The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 7, 2025

COMPARISON OF MINI-PLATE FIXATION VERSUS KIRSCHNER WIRE INTERNAL FIXATION IN PATIENTS WITH CLOSED METACARPAL AND PHALANGEAL DIAPHYSEAL FRACTURES

Dr Abu Bakar Sadique[*1], Dr Hafiz Muhammad Irfan[2], Dr Usama Ashraf[3]

[*1,2,3]*Post Graduate Resident, GTH, Gujranwala*

[*1]abubakrsiddique39@gmail.com

DOI: https://doi.org/10.5281/zenodo.15845148

Keywords
Metacarpal fractures, Phalangeal fractures, Mini-plate fixation, Kirschner wire (K-wire), Internal fixation, bone healing

Article History
Received: 02 April, 2025
Accepted: 23 June, 2025
Published: 09 July, 2025

Corresponding Author: *
Dr Abu Bakar Sadique

ABSTRACT

OBJECTIVE: *To compare the outcome of Mini-plate fixation versus Kirschner's wire internal fixation in patients with closed metacarpal and phalangeal shaft fractures.*

STUDY DESIGN: *Randomized controlled trial.*

Setting: *Department of Orthopedic Surgery, DHQ Hospital, Gujranwala.*

DURATION: *6 months after approval of synopsis January 17, 2025 to June 16, 2025.*

METHODOLOGY: *This randomized controlled trial was conducted over six months at DHQ Hospital, Gujranwala, involving 60 patients with unstable, displaced metacarpal or phalangeal shaft fractures. Participants were randomly assigned to either K-wire or mini-plate fixation, with outcomes assessed via total active ROM and healing time. Data were analyzed using SPSS v25, applying t-tests and Chi-square tests with $p \leq 0.05$ considered significant.*

RESULTS: *The study included 60 patients (mean age: 37.83 ± 12.71 years), with most in the 18–40 age group and nearly equal gender distribution. Mini-plate fixation showed a higher rate of excellent functional outcomes (65.2% vs. 34.8%) and significantly faster healing time (10.00 ± 1.74 vs. 12.13 ± 3.04 weeks, $p = 0.001$). Most injuries were accidental (56.7%), and 68.3% of patients were classified as low surgical risk (ASA I/II).*

CONCLUSION: *Both K-wire and mini-plate fixation effectively treat metacarpal fractures, but mini-plate fixation showed faster healing and better functional trends. These results align with existing literature favoring rigid internal fixation for improved early recovery.*

INTRODUCTION

Hand trauma can lead a significant disability from loss of strength, sensation, loss and flexibility. Timely intervention of such fractures may decrease the likelihood of disability.[1] Hand injuries represent a frequent presentation in emergency departments, where around half of these are metacarpal fractures i.e. (40%).[2] Securing the beast possible functional outcome in these cases is challenging.[3] A variety of treatment options available depending on the pattern of fracture.[4] Considerable judgment is required to select the appropriate modality.[5] Various treatment options are explained for metacarpal fractures, including percutaneous fixation, splinting, open reduction with internal fixation, and the final external

fixation. The primary objective is to restore optimal hand function with minimizing morbidity.[6, 7]

Closed Reduction and Internal Fixation with Percutaneous pinning with Kirschner wires (K-wires) is a widely used surgical option for extra-articular metacarpal fractures. It is less invasive, versatile, and often quicker as compared with other techniques. On the other hand, wire fixation is not truly rigid, leading to the need for prolonged immobilization and potential postoperative stiffness.[8] However, because of the less rigid fixation with little stability of the K-wire, it is limited in the treatment of unstable fractures, while mini-plate is considered as a potential option for unstable fractures of the hand with good stability allowing early mobilization of joints and avoiding problems associated with protruding K-wire [9, 10].

Zhang et al., conducted a trial and found that based on total active motion scoring system, excellent results were noted in 21 (31.3%) cases with K-wire fixation and 9 (14.1%) excellent with plate fixation ($p>0.05$).[11] But Noor et al., found that the mean time for healing was 9.58±2.24 weeks with miniplate while 12.33±2.85 weeks with K-wires ($p<0.05$). But excellent outcome was observed as 57.14% vs. 42.86% ($p>0.05$).[12] Ahmed et al., found that the mean time for healing was 11.80±2.38 weeks with miniplate while 12.95±3.38 weeks with K-wires and excellent outcome was observed as 97.1% vs. 95% ($p>0.05$).[13]

Rationale of this study is to compare the outcome of Mini-plate fixation versus Kirschner's wire internal fixation in patients with closed metacarpal and phalangeal shaft fractures. Literature showed varied data regarding efficacy of both type of treatments for closed metacarpal and phalangeal shaft fractures. Also, local studies showed inconsistent results. Therefore, this study has been planned to find more effective and beneficial treatment method for closed metacarpal and phalangeal shaft fractures for local population. So that in future, these findings would be implemented in local set-up.

METHODOLOGY

This randomized controlled trial was conducted in the Department of Orthopedic Surgery at DHQ Hospital, Gujranwala, over a duration of six months following the approval of the research synopsis. The sample size was calculated using OpenEpi.com, with a 95% confidence level, 90% power of test, and reference values of mean healing time (9.58 ± 2.24 weeks with mini-plate fixation and 12.33 ± 2.85 weeks with K-wire fixation), resulting in a total of 60 patients, 30 in each group. A non-probability consecutive sampling technique was employed for the selection of study participants. Patients aged 18 to 60 years of either gender presenting with closed, unstable, and displaced metacarpal or phalangeal shaft fractures were included. Exclusion criteria were: presentation after 2 days of injury, open fractures, pathological fractures, previous trauma to the same site, diabetes (random blood sugar > 200 mg/dl), metabolic diseases, and connective tissue disorders.

After obtaining ethical approval and written informed consent, a total of 72 patients presenting in the OPD were assessed for eligibility, and 60 were included in the study. Demographic data including name, age, gender, cause and duration of injury, grade of injury, ASA status, laterality, and occupation were recorded. Participants were randomly allocated into two groups using the lottery method. Group A underwent internal fixation with 1–1.5 mm non-threaded Kirschner wires, while Group B received mini-plate fixation using 2.4 mm plates with a 1.8 mm drill bit. All procedures were performed under local anesthesia by a single surgical team with the assistance of the principal investigator. Operative time was recorded for each patient. Standard postoperative care included administration of prophylactic antibiotics for 7 days and limb elevation to reduce edema. Range of motion (ROM) exercises were initiated within one week post-surgery.

Patients were followed up weekly for the first month, then fortnightly until the final assessment at three months. Functional outcome was evaluated based on total active ROM measured using a goniometer and categorized as excellent, good, fair, or poor. Healing time was assessed using the Hammer et al. classification system, with grade 1 or 2 considered as complete union. Data were recorded on a structured proforma.

Data analysis was conducted using SPSS version 25. Quantitative variables such as age, duration of injury, operative time, healing time, and ROM were expressed as mean ± standard deviation. Categorical variables such as gender, cause of injury, ASA status, laterality, and outcome classification were presented as frequencies and percentages. The Shapiro-Wilk test

was applied to assess data normality. Independent samples t-test was used to compare mean healing time and ROM between groups, while the Chi-square test was applied to compare the proportion of excellent outcomes. A p-value of ≤0.05 was considered statistically significant. Data were further stratified by age, gender, cause and duration of injury, grade of injury, ASA status, laterality, and operative time. Post-stratification, appropriate statistical tests (t-test and Chi-square) were applied within each stratum.

RESULTS:

Table 1: Demographic Variables (n=60)

This table outlines the demographic profile of the patients included in the study. The mean age was 37.83 ± 12.71 years, reflecting a fairly wide age range among participants. The majority of the patients (56.7%) were in the 18–40 year age group, while 43.3% were aged between 41 and 60 years. Gender distribution was nearly equal, with 51.7% males and 48.3% females. Occupational data revealed that a significant proportion of patients (80.0%) were engaged in non-manual work, whereas 20.0% were involved in manual labor. The mean duration of injury was 1.47 ± 0.50 days, indicating that most patients presented early after trauma. Specifically, 53.3% of patients reported within 1 day of injury, while 46.7% presented after 2 days.

Table 2: Injury-Related Variables (n=60)

This table highlights the characteristics related to the injury. The most common cause of injury was accidental trauma, accounting for 56.7% of cases, while 43.3% were related to occupational activities. The duration of injury before presentation, as also noted in Table 1, showed a majority of patients (53.3%) presenting within a day of trauma. The severity of injury was categorized as Grade I in 46.7% and Grade II in 53.3% of patients, suggesting that slightly more than half of the cases involved more complex fractures.

Table 3: Clinical Variables (n=60)

This table presents the ASA (American Society of Anesthesiologists) physical status classification of patients to assess surgical risk. Most of the patients (68.3%) were classified as low risk (ASA I & II), while 31.7% were considered high risk (ASA III). This distribution implies that the majority of patients were generally fit for surgery with minimal anesthetic risk.

Table 4: Comparison of Clinical Outcome

This table compares the post-operative functional outcomes between the two intervention groups—K-wire and mini-plate fixation. An excellent outcome, defined as achieving ≥85% of total active range of motion, was observed in 15 patients (65.2%) in the mini-plate group compared to 8 patients (34.8%) in the K-wire group. Although this difference favored mini-plate fixation, it did not reach statistical significance (p = 0.089). A good outcome (70–84%) was recorded in 20 patients (57.1%) from the K-wire group and 15 patients (42.9%) from the mini-plate group. A fair outcome (50–69%) was observed only in the K-wire group, with two patients (100%), while no patients in the mini-plate group fell into this category. These findings suggest a trend toward better functional recovery with mini-plate fixation.

Table 5: Comparison of Healing Time (Weeks) in Both Groups

This table compares the average healing time between the two groups. The mean healing time in the K-wire group was 12.13 ± 3.04 weeks, while in the mini-plate group it was significantly lower at 10.00 ± 1.74 weeks. This difference was statistically significant with a p-value of 0.001, indicating that mini-plate fixation was associated with faster bone healing compared to K-wire fixation.

Table 1: Demographic Variables(n=60)

Variable	Group	Frequency	Percent
Age Group	18-40 years	34	56.7%
	> 40-60 years	26	43.3%
Gender	Male	31	51.7%
	Female	29	48.3%
Occupation	Non-manual	48	80.0%

	Manual Labor	12	20.0%

Table 2: Injury-Related Variables(n=60)

Variable	Group	Frequency	Percent
Cause of Injury	Accidental	34	56.7%
	Occupational	26	43.3%
Duration of Injury	1 Day (Early)	32	53.3%
	2 Days (Delayed)	28	46.7%
Grade of Injury	Grade I	28	46.7%
	Grade II	32	53.3%

Table 3: Clinical Variables

Variable	Group	Frequency	Percent
ASA Status	Low Risk (ASA I & II)	41	68.3%
	High Risk (ASA III)	19	31.7%

Table 4: Comparison of clinical outcome

Outcome	Group		Total	P value
	K-Wire (n=30)	Mini Plate (n=30)		
Excellent (≥85%)	8	15	23	0.089
	34.8%	65.2%	100.0%	
Good (70–84%)	20	15	35	
	57.1%	42.9%	100.0%	
Fair (50–69%)	2	0	2	
	100.0%	0.0%	100.0%	

Table 5: Comparison of Healing Time (weeks) in both groups

Group	N	Mean	Std. Deviation	P value
K-Wire	30	12.13	3.037	0.001
Mini Plate	30	10.00	1.742	

DISCUSSION

This randomized controlled trial aimed to evaluate and compare the clinical effectiveness of Kirschner wire (K-wire) and mini-plate fixation in patients with metacarpal fractures, focusing on functional outcomes and healing time. While both techniques achieved satisfactory results in most cases, our findings suggest that mini-plate fixation may offer superior clinical advantages, particularly in terms of faster fracture healing and a higher proportion of excellent functional outcomes.

The demographic characteristics of our study population were consistent with those reported in prior literature. The mean age was 37.83 ± 12.71 years, and the gender distribution was nearly equal. These values align with the findings of Noor et al[12] whose study similarly involved adult patients commonly injured during occupational or accidental activities. Most of our patients belonged to ASA physical status class I or II, indicating a low-risk surgical population, comparable to the cohorts used by Elmalt et al[14] in their comparative study of fixation techniques. These similarities enhance the external validity of our findings.

From a functional perspective, our data revealed that 65.2% of patients in the mini-plate group achieved excellent outcomes (defined as ≥85% of total active range of motion), compared to 34.8% in the K-wire

group. Although this difference did not reach statistical significance (p = 0.089), the trend is in favor of mini-plate fixation. Similar results have been demonstrated in several other studies. For instance, Shaikh et al[15] reported a significantly higher percentage of good-to-excellent functional outcomes with mini-plates in both metacarpal and phalangeal fractures. Likewise, Noor et al. found that mini-plate fixation was associated with better DASH scores, suggesting improved upper limb function and patient satisfaction. Our findings also align with those of Chen et al[16] who studied fifth metacarpal shaft fractures and concluded that mini-plate fixation provided better angular correction and functional outcomes than K-wire fixation. Additionally, Zhang et al[17] observed superior total efficacy (95.65% vs. 73.91%), better range of motion, and faster recovery with mini-plate fixation in their cohort of fifth metacarpal basal fractures. These studies collectively support the view that the rigid stabilization offered by mini-plates enhances early mobilization and facilitates better recovery of hand function.

Despite the non-significant p-value in our study's functional outcomes, the overall trend across multiple studies favors mini-plates for more predictable and robust results. However, it's essential to note that functional recovery is multifactorial, influenced by rehabilitation protocols, patient compliance, fracture type, and surgical technique. Variability in post-operative care and therapy access can affect results, as was noted in our own cohort, where differences in patient adherence to hand therapy may have diluted the statistical strength of our observations. One of the most statistically significant findings in our study was the healing time. Patients treated with mini-plates had a shorter mean healing duration (10.00 ± 1.74 weeks) compared to those treated with K-wires (12.13 ± 3.04 weeks), with a p-value of 0.001. This finding is strongly supported by Bissar et al[18] who reported similar results, with patients in the mini-plate group achieving fracture union more rapidly. Early union is a crucial factor in reducing immobilization time and expediting return to work, particularly for laborers and those with demanding daily activities.

However, while mini-plates may offer faster healing, other studies have shown mixed results regarding time to union. Some investigations, such as those by Varitimidis et al[19] and Li et al[20] observed no significant difference in union times between K-wires and mini-plates, emphasizing that fracture biology and patient factors also play key roles. Nonetheless, our findings and those of several others lean in favor of mini-plates for accelerated bone healing, particularly in shaft fractures requiring stable internal fixation.

In terms of complications, our study observed no statistically significant differences between the two groups. This observation aligns with those of Kibar et al[21] and Kang et al[22] who found that overall complication rates were comparable, although the nature of complications varied between the two methods. K-wires are traditionally associated with pin tract infections, wire migration, and loss of reduction. Our results support these concerns, although no major infections occurred. Conversely, mini-plates may result in soft tissue irritation, extensor tendon adherence, or the need for secondary procedures for implant removal, as also reported by Kang et al[22] and Varitimidis et al.[19] In our study, a few patients in the mini-plate group required hardware removal due to irritation, which is a well-documented issue in dorsal plating.

In the broader context, the literature suggests that while K-wires are less invasive and more cost-effective, they are also associated with limitations such as lower rotational stability and higher dependency on external splinting. On the other hand, mini-plates offer biomechanical advantages with stable three-point fixation, allowing earlier mobilization. However, they necessitate more extensive surgical exposure, longer operative time, and higher implant costs. Our findings on operative time support this, with plating procedures requiring more surgical time compared to percutaneous pinning. Importantly, some studies have emphasized that while mini-plates may confer early advantages, long-term outcomes between the two methods tend to equalize. For example, Li et al.[20] and Kibar et al.[21] concluded that both methods ultimately provide satisfactory results, and the choice may depend on the surgeon's expertise, available resources, and patient-specific factors. Our study supports this perspective, especially since no significant long-term differences were observed in overall hand function between the two groups beyond the initial post-operative period. Additionally, newer fixation techniques, such as intramedullary cannulated screws, have emerged as alternatives, attempting to combine

the benefits of both rigid fixation and minimal invasiveness. Kibar et al.[21] compared cannulated screws with mini-plates and found comparable outcomes with shorter surgical time in the screw group. However, these newer modalities require further evaluation in larger trials and were not within the scope of our current study.

The findings of our study have important clinical implications. While both fixation techniques are effective for managing metacarpal shaft fractures, the choice of method should be tailored to individual patient needs. Mini-plate fixation may be preferred in cases requiring anatomical reduction, early mobilization, or faster return to work, particularly in fractures with oblique or spiral patterns prone to rotational instability. In contrast, K-wire fixation remains a practical option for simple transverse fractures, especially when surgical resources are limited or when minimizing operative time is crucial. Moreover, in pediatric or adolescent populations, where preserving growth potential and avoiding extensive dissection are priorities, K-wires may be favored. Similarly, in high-risk patients where wound complications must be minimized, the less invasive K-wire technique may offer a safer profile. Hence, decision-making should incorporate not only fracture morphology but also patient occupation, comorbidities, compliance with rehabilitation, and surgeon expertise.

This study possesses several strengths that enhance its clinical relevance. First, it was designed as a randomized controlled trial, minimizing selection bias and improving the internal validity of our findings. Second, both treatment groups were demographically and clinically comparable, ensuring fair analysis. Third, the study focused on early-presenting fractures, standardizing the timing of surgical intervention and reducing variability in healing outcomes. Fourth, outcome assessments included both objective clinical parameters and functional measures, providing a comprehensive evaluation.

Nevertheless, the study also had limitations. The sample size, though adequate for primary outcomes, was relatively small (n=60), limiting the power to detect differences in subgroup analyses. Additionally, the follow-up duration was confined to short- to mid-term recovery. While this timeframe suffices for assessing healing time and initial functional results, it may not capture long-term complications such as implant-related issues or post-traumatic joint stiffness. Furthermore, patient compliance with rehabilitation was not strictly monitored, which could have influenced functional recovery. Finally, the study was conducted at a single center, potentially limiting generalizability across diverse healthcare settings.

CONCLUSION

Both K-wire and mini-plate fixation are effective options for treating metacarpal fractures, with high union rates and acceptable complication profiles. However, our study demonstrated that mini-plate fixation is associated with significantly faster healing and a trend toward superior functional outcomes. These findings are consistent with several published studies supporting the role of rigid internal fixation in enhancing early recovery.

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