Bostman Criteria (N = 38)

Outcome	Metacarpal	Phalangeal	Total	Percentage (%)
Excellent	10	12	22	57.9
Good	2	14	16	42.1
Fair	0	0	0	0
Poor	0	0	0	0
Total	12	26	38	100.0

A total of 22 out of 38 fracture sites (57.9%) were rated as excellent, while 16 out of 38 fracture sites (42.1%) were rated as good.

3.4.3. Outcomes at 3-Month Follow-up

All surgical scars were well healed and supple, with no cases of hardware exposure or bone exposure, and no adverse reactions to plates and screws. At the 3-month follow-up, no patient showed evidence of nonunion or muscle atrophy.

Table 10. Radiographic Bone Union at 3 Months (N = 38)

Bone Union Outcome	Metacarpal	Phalangeal	Total	Percentage (%)
Union	11	25	36	94.7
Delayed union	1	1	2	5.3
Total	12	26	38	100.0

Assessment of bone healing in 38 fractures among 33 patients showed that 36 fractures (94.7%) achieved good bone union. Delayed union was observed in 2 cases (5.3%).

Table 11. Pain Level During Motion at 3 Months (N = 38)

Pain Level	Metacarpal	Phalangeal	Total	Percentage (%)
No pain	11	22	33	86.8
Mild pain	1	4	5	13.2
Total	12	26	38	100.0

Among the 33 patients with 38 fracture sites, 33 sites (86.8%) were pain-free during motion, while mild pain at the fracture site was reported in 5 cases (13.2%).

Table 12. Work Capacity at 3 Months (N = 33)

Work Capacity	Metacarpal	Phalangeal	Total	Percentage (%)
Return to previous work	11	19	30	90.9
Slightly limited work	1	2	3	9.1
Severely limited/loss of function	0	0	0	0
Total	12	21	33	100.0

With 33 patients followed up to 3 months, 90.9% returned to their pre-injury work without limitation, whereas 9.1% resumed work with mild functional limitations.

Table 13. Functional Outcomes According to ASSH (N = 38)

Functional Outcome	Metacarpal	Phalangeal	Total	Percentage (%)
Excellent	10	14	24	63.2
Good	2	11	13	34.2
Fair	0	1	1	2.6
Total	12	26	38	100.0

Table 13 summarizes the functional outcomes, range-of-motion outcomes of the metacarpophalangeal and proximal interphalangeal joints were rated as excellent in 63.2% of cases. Good results were observed in 11 fracture sites (34.2%), while 1 site (2.6%) had a fair outcome. The mean Total Active Motion (TAM) at 3 months postoperatively was 231.27° ± 9.96°.

4. DISCUSSION

Among the 33 patients included in this study, metacarpal and phalangeal fractures were most common in the 16–40-year age group, accounting for 48.5% of cases, with males comprising 72.7%. Individuals under 40 years represent the primary working population; therefore, inadequate restoration of hand function may result in loss or reduction of work capacity. Given the increasing demand for manual dexterity in modern occupations, full functional recovery of the hand is critically important.

Regarding the mechanism of injury, trauma was classified into three groups: domestic accidents, occupational accidents, and traffic accidents. In our study, metacarpal and phalangeal fractures were mainly caused by traffic accidents (45.5%) and domestic accidents (30.3%), corresponding to 15 and 10 patients, respectively. Occupational accidents accounted for the lowest proportion (24.2%, 8 cases). Phan Minh Tri and Do Phuoc Hung reported that traffic accidents were the leading cause of metacarpal and phalangeal fractures (68%) [11]. Fahad A. Alhumaid et al. (2019) found that common causes of hand fractures included falls (40.5%), traffic accidents (20.3%), crush injuries (9.5%), and machinery-related injuries (9.5%) [12]. Our findings are therefore consistent with previous studies, in which traffic and domestic accidents were predominant causes. The relatively lower proportion of occupational injuries suggests improved workplace safety; however, the high incidence of traffic- and domestic-related injuries indicates the need for continued preventive measures.Clinical manifestations were diverse. Pain aggravated by motion and restricted motion were present in all patients. Other symptoms, in descending order of frequency, included localized swelling and ecchymosis (60.6%) and soft-tissue injury (54.5%). Typical deformity at the fracture site was the least common sign (21.2%).

Open fractures predominated (57.6%), including 14 Grade II (73.7%) and 5 Grade I (26.3%) injuries according to the Gustilo–Anderson classification, whereas closed fractures accounted for 42.4%. This may be explained by the high rate of traffic accidents and polytrauma. Accurate identification and classification of open fractures are essential, as they influence treatment success, particularly with regard to soft-tissue damage and fracture complexity [13].

Most patients (84.8%) had a single fracture line, while 15.2% had two fracture lines. The number of fracture sites affects postoperative recovery, as multiple fractures are associated with more severe pain and more difficult rehabilitation. These findings align with studies by Phan Minh Tri, Do Phuoc Hung [11], and Nguyen Minh Man [14].

Fractures of the shaft were most common (71.1%), followed by head fractures (18.4%) and base fractures (10.5%). This distribution is similar to that reported by Vu Thiet Son, where shaft fractures accounted for 80.6% [8]. Comparable findings were reported by Nguyen Minh Man (55.6%) [14] and Praveen and Veerabhadra (71.8%) [15]. Oblique fractures were most frequent (50.0%), followed by transverse fractures (42.1%). Although these patterns may be managed conservatively, the high functional demands of patients in this study justified surgical fixation using mini-plates or Kirschner wires. Comminuted fractures were least common (7.9%). Similar distributions were reported in other studies [11,15,16].

No postoperative infections, bleeding, or secondary tendon injuries were observed. Early mobilization may help reduce edema and improve circulation. Internal fixation with mini-plates and K-wires provided stable anatomical reduction. Early postoperative assessment showed satisfactory alignment in 94.7% of fracture sites. Locking plate fixation offers anatomical contouring, stable fixation, and allows early rehabilitation. The benefits of internal fixation for metacarpal and phalangeal fractures are well established. The development of mini locking plates has improved stability, particularly in periarticular and intra-articular fractures [17]. Indications include displaced closed fractures, rotational deformities, longitudinal fractures, failed conservative treatment, and fractures associated with neurovascular or tendon injuries. Locking screws or cancellous screws can be used depending on fracture configuration [18]. Zulfiqar Ahmed et al. reported that K-wire and mini-plate fixation provide comparable outcomes in terms of TAM, ROM, and complication rates [19]. Adequate reduction combined with early rehabilitation facilitates bone healing and functional recovery.

In our study, the union rate was high (94.7%), with only 5.3% delayed union and no nonunion. Stable fixation with K-wires or mini-plates is a key factor for successful healing. Most fracture sites were pain-free during motion (86.8%). Range-of-motion outcomes assessed by ASSH criteria showed excellent and good results in 97.4% of cases, with a mean TAM of 231.27° ± 9.96°, comparable to results reported by Tran Trung Dung [16].

Recovery of TAM is closely related to fracture characteristics, soft-tissue injury, fracture type (open vs. closed), fixation technique, and the effectiveness of rehabilitation.

5. CONCLUSION

Internal fixation with Kirschner wires or mini-plates provided stable anatomical reduction and a high union rate (94.7%) in metacarpal and phalangeal fractures. Complications were minimal, and most patients were pain-free with good functional recovery. Range-of-motion outcomes were predominantly excellent to good, with a mean TAM of 231.27° at 3 months. Early mobilization combined with appropriate rehabilitation contributed to favorable clinical results.

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