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Research Article

COMPARATIVE EVALUATION OF CLINICAL, RADIOLOGICAL, AND PATIENT-REPORTED OUTCOMES BETWEEN PLATE FIXATION AND KIRSCHNER WIRE FIXATION IN METACARPAL FRACTURES: A PROSPECTIVE STUDY

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Abstract: ***Introduction:*** Metacarpal fractures are common hand injuries that require stable fixation to allow for early rehabilitation. This study compares the clinical, radiological, and patient-reported outcomes of open reduction and internal fixation (ORIF) with plating versus Kirschner wire (K-wire) fixation.**Methods**: In this prospective comparative study, 30 patients with displaced metacarpal fractures were divided into two groups (n=15 each). Group A underwent ORIF with a 2.4 mm Locking Compression Plate (LCP), while Group B was treated with K-wire fixation (Bouquet or Retrograde technique). Outcomes were evaluated at 2 weeks, 1 month, 3 months, and 6 months postoperatively. Primary endpoints included the time to radiological union, Total Active Motion (TAM), grip strength, and the Disabilities of the Arm, Shoulder, and Hand (DASH) score.**Results:** The mean time to radiological union was significantly shorter in the plating group (7.2 ±1.4 weeks) compared to the K-wire group (8.5 ±1.8 weeks, p=0.042). At 3 months, 73.3% of Group A achieved "Excellent" TAM, whereas only 53.3% of Group B reached this status (p=0.035). At the 6-month follow-up, the mean DASH score was significantly better in the plating group (11.8 ±3.9) than in the K-wire group (20.4 ±6.2, p=0.001). Grip strength recovery was also superior in Group A (92% vs. 84%). Complications in the K-wire group were primarily joint stiffness (n=4) and malunion (n=2), while the plating group reported higher hardware irritati4n (n=3).**Conclusion:** Plate fixation for metacarpal fractures provides superior primary stability and facilitates earlier mobilization, leading to significantly better functional recovery and patient satisfaction scores compared to K-wire fixation. While K-wires remain a viable minimally invasive option, plating is the preferred modality for achieving optimal short-term functional outcomes.

Keywords: Metacarpal fracture, Plate fixation, K-wire, DASH score, Total Active Motion (TAM), Hand surgery.

INTRODUCTION

Fractures of the metacarpals and phalanges represent a substantial portion of orthopedic trauma, accounting for up to 44% of all musculoskeletal fractures (1,2)These injuries, frequently secondary to vehicular accidents or industrial trauma, present significant rehabilitative challenges (3–5). Inadequate management often results in permanent functional impairment, including sensory deficits and diminished grip strength (6,7)While conservative management remains the gold standard for stable, non-displaced fractures, unstable configurations necessitate surgical intervention (8)Historically, Kirschner wires (K-wires) and internal plate fixation have emerged as the primary osteosynthesis techniques (9). The selection of fixation modalities for solitary metacarpal fractures—specifically those exhibiting rotational deformity or significant shortening—remains a subject of clinical debate (10). Although intramedullary K-wire fixation is valued for its cost-effectiveness and minimally invasive nature, its mechanical stability is often suboptimal, potentially leading to higher rates of malunion or infection(11,12). Conversely, while plate fixation offers rigid stabilization, it is associated with risks such as skin necrosis and hardware irritation [12]. Given the conflicting evidence regarding the clinical superiority of these two methods, further comparative analysis is required to optimize patient outcomes

(13).Despite the prevalence of hand fractures, current literature provides equivocal evidence regarding the most efficacious surgical intervention (13). This study aims to provide a rigorous clinical and radiological comparison between Open Reduction Internal Fixation (ORIF) via plating and K-wire fixation (whether open or closed) in the management of metacarpal fractures. By evaluating functional recovery and osseous healing across both cohorts, this research seeks to clarify the indications for each respective modality.

MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of Orthopaedics at Sree Mookambika Institute of Medical Sciences, Kanyakumari, spanning from January 2024 to October 2025. The study protocol was reviewed and approved by the Institutional Review Board (IRB). All participating patients, or their legal guardians, provided informed written consent prior to enrolment. A total of 30 patients (from an initial screening of 34) presenting with metacarpal fractures via the Outpatient Department (OPD) or Emergency Services were enrolled. Diagnosis was confirmed through clinical examination and standardized radiological imaging.

Inclusion Criteria:

- Patients aged 18 to 60 years.
- Closed, displaced metacarpal fractures (defined as >10° angulation, >3mm shortening, or any rotational deformity).
- Fractures less than three weeks old.
- Solitary or multiple metacarpal involvement.

Exclusion Criteria:

- Fracture Complexity: Open fractures (Gustilo-Anderson Grade II or III), intra-articular involvement, or comminuted fractures (>3 fragments).
- Bone Pathology: Pathological fractures or pre-existing hand deformities.
- Soft Tissue & Systemic Factors: Massive soft-tissue injury, previous trauma at the same site, and neurological deficits in the affected limb.
- Systemic Comorbidities: Diabetes mellitus, metabolic bone diseases (e.g., chronic renal failure), or connective tissue disorders that might impede healing.
- Stable Injuries: Undisplaced fractures.

Eligible participants were randomized into two cohorts. After a comprehensive explanation of the benefits and potential complications associated with each surgical modality, patients were assigned to one of the following groups:

- Group A (n=15): Managed via Open Reduction and Internal Fixation (ORIF) with Plating.
- Group B (n=15): Managed via Kirschner wire (K-wire) fixation (Open or Closed reduction).

Surgical Techniques

1. Open Reduction and Internal Fixation (ORIF) with Plating (Group A)

For solitary metacarpal fractures, a longitudinal dorsal incision was centered directly over the affected bone. In cases involving adjacent fractures, a single midline dorsal incision was utilized between the involved metacarpals. Meticulous dissection was performed to identify and preserve the dorsal sensory nerve branches. The extensor apparatus was retracted to allow for subperiosteal exposure of the fracture site. Following the evacuation of the fracture hematoma and debridement of debris, anatomical reduction was achieved and provisionally maintained with Kirschner wires (K-wires). Definitive fixation was performed using the 2.4 mm Locking Compression Plate (LCP) system, utilizing straight, T-plates, or condylar plates based on fracture morphology. Whenever anatomically feasible, the periosteum was closed over the plate to minimize tendon-to-implant contact and reduce the risk of adhesions. Screw length and plate positioning were verified via intraoperative fluoroscopy. The subcutaneous layer was closed using polyglactin absorbable sutures.

2. Kirschner Wire Fixation (Group B)

In the K-wire cohort, the majority of fractures were managed via closed reduction; however, open reduction was necessitated in cases where anatomical alignment could not be achieved closed. The surgical approach for open cases followed the same dorsal dissection protocol described for the plating group. For metacarpal neck fractures, the Jahss maneuver was employed—flexing the MCP and PIP joints and applying a dorsally directed force through the proximal phalanx to correct volar angulation. Shaft fractures were reduced via longitudinal traction and digital manipulation under fluoroscopic guidance. Fixation Techniques: Antegrade (Bouquet) Technique: A small proximal incision was made over the metacarpal base. After protecting the neurovascular structures, a 0.062-inch K-wire created a cortical entry point. Subsequently, 0.054-inch K-wires with pre-bent tips were advanced distally across the fracture site. Retrograde Technique: Primarily used for shaft fractures, an incision was made over the MCP joint, and the extensor tendon was split to allow for the insertion of a 0.059-inch K-wire through the dorsal portion of the metacarpal head, traversing the fracture site.

Standardized post-operative protocol and follow-up

Postoperatively, all patients received a standardized regimen of intravenous antibiotics for three days, followed by oral antibiotics for an additional seven days. The operated extremity was initially stabilized in a volar bulky dressing or splint and maintained in an arm sling to reduce edema. On the third postoperative day, the surgical site was inspected for wound healing, and baseline radiographs were obtained to verify the maintenance of fracture reduction.

The rehabilitation protocol was tailored to the stability of the internal fixation:Group A (Plating): Due to the rigid nature of the locking compression plates, patients initiated early active-assisted range of motion (ROM) of the metacarpophalangeal (MCP) and interphalangeal (IP) joints within the first week, as tolerated by pain.Group B (K-wire): The hand remained immobilized in a volar splint for four to six weeks. Controlled mobilization of the fingers commenced only after clinical and radiological evidence of early callus formation was observed. During this phase, pin-site care was emphasized to the patients to prevent tract infections. For both cohorts, progressive strengthening and resisted exercises were introduced after the eighth week, once stable osseous union was confirmed.

Criteria for K-wire Removal: Serial radiographs were obtained during follow-up to monitor for the presence of a bridging callus and the disappearance of the fracture line. Once stable radiological union was confirmed—typically between the sixth and eighth postoperative week—the Kirschner wires were removed.

Procedure for Removal: Wire removal was performed as an outpatient procedure. Under aseptic precautions, the wires were extracted using a standard wire puller or heavy needle driver. Local anesthesia was generally not required unless the wires were buried beneath the skin. Following extraction, the pin-site wounds were dressed, and the patients were

transitioned into an intensive physical therapy program to address the joint stiffness associated with the immobilization period.

Follow-up and Outcome Evaluation

Patients were monitored in the Outpatient Department (OPD) at two weeks, one month, three months, and six months. During these intervals, the following parameters were rigorously evaluated:

- Radiological Assessment: Serial X-rays were utilized to determine the time to bone union and to screen for any loss of reduction or implant loosening.
- Clinical Assessment: Pain was quantified using the Visual Analog Scale (VAS). Functional outcomes were measured via Total Active Motion (TAM) of the digits and Grip Strength (expressed as a percentage of the contralateral unaffected hand) at the six-month mark.
- Patient-Reported Outcomes: Upper extremity function and patient satisfaction were measured using the DASH (Disabilities of the Arm, Shoulder, and Hand) score.
- Complications: The incidence of MCP joint stiffness, infection, hardware prominence, and malunion was recorded throughout the follow-up period.

For the purposes of this study, all demographic and clinical data were analyzed based on the total number of patients (N=30) rather than the number of fractures. In cases where a patient presented with multiple metacarpal fractures, the most clinically significant fracture was used for anatomical and functional categorization to maintain statistical independence

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	Group A (Plating) (n=15)	Group B (K-wire) (n=15)	p-value
Age (Years), Mean± SD	34.2 ± 8.5	36.1 ± 7.2	>0.05
Gender (M:F)	12:3	11:4	>0.05
Involved Hand (Dominant:Non-dominant)	10:5	9:6	>0.05
Mechanism of Injury			
Road Traffic Accident (RTA)	8	9	-
Industrial/Machine Injury	5	4	-
Direct Assault/Fall	2	2	-
Metacarpal Digit Involved			
Second Metacarpal	3	2	-
Third Metacarpal	4	5	-
Fourth Metacarpal	5	4	-
Fifth Metacarpal	3	4	-
Anatomical Fracture Site			
Neck	4	6	-
Shaft	9	7	
Base	2	2	
Time from Injury to Surgery (Days)	2.4 ±1.1	2.1 ±0.9	>0.05

Table 2: Clinical and Radiological Outcomes

Outcome Measure	Group A (Plating) (n=15)	Group B (K-wire) (n=15)	p-value
Time to Radiological Union (Weeks)	7.2 ± 1.4	8.5 ± 1.8	0.042 *
TAM at 3 Months Post-op (n)			
Excellent (>210°)	11	8	0.035 *
Good (150°– 210°)	3	4	-
Fair (75 °– 150°)	1	2	-
Poor (<75°)	0	1	-
Grip Strength at 6 Months (% of Contralateral)	92% ± 5.1	84% ± 6.8	0.015 *

Table 3: Comparison of Patient-Reported Recovery (DASH Score) at 6-Month Follow-up

DASH Category (Score Range)	Group A (Plating) (n=15)	Group B (K-wire) (n=15)	p-value
Excellent (0–15)	11 (73.3%)	6 (40.0%)	0.002 *
Good (16–30)	3 (20.0%)	5 (33.3%)	-
Satisfactory (31–45)	1 (6.7%)	3 (20.0%)	-
Poor (>45)	0 (0.0%)	1 (6.7%)	-

Mean DASH Score (±SD)	11.8 ±3.9	20.4 ± 6.2	0.001 *

Table 4: Analysis of Postoperative Complications

Complication Type	Group A (Plating) (n=15)	Group B (K-wire) (n=15)
Stiffness of Fingers (MCP Joint)	2	4
Infection	1	3
Implant Loosening	1	2
Hardware Irritation / Prominence	3	1
Malunion	0	2

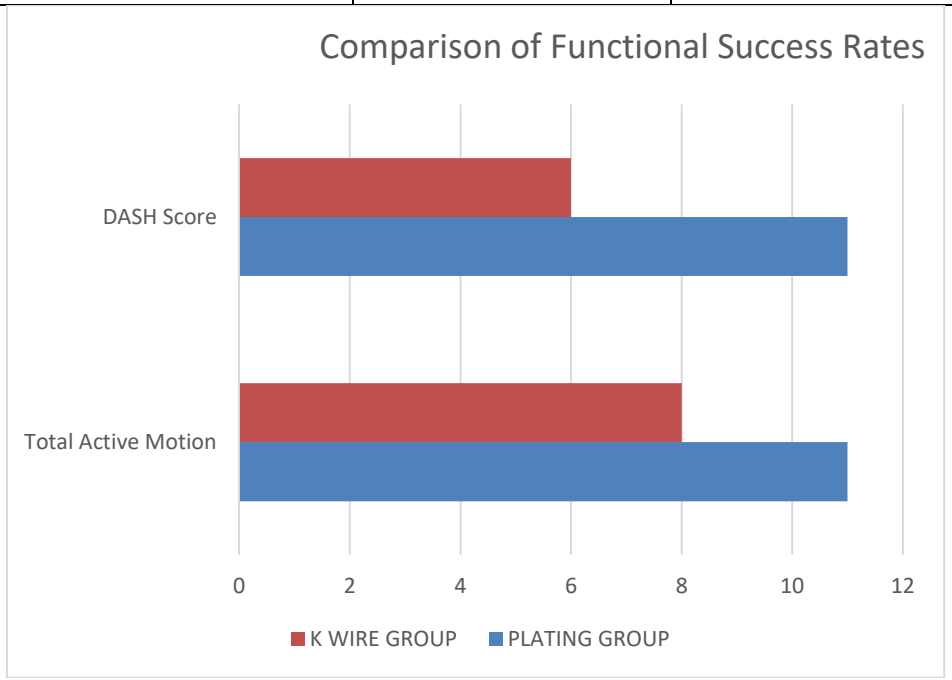

Figure 1: Comparison of Functional Success Rates

Figure 1. Comparison of "Excellent" clinical outcomes between the Plating and K-wire groups. "Excellent" status was defined as a Total Active Motion (TAM) >210° at 3 months and a DASH score <15 at 6 months. The plating group (Group A) showed a statistically higher proportion of excellent results in both objective and patient-reported metrics ($p < 0.05$).

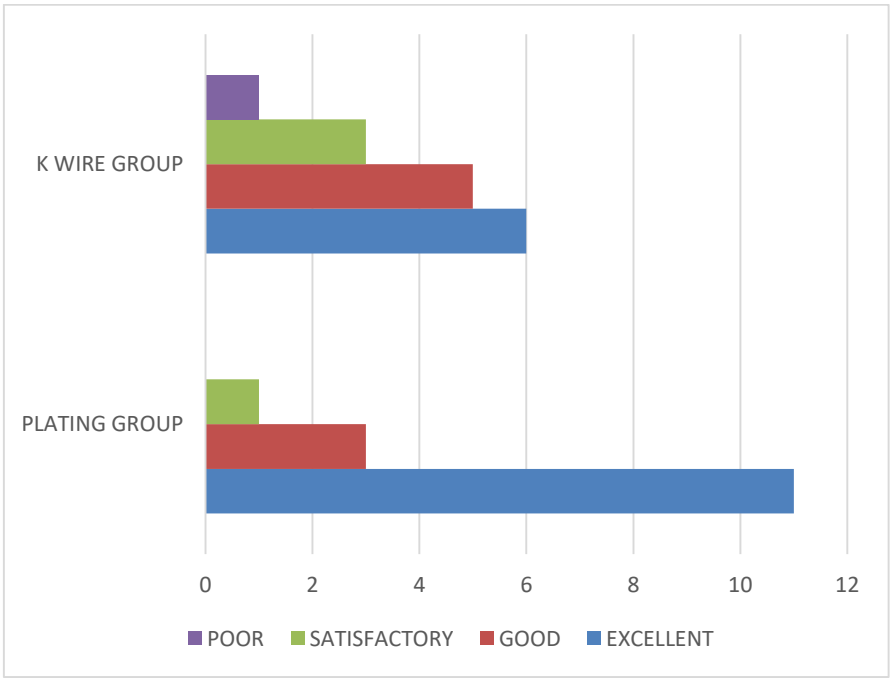

Figure 2: Distribution of DASH score outcome

Figure 2. Bar graph representing the distribution of Disabilities of the Arm, Shoulder, and Hand (DASH) scores at the 6-month follow-up. The plating group exhibited lower scores (indicating better function) and less variance compared to the K-wire group (p=0.001).

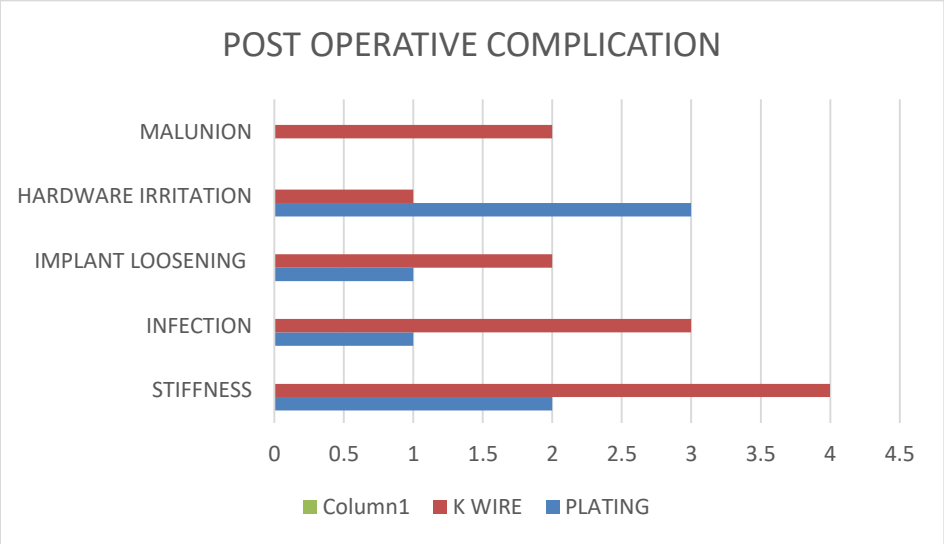

Figure 3: Comparative Analysis of Postoperative Complications

Figure 3. Incidence and types of complications observed in both treatment cohorts. Group A (Plating) was primarily associated with hardware-related irritation, whereas Group B (K-wire) demonstrated a higher prevalence of MCP joint stiffness and malunion, reflecting the differences in stability and mobilization protocols between the two modalities.

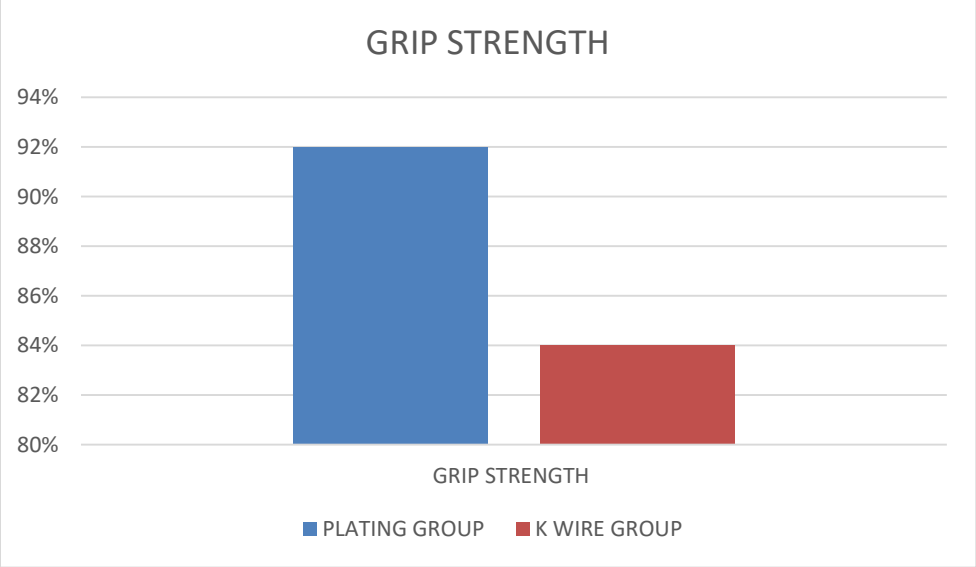

Figure 4: Recovery of Grip Strength

Figure 4. Mean percentage of grip strength recovery relative to the contralateral unaffected hand at 6 months post-surgery. Patients in the plating group achieved 92% recovery, significantly outperforming the 84% recovery observed in the K-wire group (p=0.015).

RESULTS

A total of 30 patients were included in the final analysis, divided equally into **Group A (Plating, n=15)** and **Group B (K-wire, n=15)**. The mean age of the participants was 34.2 ±8.5 years in the plating group and 36.1 ±7.2 years in the K-wire group. Road Traffic Accidents (RTA) were the primary mechanism of injury across both cohorts. Anatomically, shaft fractures were the most common (n=16), followed by neck (n=10) and base (n=4) fractures. The mean time to radiological union was significantly shorter in the plating group (7.2 ±1.4 weeks) compared to the K-wire group (8.5 ±1.8 weeks, p=0.042). At the 3-month follow-up, **Group A** demonstrated superior **Total Active Motion (TAM)**,

with 11 patients (73.3 %) achieving "Excellent" results, compared to only 8 patients (53.3 %) in **Group B**.

Furthermore, at 6 months post-surgery, the plating group exhibited significantly higher grip strength (92 % ±5.1 of the contralateral hand) compared to the K-wire group (84 % ±6.8, p=0.015).

The assessment of subjective recovery at 6 months using the **DASH score** showed a statistically significant advantage for plate fixation. Group A recorded a mean DASH score of 11.8 ±3.9, while Group B recorded 20.4 ±6.2 (p=0.001). In terms of qualitative grading, 73.3 % of the plating group achieved an "Excellent" rating, whereas the K-wire group had a broader distribution, including "Satisfactory" and "Poor" outcomes.

The overall profile of adverse events differed by modality. **Stiffness of the MCP joints** was the most frequent complication in the K-wire group (n=4), likely due to prolonged immobilization. Conversely, **Hardware Irritation** was more prevalent in the plating group (n=3). Implant loosening was noted in 2 cases in Group B and 1 case in Group A. Notably, rotational or angular malunion was only observed in the K-wire group (n=2).

DISCUSSION

The management of metacarpal fractures seeks to achieve anatomical alignment while facilitating early mobilization to prevent tendon adhesions and joint stiffness. Our study compared the efficacy of Open Reduction Internal Fixation (ORIF) with plating (Group A) against Kirschner wire (K-wire) fixation (Group B). The results demonstrate a significant clinical and functional advantage in the plating cohort, particularly regarding recovery speed and patient-reported satisfaction.

In our series, the plating group achieved "Excellent" Total Active Motion (TAM) in 73.3 % of cases, compared to 53.3 % in the K-wire group (**Table 2**). This disparity is largely attributable to the rigid stability provided by the 2.4 mm locking compression plates, which allowed for immediate postoperative mobilization. Conversely, the K-wire group required a period of immobilization until radiological union (mean 8.5 weeks), which contributed to higher rates of MCP joint stiffness (**Table 4**). These findings are consistent with the study by **Souer et al.**, who reported that stable internal fixation allows for early rehabilitation, resulting in superior range of motion compared to K-wire techniques (14).

We observed a significant difference in grip strength at six months, with Group A reaching 92 % of the contralateral hand's strength compared to 84 % in Group B (**Table 2**). This objective metric correlated directly with the DASH scores (**Table 3**), where the plating group showed a lower mean score (11.8 ±3.9), indicating superior functional recovery. Our data aligns with research by **Facca et al.**, which highlighted that patients undergoing plate fixation return to activities of daily living (ADLs) sooner than those managed with percutaneous pinning (12). The qualitative grading of DASH scores in our study—where 73.3 % of Group A was "Excellent" versus 40 % in Group B—further underscores the subjective benefits of rigid fixation.

The complication profiles revealed distinct challenges for each modality (**Table 4**). The K-wire group exhibited higher rates of infection and malunion. The occurrence of malunion in the K-wire group (n=2) suggests that while pinning is minimally invasive, it may lack the rotational stability required for complex shaft fractures. **Ozer et al.** similarly noted that K-wires are more susceptible to migration and loss of reduction(15). However, plating was not without drawbacks; hardware prominence and irritation were more frequent in Group A (n=3). This "hardware-related morbidity" is a well-documented complication in hand surgery due to the minimal subcutaneous tissue overlying the metacarpals.

Group A showed a significantly faster mean time to radiological union (7.2 weeks) than Group B (8.5 weeks). While some literature suggests that closed K-wire fixation preserves the fracture hematoma and enhances biological healing, our results suggest that the primary stability of locking plates may facilitate primary bone healing or at least permit earlier load-bearing, which accelerates the clinical perception of union.

The study is limited by its small sample size (N=30) and a relatively short six-month follow-up period, which may not capture long-term complications or hardware-related morbidity. Additionally, the inclusion of various fracture sites (neck, shaft, and base) introduces anatomical heterogeneity that could influence the specific functional outcomes of each fixation method.

CONCLUSION

This prospective study concludes that Open Reduction Internal Fixation with Plating is superior to K-wire fixation for the management of displaced metacarpal fractures in terms of functional outcomes and patient satisfaction.Plating offers superior primary stability, allowing for early mobilization, which results in higher TAM scores and significantly lower DASH scores.K-wire fixation, while cost-effective and minimally invasive, is associated with prolonged immobilization, a higher risk of joint stiffness, and inferior grip strength recovery.The choice of implant should be tailored to the fracture morphology; however, for patients requiring a rapid return to work and high functional demand, plate fixation is the preferred modality.

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