

Kirschner Wire Fixation Versus Mini Plate Fixation in Multiple Metacarpal Shaft Fractures of Hand to Compare Early Range of Motion in Hand

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ABSTRACT

Background: Metacarpal bone plays vital role in supporting motor functions of the human palm and is subjected to frequent stress. If a fracture of the metacarpal bone occurs, it can destabilize the palm, disrupt muscular-tendon tension, impair functions of palm joints, and have adverse impacts on the daily life and work of the patient.

Objectives: To compare early range of motion (ROM) in hand following K-wire fixation versus mini plate fixation in patients with multiple metacarpal shaft fractures.

Methods: Cross-sectional analysis of patients with multiple metacarpal shaft fractures was done at Mufti Mehmood Memorial Teaching Hospital, between 2021 and 2022, and comprised 108 patients managed with K-wire Fixation and mini plate fixation. The success rate as well as clinical outcome of both techniques was measured as early ROM in the hand, which was assessed at eight weeks post-surgery using DASH scores.

Results: Majority of patients ($p < 0.05$) were males (73.14%), common fractures ($p < 0.05$) were closed type (75.03%), right sided (62.96%) and common cause of injury ($p < 0.05$) was traffic accidents ($n=48$), industrial accidents ($n=13$), fall ($n=12$), agriculture accidents ($n=12$) and assault ($n=10$). Our findings revealed that occurrence of complications was significantly higher among the patients of group K-wire fixation (11.11%) than mini wire fixation (6.48%) and assessment of ROM through DASH score system of mini plate fixation was better than K-wire fixation.

Practical implication The surgeons will confidently apply mini plate fixation in patients with multiple shaft fractures rather than K-wire fixation after reading this article.

Conclusion: Mini plate fixation may be more effective than K-wire fixation in restoring early ROM in the hand following surgery for multiple metacarpal shaft fractures.

Keywords: DASH scoring; Palm fracture; Range of motion; Shaft fracture.

INTRODUCTION

Hand fractures are debilitating injury, and when multiple metacarpal shaft fractures occur, they can result in significant functional impairment. Multiple metacarpal shaft fractures of the hand significantly influence the individual's ability to perform routine activities¹⁻³. Metacarpal fractures constitute 10% of total fractures in body and account for 36% of total hand fractures. They are more commonly observed in males between of 10-29 years, with males having a higher incidence of fracture than females throughout their lifespan. However, for those aged 60 and above, females have a higher incidence of fracture than males. Various sources including assault, fall, traffic accidents, industrial accidents, and agricultural accidents, can cause trauma resulting in fractures of the metacarpal bones in the hand. Hospital visits for such injuries range from 14-28%, with driving and accidental falls being the most common types of injury⁴⁻⁶.

Treatment options for these fractures include K-wire and mini plate fixation. While both maneuvers have their advantages and disadvantages, the choice between them remains a topic of debate among orthopedic surgeons⁷⁻⁸.

K-wire fixation is a common method used in the treatment of multiple metacarpal shaft fractures of the hand. It involves the insertion of a thin wire through the fractured bones to stabilize them while they heal. It is typically performed under local sedation and can be done in an outpatient setting⁹⁻¹⁰.

K-wire fixation has several advantages. It is a minimally invasive technique that does not require a large incision or general anesthesia. It is also a relatively quick procedure and K-wires are also easy to remove once the bones have healed, which can minimize the risk of infection and promote faster recovery¹¹⁻¹². However, K-wire fixation also has several disadvantages. One major disadvantage is the risk of pin tract infection, which can occur when the wire pierces the skin. In addition, K-wire fixation requires immobilization of the hand during the healing process, which can result in stiffness and curtailed range of motion. There is also a risk of wire migration or breakage, which can require further surgery¹³⁻¹⁴.

Despite its limitations, K-wire fixation remains a valuable treatment option for multiple metacarpal shaft fractures of the hand. It is particularly useful in cases where the fracture is stable and does not require more invasive methods of fixation. Additionally, K-wire fixation can be combined with other methods of fixation, such as external fixation or cast immobilization, to provide additional stability and support during the healing process¹⁵⁻¹⁶. Thus K-wire fixation is a minimally invasive and effective in the treatment of multiple metacarpal shaft fractures of hand. While it has several advantages, it also has limitations and risks that should be carefully considered when determining the appropriate treatment approach for each individual patient¹⁷.

Mini plate fixation is a surgical technique used to treat multiple metacarpal shaft fractures of hand. It involves using small metal plates and screws to hold the fractured bones in place, providing stable fixation that allows for early mobilization of the hand and facilitates early recovery¹⁸. It is typically performed under general anesthesia and requires a larger incision than K-wire fixation^{14, 19}. However, mini plate fixation provides several advantages over K-wire fixation. One major advantage is that it allows for early mobilization of the hand, which can promote faster recovery and low chances of stiffness and decreased ROM. Additionally, it provides stable fixation that can withstand greater loads, allowing patients to return to activities sooner²⁰. Another advantage of mini plate fixation is that it can be used to treat more complex fractures, including comminuted fractures, fractures with significant displacement, and fractures that require multiple fixation points. The plates and screws used in mini plate fixation are made of strong, biocompatible materials that can remain in the body for extended periods of time without causing adverse reactions²¹⁻²².

However, like any surgical procedure, mini plate fixation carries some risks and limitations. One major limitation is the need for a larger incision, increasing risk of scarring and infection. There is also a risk of plate and screw loosening or breakage, which can require further surgery. In addition, the use of metal implants can interfere with imaging studies, making it difficult to assess healing progress or detect complications²³⁻²⁴.

Despite these limitations, mini plate fixation remains a valuable treatment option for multiple metacarpal shaft fractures of the hand. It is particularly useful in cases where the fracture is unstable or complex and requires more invasive methods of fixation. Additionally, mini plate fixation can be combined with other methods of fixation, such as K-wire fixation or external fixation, to provide additional stability and support during the healing process^{16, 18, 25}. Mini plate fixation provides stable fixation and early mobilization in treating multiple metacarpal shaft fractures. Careful consideration of the risks and benefits of each treatment approach is essential to ensure the best possible outcome for each individual patient²⁶.

Thus both treatment options for these types of fractures have their advantages and disadvantages, but the choice between them remains a topic of debate among surgeons. The principal objective of this research is to compare the early ROM in hand following K-wire versus mini plate fixation in patients with multiple metacarpal shaft fractures. By comparing these two treatment modalities, we aim to provide valuable insights into which method may be more effective in restoring hand function and facilitating early recovery.

MATERIAL AND METHODS

This cross-sectional analysis of patients who underwent surgery for multiple metacarpal shaft fractures at Mufti Mehmood Memorial Teaching Hospital, Dera Ismail Khan, between 2021 and 2022. The study comprised 108 patients who were classified into two categories: Group A; those who underwent Kirschner Wire Fixation and Group B; those who underwent Mini Plate Fixation.

Direct incision was made on the border of radius and first two metacarpals and on border of ulna and 5th metacarpal. To expose the fracture site, a longitudinal incision was made between 3rd and 4th metacarpals. By elevating the fracture, periosteum was incised and exposed to avoid damaging the gliding space, periosteum, and extensor tendon. Drill opening was made in proper location on the first try. When fixation was achieved, the periosteal layer was returned to its original position and sutured. After wound closure, a soft dressing was applied, and the next day, an active ROM exercise was initiated under the supervision.

The duration of follow-up was eight weeks. The surgical site was evaluated weekly, and X-rays were taken to monitor reduction loss and bone regeneration. Active ROM was measured, and patients were discharged once active ROM reached its peak and the fracture had substantially healed. The success rate and clinical outcome of both techniques was measured as early ROM in the hand, which was assessed at eight weeks post-surgery using DASH scores.

The DASH (Disability of Arm, Shoulder, and Hand) scoring system is a questionnaire-based assessment tool that is commonly used to evaluate the functional limitations of the upper extremities. It was originally developed for patients with musculoskeletal disorders, including fractures of upper limbs. DASH scoring system consists of 30 items that assess a patient's ability to perform various activities of daily living, such as dressing, washing, and

reaching. Each item is scored on a scale from 0 to 5, with higher scores indicating greater disability. It is useful in evaluating the severity of functional limitations caused by fractures of the upper extremities, and can be used to track patient's progress over time and to compare the effectiveness of different treatment options, such as surgery or immobilization, and to identify areas where rehabilitation may be needed to improve function. Overall, the DASH scoring system provides a standardized and reliable method for assessing functional limitations in patients with upper extremity fractures, and can be a valuable tool for guiding treatment decisions and monitoring patient outcomes.

The inclusion criteria included adult patients over the age of 18 with recent closed shaft fractures with angulation of >30° or with a shorting of >2 mm or rotational deformities. We excluded pathological and contaminated fractures, having bone loss, stable un-displaced fractures, thumb metacarpal fractures, chronic and fractures with intra-articular extension.

Before the surgery, the patients were provided with information regarding the rehabilitation program following the procedure, as well as any possible complications. Prior written consent was also acquired.

As applicable, data were described by range; mean and Standard Deviation, frequencies, and percentages. Chi-square test was used to compare the quantitative variables. Statistical calculations were performed utilizing version 24.0 of SPSS.

RESULTS

The research comprised 108 patients divided into two equal groups carrying 54 patients in each. Average age of patients with multiple metacarpal shaft fractures, managed with K-wire was 31.63+9.87 and Mini plate was 30.87+9.17 years. The majority of patients (p<0.05) were males (73.14%) while, females were (26.85%; 29/108). The most common fractures were closed type (p<0.05), with the significant incidence of (78/108; 75.03%) than open type (30/108; 27.77%). Similarly, significantly greater proportion of population (p<0.05) was presented with right side metacarpal fracture than left hand with the frequency of 62.96 and 37.03%, respectively. We also examined the shape of metacarpal fractures radiological views revealed that significantly higher number of patients (p<0.05) exhibited transverse (66/108), oblique (30/108) and spiral fractures (12/108) (Table 1).

The most common cause of injury was traffic accidents (n=48), followed by industrial accidents (n=13), fall (n=12), agriculture accidents (n=12) and assault (n=10). Non-significant differences were seen between age, gender and cause of injury in both groups (Table 2). Outcome of study was also analyzed in terms of clinical parameters and it was revealed that the patients managed with mini plate exhibited better responses and success rate than K-wire fixation technique, including time of bone re-union (9.97+2.56 and 12.01+2.18 weeks, respectively), hand grip (92.20 and 89.81%, respectively) and lowered number of complications (12.96 and 22.22%, respectively), while, the surgery time and incision length of K-wire technique was lower than mini plate fixation technique (Table 3).

Table 1: Demographic data

S. No	Variables	Group A (K-wire Fixation)	Group B (Mini plate fixation)	χ ²	p-value
1	Age (Mean+SD) years	31.63+9.87	30.87+9.17	-	-
2	No. of patients (n)	54	54	0.0139	0.9061
3	Gender (n)				
	Male	38	41	14.87	0.00011*
	Female	16	13		
4	Type of fracture (n)				
	Open	16	14	13.64	0.00022*
	Closed	38	40		
5	Side of fracture (n)				
	Right	35	33	4.36	0.03663*
	Left	19	21		
6	Shape of fracture (n)				
	Transverse	34	32	30.699	0.00001*
	Spiral	7	5		
	Oblique	13	17		

Table 2: Mechanism of injury resulting in metacarpal fracture

S. No	Variables	Group A	Group B	χ ²	p-value
1	Fall	10	12	0.024	0.8770
2	Assault	6	4	0.0754	0.7836
3	Traffic accident	23	25	0.0045	0.9468
4	Industrial accidents	5	8	0.2427	0.6222
5	Agricultural accidents	8	4	0.6266	0.4285
6	Other causes	2	1	0.0003	0.9873

Table 3: Outcome of study in terms of clinical parameters

S. No	Variables	Group A	Group B
1	Duration of surgery (Mean+SD) minutes	48.18+12.98	57.10+15.04
2	Time of re-union (Mean+SD) weeks	12.01+2.18	9.97+2.56
3	Number of complications n(%)	12 (22.22)	7 (12.96)
4	Hand grip (%)	89.81	92.20
5	Incision length (Mean+SD) cm	2.89+1.21	4.01+1.89

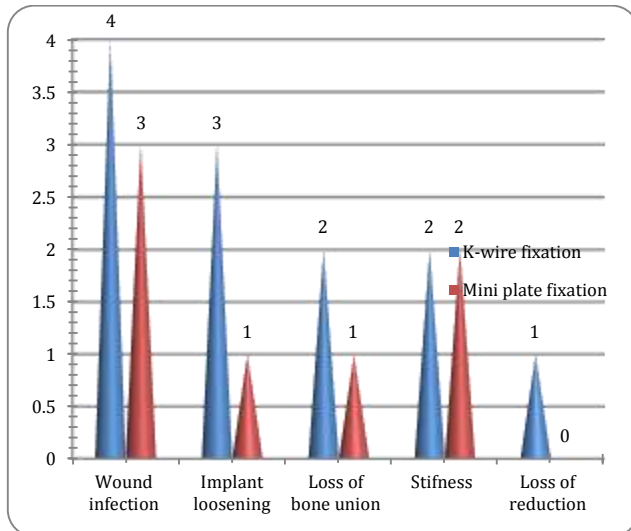


Figure 1: Complications associated with K-wire and Mini plate fixation (n)

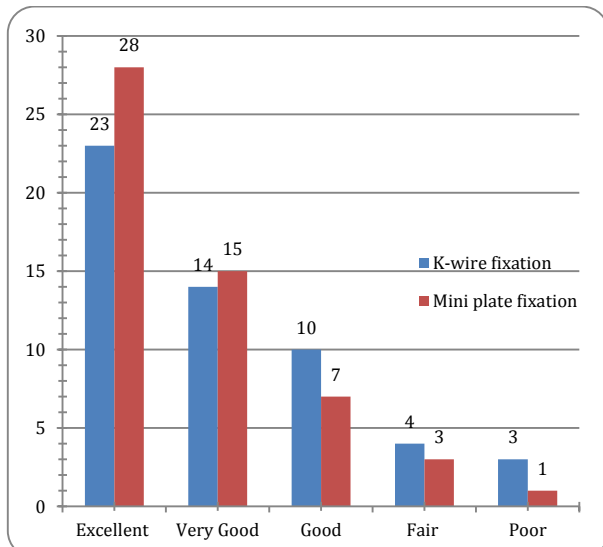


Figure 2: Assessment of early Range of Motion in the hand by DASH scoring system (n)

Figure 1 revealed the clinical complications associated with K-wire and Mini plate fixation, in terms of number of patients (n). Incidence of complications was significantly higher among the patients of group K-wire (11.11%) than mini wire fixation (6.48%) and the major complications were wound infections in both groups.

The ROM of hand and successful recovery rate of operation was assessed in terms of DASH score system (Figure 2). Our findings concluded that DASH score system of Mini plate was better than K-wire fixation and most of the patients of both groups were ranked in Excellent category, followed by very good, good and fair, while 1 patient in mini plate and 3 patients in K-wire fixation group failed to recover their ROM in hand.

DISCUSSION

Our research has shown that using mini plate fixation for surgical management of multiple metacarpal fractures leads to a higher success rate in operations, as well as better recovery of hand range of motion (ROM) and clinical outcomes compared to K-wire fixation. Patients in the mini plate group also demonstrated earlier recovery of ROM and scored better on the DASH score system, while experiencing fewer clinical complications compared to those managed with K-wire fixation. These results are consistent with previous studies that have found higher incidences of reduction loss and metacarpal head penetration in the K-wire group despite its shorter operation time, as reported in one study ², and supported by other authors ²⁷⁻²⁸.

Our findings support the notion that K-wire fixation is a type of internal fixation commonly used for treating metacarpal fractures. Although being less invasive, the operation can be challenging and may result in instability during surgery and increased risk of joint adhesion complications, which can negatively impact the healing of fracture and patient's postoperative joint function. In contrast, mini-plate fixation method is associated with less trauma and provides stable internal fixation. This technique not only facilitates the fracture's fixation but also reduces the impact on the tendon and bone joints ^{7, 29}. In 2019, a similar study was conducted at Al-Zahraa Hospital to compare the clinical and functional outcomes of treating unstable metacarpal shaft fractures with K-wires versus mini-plate fixation. Twenty patients with an unstable metacarpal shaft fracture were separated into two groups of ten each. Using the Quick DASH score, hand function was evaluated 3 months postoperatively and when patients completed physiotherapy. Joint stiffness was found to be 5% in patients treated with Mini plates and 15% in those treated with K-wires ³⁰.

Contrary to our findings, a study found that percutaneous fixation of metacarpal bones with K. wires produced more favourable outcomes than ORIF with mini-plates and screws. But without statistical significance, where mini-plate fixation yielded 85% satisfactory results and K wire fixation yielded 93% satisfactory results, resulting in an overall satisfaction rate of 90% ^{2, 31}.

CONCLUSION

In conclusion, our study suggests that mini plate fixation may be more effective than K-wire fixation in restoring early ROM in hand following surgery for multiple metacarpal shaft fractures. While both methods have their advantages and disadvantages, our findings may help guide orthopedic surgeons in their decision-making process when selecting the appropriate treatment modality for these types of fractures. Further studies are needed to confirm our findings and to assess other outcomes, such as functional outcomes and complications associated with each method.

Conflict of Interest: None.

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