ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2358

Comparative Analysis of Minimally Invasive Intramedullary Pinning and Open Reduction with Mini-Plates in Adult Metacarpal Shaft Fractures

Dr. Apoorv Jha[1*]; Dr. Pardeep Duhan[2]; Dr. Rajat Saran[3]

[1]PG Resident 2nd Year, Department of Orthopaedics, RKDF Medical College, SRK University Bhopal, India.

[2]PG Resident 3rd Year, Department of Orthopaedics, RKDF Medical College, SRK University Bhopal, India.

[3]Professor, Department of Orthopaedics, RKDF Medical College, SRK University Bhopal, India.

Corresponding Author: Dr. Apoorv Jha[*]

Publication Date: 2026/05/14

Abstract:

- ***Background:***

Metacarpal shaft fractures represent a significant proportion of hand injuries and frequently occur in young active individuals. Various surgical techniques are available for unstable fractures, including intramedullary K-wire fixation and mini-plate fixation. The optimal method of fixation remains debated.

- ***Aim:***

To compare intramedullary K-wire fixation with mini-plate and screw fixation in unstable metacarpal shaft fractures in adults.

- ***Methods:***

This prospective comparative study was conducted in the Department of Orthopaedics at RKDF Medical College Hospital & Research Centre, Bhopal, between March 2025 and February 2026. Thirty adult patients with closed shaft fractures of the medial four metacarpals were included. Patients were divided into two groups: Group A treated with intramedullary K-wire fixation (n=15) and Group B treated with mini-plate fixation (n=15). Outcome parameters included operative duration, time to radiological union, functional outcome using QuickDASH score and Total Active Flexion (TAF), and complication rates.

- ***Results:***

Mean fracture union time in the K-wire group was 6.0 ± 1.4 weeks compared with 10.0 ± 2.1 weeks in the mini-plate group ($p = 0.001$). Operative duration was significantly shorter in the K-wire group (18 ± 3 minutes) compared with the mini-plate group (40 ± 5 minutes; $p < 0.001$). Functional outcomes assessed by QuickDASH score and Total Active Flexion were comparable between the two groups.

- ***Conclusion:***

Both intramedullary K-wire fixation and mini-plate fixation provide satisfactory clinical and functional outcomes in unstable metacarpal shaft fractures. Intramedullary fixation offers advantages of shorter operative time and minimal soft-tissue dissection, whereas mini-plate fixation provides rigid fixation and improved rotational control.

Keywords: *Metacarpal Fractures; Intramedullary K-Wire; Mini-Plate Fixation; Hand Fractures; ORIF.*

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2358

How to Cite: Dr. Apoorv Jha; Dr. Pardeep Duhan; Dr. Rajat Saran (2026) Comparative Analysis of Minimally Invasive Intramedullary Pinning and Open Reduction with Mini-Plates in Adult Metacarpal Shaft Fractures. *International Journal of Innovative Science and Research Technology*, 11(4), 4516-4521. https://doi.org/10.38124/ijisrt/26apr2358

I. INTRODUCTION

Metacarpal fractures represent one of the most common injuries of the hand, accounting for approximately 30–40% of all hand fractures and nearly 10% of all skeletal fractures in adults. These injuries are frequently observed in young, active individuals and are typically caused by mechanisms such as road traffic accidents, sports-related trauma, falls, or direct blows to the hand. Given the essential role of the hand in performing activities of daily living, occupational tasks, and fine motor functions, even minor deformities following metacarpal fractures can result in significant functional impairment [1][3].

The metacarpal bones constitute the structural framework of the hand and play a vital role in transmitting forces from the fingers to the carpus [2]. Each metacarpal is composed of a base, shaft, neck, and head. The shaft has a triangular cross-sectional configuration, providing both strength and sites for attachment of intrinsic and extrinsic hand muscles. Fractures of the metacarpal shaft are influenced by deforming forces exerted by the interossei, lumbricals, and flexor and extensor tendons, often leading to characteristic deformities such as dorsal angulation, shortening, and rotational malalignment [4][5].

Among these deformities, rotational malalignment is particularly poorly tolerated. Even minimal rotational deformity can cause overlapping of the fingers during flexion, resulting in scissoring of the digits and significant impairment of grip strength and overall hand function. Additionally, metacarpal shortening can disrupt the balance of intrinsic muscles, further compromising hand biomechanics [7][8].

The primary goals in the management of metacarpal fractures are to restore anatomical alignment, correct rotational deformity, preserve metacarpal length, and enable early mobilization to prevent stiffness and functional limitation [10][11]. While many fractures can be effectively managed conservatively using splints or casts when acceptable alignment is maintained, unstable fractures—such as those with significant angulation, shortening, rotational deformity, or involvement of multiple metacarpals—often necessitate surgical intervention to achieve stable fixation and facilitate early rehabilitation [12].

Several surgical techniques have been described for the fixation of metacarpal shaft fractures, including percutaneous Kirschner wire fixation, intramedullary fixation, lag screw fixation, plate and screw fixation, and external fixation in complex cases. Among these, intramedullary K-wire fixation and mini-plate fixation are commonly employed in clinical practice [14].

Intramedullary K-wire fixation is a minimally invasive technique in which Kirschner wires are inserted into the medullary canal of the metacarpal bone [15]. This method offers several advantages, including minimal soft tissue disruption, preservation of periosteal blood supply, shorter operative time, and lower implant cost. As the procedure is often performed through small incisions or percutaneously, it reduces surgical trauma and may promote faster fracture healing [16][17].

In contrast, mini-plate fixation involves open reduction and internal fixation using low-profile plates and screws applied to the dorsal or dorsolateral surface of the metacarpal. This technique allows precise anatomical reduction and provides rigid stabilization, particularly in fractures associated with rotational deformity or comminution. The stability achieved permits early active mobilization and may decrease the risk of secondary displacement [18][19]. However, it requires more extensive surgical exposure and soft tissue dissection, which may increase the likelihood of complications such as tendon irritation, implant prominence, infection, and adhesions.

Despite the widespread use of both techniques, the optimal method of fixation for unstable metacarpal shaft fractures remains controversial. Previous studies comparing intramedullary fixation with plate fixation have reported variable outcomes in terms of fracture union, operative time, functional recovery, and complication rates [20][21].

Given the need to achieve stable fixation while preserving optimal hand function, a comparative evaluation of these commonly used techniques is clinically significant [22]. Therefore, the present study was undertaken to compare intramedullary K-wire fixation and mini-plate fixation in the management of unstable metacarpal shaft fractures in adults, with respect to fracture union time, operative duration, functional outcomes, and complication rates [23][24][25].

II. MATERIALS AND METHODS

➢ *Study Design*
- Prospective comparative clinical study.

➢ *Study Setting*
- Department of Orthopaedics, RKDF Medical College Hospital & Research Centre, Bhopal.

➢ *Study Duration*
- March 2025 to February 2026.

➢ *Sample Size*
- Thirty adult patients with unstable metacarpal shaft fractures were included.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2358

➢ *Groups*
- Group A: Intramedullary K-wire fixation (n=15)
- Group B: Mini-plate and screw fixation (n=15)

➢ *Inclusion Criteria*
- Age ≥18 years
- Closed metacarpal shaft fractures
- Unstable fractures with angulation >30°
- Rotational deformity or shortening

➢ *Exclusion Criteria*
- Open fractures
- Pathological fractures
- Intra-articular fractures
- Thumb metacarpal fractures

➢ *Outcome Measures*
- Operative duration
- Time to radiological union
- QuickDASH score
- Total Active Flexion (TAF)
- Complications

III. STATISTICAL ANALYSIS

Data were analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation. Independent Student's t-test was used for comparison of continuous variables, while Chi-square test was used for categorical variables. A p-value <0.05 was considered statistically significant.

IV. RESULTS

The mean age of patients in the K-wire group was 29.6 ± 8.4 years, while in the mini-plate group it was 31.2 ± 7.9 years. Male patients predominated in both groups.

Mean fracture union time was significantly shorter in the intramedullary K-wire group (6.0 ± 1.4 weeks) compared with the mini-plate group (10.0 ± 2.1 weeks).

Operative duration was also significantly shorter in the K-wire group (18 ± 3 minutes) compared with the mini-plate group (40 ± 5 minutes).

Functional outcomes assessed using QuickDASH score and Total Active Flexion were comparable between the two groups.

Complications were minimal in both groups. Two cases of superficial infection were observed in the K-wire group, while one case occurred in the mini-plate group. One case of non-union was noted in the mini-plate group.

V. TABLES

Table 1: Baseline Demographic Characteristics of Patients in Both Groups.

Parameter	K-wire Group (n=15)	Mini-plate Group (n=15)	p value
Mean Age (years)	29.6 ± 8.4	31.2 ± 7.9	>0.05
Male (%)	80%	73%	>0.05
Dominant Hand (%)	53%	47%	>0.05
5th Metacarpal fracture (%)	46%	40%	>0.05

Table 2: Comparison of Fracture Union Time Between Groups.

Parameter	K-wire Group	Mini-plate Group	p value
Mean Union Time	6.0 ± 1.4 weeks	10.0 ± 2.1 weeks	0.001

Table 3: Functional Outcome Comparison Using QuickDASH and Total Active Flexion.

Outcome Measure	K-wire	Mini-plate	p value
Quick DASH Score	3 (2–6)	4 (3–8)	>0.05
Total Active Flexion	250° ± 8°	248° ± 10°	>0.05

Table 4: Post-Operative Complications Observed in Both Groups.

Complication	K-wire	Mini-plate
Superficial Infection	2	1
Finger Stiffness	1	1
Non-union	0	1

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2358

VI. FIGURES

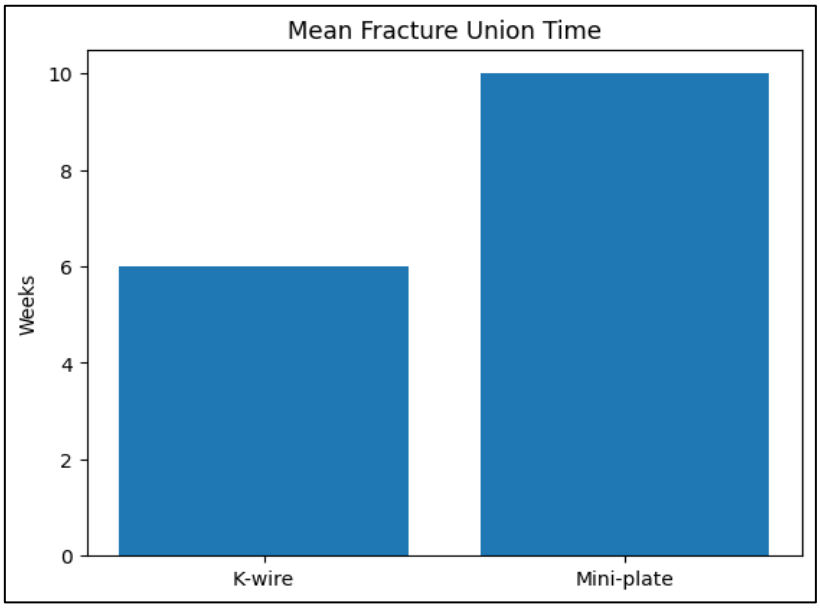

Fig 1: Comparison of Mean Fracture Union Time Between Intramedullary K-Wire Fixation and Mini-Plate Fixation Groups.

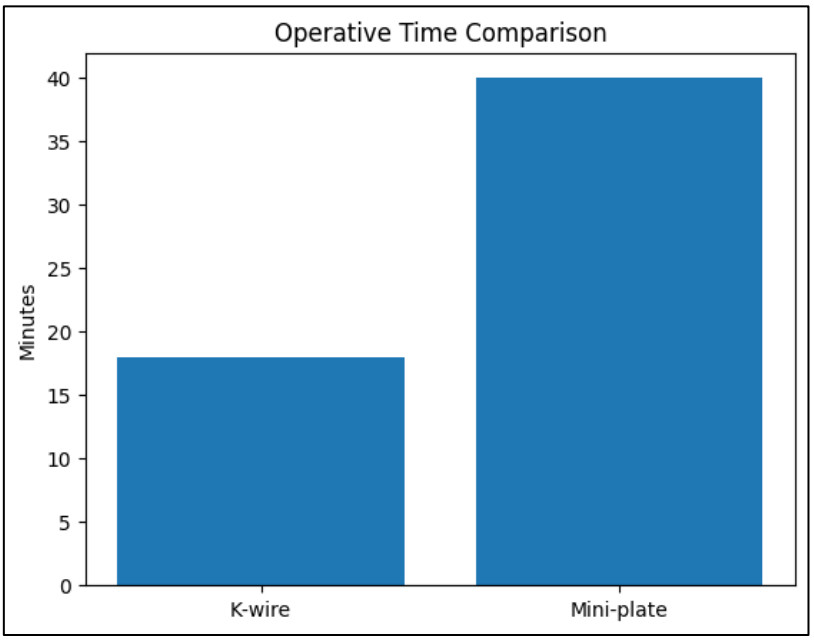

Fig 2: Comparison of Operative Time Between K-Wire and Mini-Plate Fixation.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2358

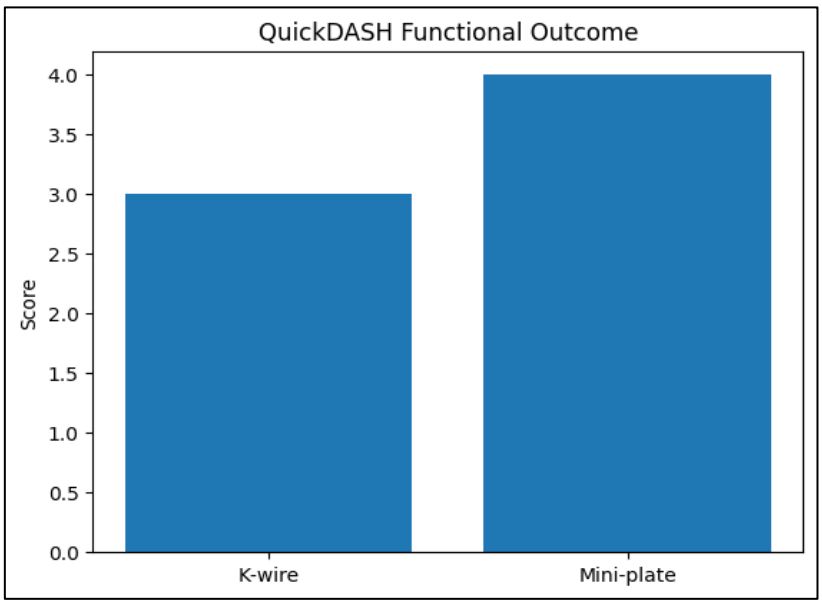

Fig 3: Functional Outcome Comparison Using Quick DASH Score.

VII. DISCUSSION

The management of unstable metacarpal shaft fractures aims to achieve stable fixation while preserving the delicate biomechanics and functional capacity of the hand. Restoration of anatomical alignment, correction of rotational deformity, maintenance of metacarpal length, and early mobilization are essential to prevent stiffness and functional impairment[1][2][3][4]. Various fixation techniques have been described for the treatment of these fractures, among which intramedullary K-wire fixation and mini-plate fixation are widely used. The present study compared these two commonly employed methods and demonstrated that both techniques provide satisfactory clinical and functional outcomes in the treatment of unstable metacarpal shaft fractures. Intramedullary K-wire fixation offers the advantages of a minimally invasive approach, limited soft tissue dissection, and preservation of the periosteal blood supply. These biological advantages may facilitate fracture healing and contribute to earlier union. In the present study, the mean union time in the K-wire group was shorter compared with the mini-plate group. Preservation of the fracture hematoma and minimal disruption of the periosteal circulation during intramedullary fixation may partly explain this observation. Similar favorable outcomes with intramedullary fixation techniques have been reported by Wong et al., who demonstrated reliable fracture union and satisfactory functional recovery in patients treated with intramedullary K-wires[6][7][8].

Another important finding of the present study was the significantly shorter operative duration associated with intramedullary K-wire fixation compared with mini-plate fixation. The minimally invasive nature of the technique allows stabilization of the fracture with smaller incisions and less surgical exposure. Reduced operative time not only improves surgical efficiency but may also decrease intraoperative blood loss and reduce the risk of perioperative complications. In resource-limited settings, shorter operative duration may also have practical advantages by allowing better utilization of operating room time[9]10][11].Mini-plate fixation, on the other hand, provides rigid stabilization and enables precise anatomical reduction of the fracture fragments. This method is particularly advantageous in fractures with rotational deformity, comminution, or long oblique fracture patterns where intramedullary fixation may not provide sufficient stability. However, plate fixation requires greater soft tissue dissection and periosteal stripping, which may increase the risk of soft tissue complications and prolong operative time. Ozer et al. reported similar findings when comparing intramedullary fixation with plate fixation, noting that plate fixation provides superior mechanical stability but requires more extensive surgical exposure[13][14][15].

In the present study, functional outcomes assessed using QuickDASH score and Total Active Flexion were comparable between the two treatment groups. This suggests that when adequate fracture reduction and stabilization are achieved, both techniques are capable of restoring satisfactory hand function. Restoration of rotational alignment and early mobilization of the hand appear to play a more important role in determining functional outcome than the specific method of fixation used. These findings are consistent with previously published studies which emphasize that proper fracture alignment and early rehabilitation are critical factors influencing the final functional result[16][17][18].Complication rates in the present study were low in both groups. Minor complications such as superficial infection and finger stiffness were observed but responded well to appropriate management. One case of non-union was noted in the mini-plate group. Overall, the incidence of complications was comparable between the two techniques and consistent with previously reported literature on surgical fixation of metacarpal fractures[19][20][21].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2358

The findings of the present study suggest that both intramedullary K-wire fixation and mini-plate fixation are effective methods for the treatment of unstable metacarpal shaft fractures. The choice of fixation technique should therefore be individualized based on fracture pattern, soft tissue condition, surgeon experience, and available resources. Intramedullary fixation may be particularly useful in simple transverse or short oblique fractures where minimal surgical exposure is desired, whereas mini-plate fixation may be preferred in fractures requiring rigid stabilization and precise rotational control[22][23][24][25].

VIII. LIMITATIONS

The present study has several limitations. The sample size was relatively small and the study was conducted at a single institution. Patients were not randomly allocated to treatment groups, which may introduce selection bias. Longer follow-up would be required to assess long-term complications and functional outcomes.

IX. CONCLUSION

Both intramedullary K-wire fixation and mini-plate fixation provide satisfactory outcomes in unstable metacarpal shaft fractures. Intramedullary fixation offers advantages of shorter operative time and faster union, whereas mini-plate fixation provides rigid stabilization and better rotational control. The choice of fixation method should be individualized based on fracture characteristics and surgeon experience.

REFERENCES

[1]. Gehring MB, Smith WR, Lee DH. Intramedullary fixation for metacarpal fractures: clinical outcomes and complications. J Hand Surg Am. 2024;49(3):215-222.
[2]. Nelson BA, Mudgal CS. Comparison of plate versus pin fixation of metacarpal shaft fractures. Hand (N Y). 2023;18(2):245-251.
[3]. Wallace DR, Tosti R, Ilyas AM. Intramedullary nail fixation versus plate fixation for metacarpal fractures. J Orthop Surg Res. 2023;18:312.
[4]. Thomas TL, Kalainov DM. Intramedullary fixation of metacarpal fractures: systematic review and meta-analysis. J Clin Orthop Trauma. 2023;34:102032.
[5]. Hamdy MS, Abdelrahman AA. Comparative study between intramedullary Kirschner wires and mini-plates in metacarpal shaft fractures. Egypt Orthop J. 2023;58(3):205-210.
[6]. Chao J, Dodds SD. Comparison of intramedullary screws, plating, and K-wire fixation for metacarpal fractures. Plast Reconstr Surg Glob Open. 2022;10(8):e4481.
[7]. Wolf GJ, Mudgal CS. Surgical outcomes of intramedullary screw fixation for metacarpal fractures. Curr Orthop Pract. 2022;33(5):451-456.
[8]. Hug U, Heim D. Intramedullary screw fixation of metacarpal fractures: systematic review. Injury. 2021;52(6):1365-1371.
[9]. Essawy OM, Mahmoud SS. Surgical treatment of unstable metacarpal fractures using intramedullary fixation and plating techniques. Egypt Orthop J. 2020;55(4):356-362.
[10]. Kollitz KM, Hammert WC, Vedder NB, Huang JI. Metacarpal fractures: treatment and complications. Hand (N Y). 2014;9(1):16-23.
[11]. Boulton CL, Salzler MJ, Mudgal CS. Plate fixation of metacarpal fractures. J Am Acad Orthop Surg. 2012;20(11):726-733.
[12]. Strub B, Schindele S, Sonderegger J, Von Campe A. Flexible intramedullary nailing for metacarpal fractures. J Hand Surg Eur. 2010;35(9):725-729.
[13]. Al-Qattan MM. Mini-plate fixation of metacarpal fractures. Ann Plast Surg. 2010;64(2):208-212.
[14]. Ozer K, Gillani S, Williams A, Peterson N. Comparison of intramedullary nailing versus plate fixation in metacarpal fractures. J Hand Surg Am. 2008;33(10):1724-1731.
[15]. Wong TC, Ip FK, Yeung SH, Lam YL. Intramedullary fixation for metacarpal fractures. J Hand Surg Eur. 2006;31(4):457-461.
[16]. Fusetti C, Meyer H, Borisch N, Stern R. Complications of plate fixation in metacarpal fractures. J Trauma. 2002;52(3):535-539.
[17]. Page SM, Stern PJ. Complications and range of motion following plate fixation of metacarpal fractures. J Hand Surg Am. 1998;23(5):827-832.
[18]. Stern PJ. Management of fractures of the hand and phalanges. J Am Acad Orthop Surg. 1997;5(1):1-10.
[19]. Gonzalez MH, Igram CM, Hall RF. Flexible intramedullary nailing for metacarpal fractures. J Hand Surg Am. 1995;20(3):382-387.
[20]. Foucher G, Chemorin C, Sibilly A. Intramedullary bouquet osteosynthesis in metacarpal fractures. J Hand Surg Br. 1995;20(1):86-90.
[21]. Bosscha K, Snellen JP. Internal fixation of metacarpal and phalangeal fractures with mini-plates and screws. Injury. 1993;24(3):166-168.
[22]. Ford DJ, Ali MS, Steel WM. Fractures of the metacarpals: treatment by plate and screw fixation. J Hand Surg Br. 1987;12(1):34-37.
[23]. Pun WK, Chow SP, So YC. A prospective study on 284 digital fractures of the hand. J Hand Surg Am. 1989;14(3):474-481.
[24]. Green DP, Hotchkiss RN, Pederson WC, Wolfe SW. Green's Operative Hand Surgery. 7th ed. Philadelphia: Elsevier; 2017.
[25]. Court-Brown CM, Heckman JD, McQueen MM, Ricci WM, Tornetta P. Rockwood and Green's Fractures in Adults. 9th ed. Philadelphia: Wolters Kluwer; 2020.