The Egyptian Orthopaedic Journal

Vol. 60, No. 3, 2025
ISSN: 1110-1148 (print)
ISSN: 2090-9926 (online)
DOI: 10.21608/EOJ.2025.449733

ORIGINAL ARTICLE

Comparative Study between Using Kirschner Wires Versus Mini-set Plates in Management of Metacarpal Shaft Fractures in Souad Kafafi University Hospital, Egypt

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Background Metacarpal shaft fractures typically exhibit stability and minimal displacement, attributed to the distal connection by interosseous ligaments and proximal linkage by intrinsic hand muscles. This work aimed to compare percutaneous intramedullary Kirschner wires and open reduction with internal fixation using a mini plate in treating unstable metacarpal shaft fractures in adults.

Patients and Methods This prospective interventional work had been conducted on 60 participants ranging in age from 20 to 60 years old, both genders, with any rotational deformity, angulation >10° in the index and middle fingers, 20° for the ring finger, and 30° for the little finger, shaft displacement of more than 50%, more than 3mm shortening. All patients were subjected to open reduction and internal fixation with mini-plates and screws and percutaneous pinning with K-wires.

Results Union time is significantly lower in the k-wires group contrasted to the mini-plates group. No significant variation existed among the groups regarding hand grip. No significant variation existed among both studied groups as regard complications. Occupation, fracture side, side affected details, and pattern of fracture distribution were insignificantly different between both groups.

Conclusions Percutaneous intramedullary K-wires or open reduction internal fixation utilizing mini-plates and screws are viable methods for addressing unstable metacarpal fractures, as they facilitate reduction and fixation, enabling mobilization of adjacent joints and promoting favorable functional outcomes.

Keywords Kirschner Wires, Metacarpal Shaft Fractures, Mini-Set Plates.
Received: 19 September 2024, **Accepted:** 02 January 2025

INTRODUCTION

The hand serves as a tool for both performance and safeguarding. In various scenarios, an individual's reflexes instinctively position the hand as a barrier against potential harm, serving to shield the head and body [1].

Hands are highly susceptible to injuries, and the metacarpals, being small, long bones, exhibit a slight arch along their long axis with a concave structure on the palmar surface. Their most vulnerable point is situated just behind the head [2].

Metacarpal fractures typically arise from a direct impact on the knuckles. The short lever arm provided by the distal fragment can make reduction challenging, and sustaining the reduction becomes problematic due to the influence of intrinsic muscles on the distal fragment [3].

Fractures of the hand can present complications, including deformity resulting from untreated cases, stiffness due to prolonged immobilization, and a combination of both deformity and stiffness arising from inadequate treatment [4].

Improperly treated metacarpal fractures can lead to notable swelling, deformity, and functional impairment [5]. Treatment objectives for fractures of these tubular bones encompass accurate diagnosis, achieving anatomic or near-anatomic reduction to correct angular and rotational deformities, providing effective stability, addressing consideration of soft tissues, initiating early rehabilitation, preserving the integrity of longitudinal and transverse arches, ensuring rotational alignment to prevent digital overlap, and maintaining length to prevent imbalances between extrinsic and intrinsic hand muscles [6].

Metacarpal shaft fractures typically exhibit stability and minimal displacement, attributed to the distal connection by interosseous ligaments and proximal linkage by intrinsic muscles of hand [7].

The treatment options for metacarpal fractures have significantly broadened. These fractures can be addressed through closed reduction and splinting, although this method has the drawback of posing challenges in preserving joint mobility to prevent stiffness [8].

Percutaneous pin fixation is a frequently employed technique for hand fractures, benefiting from its subcutaneous nature, small size, and limited loading potential of hand bones, which minimizes stress on hardware [9].

The management of metacarpal shaft fractures using Kirschner wires versus miniplates is a topic of debate in the orthopaedic literature due to varying opinions on efficacy, complications, and long-term outcomes. The controversies stem from differences in fixation stability, functional recovery, complication rates, and cost-effectiveness.

While some studies favor miniplates for their superior stability and functional outcomes, others highlight the simplicity, affordability, and comparable results of K-wires for many fracture types. This lack of standardization in treatment guidelines has contributed to ongoing debate.

Individual factors such as fracture complexity, patient activity level, and surgeon expertise also influence outcomes, making it difficult to generalize the superiority of one method over the other. These conflicting findings and the lack of consensus in existing studies highlight the need for further research. By comparing functional and radiological outcomes, this study aims to provide clarity on the optimal fixation method for unstable metacarpal shaft fractures.

This work aimed to compare the clinical and functional outcome of treatment of unstable metacarpal shaft fractures using Kirschner wires versus open reduction with internal fixation using mini plates.

PATIENTS AND METHODS

This prospective interventional study had been conducted on 60 participants aged from 20 to 60 years old, both sexes, patients were allocated randomly into 2 equally divided groups, group (A) treated with Kirschner wires and group (B) treated with mini-set plates and screws. with any rotational deformity, angulation of >10° in index and middle fingers, 20° for ring finger, and 30° for little finger, shaft displacement of greater than 50%, shortening >3mm and closed or G I open displaced metacarpal shaft fracture. The work had been conducted from September 2023 to September 2024. Each participant provided written informed consent.

Criteria for exclusion had been pathological fractures, fractures with bone loss, stable undisplaced fractures, neglected fractures (presented after more than 3 weeks of injury), and contaminated compound fractures.

Each participant had been exposed to taking of history, clinical examinations, laboratory investigations, and radiological investigations [*X*-Rays of the hand AP, lateral, and oblique views had been done for all metacarpal fractures].

Surgical techniques

Open reduction and internal fixation with mini-plates and screws: In the supine position, the incorporated hand was kept on the hand table. The fracture was exposed utilizing regional or general anaesthesia and tourniquet control. Metacarpal fractures were accessed via a straight incision along the radial margin of the 1st and 2nd metacarpals. Along the dorsal or ulnar margin of the 5th metacarpal. A dorsal longitudinal incision was made between the 3rd and 4th metacarpals to expose them. Fractures of the 1st metacarpal have been addressed with dorsolateral incisions. The skin and subcutaneous tissues were subsequently elevated as a flap while preserving the dorsal venous network; the extensor tendons and paratenon subsequently retracted. The periosteum was subsequently incised longitudinally over the fracture, conserving as much tissue as possible and maintaining the interosseous muscles origins. The site of the fracture was revealed, and the hematoma and soft tissues had been excised; thereafter, the fracture was anatomically reduced using traction and derotation, and provisionally stabilized with small bone-holding forceps. Drilling using a 1.5mm drill bit was done. The fracture was then internally fixed with a mini-plate and 2mm screws. Rotation and angulation alignments have been assessed prior to and subsequent to the internal

fixation of the fracture by monitoring the orientation of each finger. Following internal fixation, the tourniquet was released, hemostasis was achieved, and sufficient coverage of soft tissues was provided over the plate. Finally, skin closure.

Percutaneous pinning with K-wires:

The patients were placed supine on the table. The affected limb has been prepared and draped in the customary sterile manner and positioned on the image intensifier cassette. Having the metacarpophalangeal joint clearly flexed, insert a Kirschner wire into the metacarpal head and advance it to the fracture site. Utilize hand pressure and wire manipulation, assisted by an image intensifier, to decrease the fracture. Verify the reduction using radiographs: if precise, K-wires are bent and retained for subsequent removal. Sterile dressings and a prolonged below-elbow splint are utilized in a functional alignment. An *X*-Ray was conducted post-operatively to evaluate the reduction.

Postoperative plan for both methods:

A plaster of Paris splint was used postoperatively with slight extension of the wrist and slight flexion of the metacarpophalangeal joint for two weeks then removed. After ten to fourteen days postoperatively, the wound was examined, sutures were excised, and physiotherapy was initiated. Active movement of the entire hand was promoted immediately following the removal of the postoperative splint. Intensive effort was deferred until radiological evidence indicated adequate development toward union. For every case, a check *X*-Ray was taken postoperatively. The follow-up examination was done after one month, three months, and 6 months.

Statistical analysis

Statistical analysis had been conducted employing SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative parameters had been displayed as mean and standard deviation (SD) and contrasted among both groups employing an unpaired Student's *t*-test. Qualitative parameters had been displayed as frequencies and percentages (%) and analyzed using the Chi-square or Fisher's exact test when appropriate. A two-tailed *P* value <0.05 was considered statistically significant.

RESULTS

Demographic data, occupation, fracture side, side affected details and pattern of fracture distribution had been insignificantly varied among both groups (Table 1).

Union time is significantly lower in the K-wires group compared to the mini-plates group. There was statistical significant difference between the two studied groups regarding number of C-arm images. There is no significant difference between the groups regarding hand grip, DASH, TAM score, and outcomes (Table 2 and Figures 2, 3).

No significant variation existed among the two studied groups regarding complications (Table 3).

Table 1: Demographic data, occupation, fracture side, side affected details, and pattern of fracture distribution of the two studied groups:

		K-wires Group	Miniplate Group	*P*
Age (years)		33.67±10.82	33.87±10.83	0.341
Sex	Male	23(76.67%)	25(83.33%)	0.695
	Female	7(23.33%)	5(16.67%)	
Dominant Hand	RT	27(90.0%)	28(93.33%)	1
	LT	3(10.0%)	2(6.67%)	
Occupation	Light workers	16(53.3%)	19(63.3%)	0.333
	Housewives	4(13.3%)	1(3.3%)	
	Heavy workers	10(33.3%)	10(33.3%)	
Fracture side	Left	14(46.67%)	15(50.0%)	0.525
	Right	16(53.33%)	15(50.0%)	
Side affected details	Lt 2nd	2(6.67%)	0(0.0%)	0.920
	Lt 3rd	0(0.0%)	3(10.0%)	
	Lt 4th	0(0.0%)	4(13.33%)	
	Lt 5th	12(40.0%)	8(26.67%)	
	Rt 2nd	2(6.67%)	2(6.67%)	
	Rt 3rd	0(0.0%)	1(3.33%)	
	Rt 2nd and 3rd	0(0.0%)	1(3.33%)	
	Rt 3rd and 4th	1(3.33%)	0(0.0%)	
	RT 4th	1(3.33%)	1(3.33%)	
	Rt 5th	12(40.0%)	10(33.33%)	
	Comminuted	8(26.67%)	2(6.67%)	
Pattern of Fracture	Oblique	6(20.0%)	14(46.67%)	0.090
	Spiral	4(13.33%)	6(20.0%)	
	Transverse	12(40.0%)	8(26.67%)	

Data are presented as mean±SD or frequency (%); RT: Right; LT: left.

Table 2: Clinical characteristics and outcome distribution between the two studied groups:

		K-wires group	Miniplate group	*P*
Time till Union (weeks)		6.67±0.28	6.89±2.20	<0.001*
TAM score %		88.6±11.23	90.63±7.43	0.629
Grip Strength %		78.41±17.47	89.11±22.78	0.534
DASH Score		8.32±4.47	11.33±4.68	0.769
Outcomes	Poor	0(0.0%)	0(0.0%)	0.685
	Fair	3(10.0%)	3(10.0%)	
	Good	1(3.33%)	2(6.67%)	
	Excellent	26(86.67%)	25(83.33%)	

Data are presented as mean±SD or frequency (%); *: Significant; *P*-value <0.05.

Table 3: Complications between the two studied groups:

	K-wires group	Miniplate group	*P*
Hardware symptomatic	0(0.0%)	1(3.33%)	0.605
Delayed union	0(0.0%)	1(3.33%)	
Nonunion andbroken	0(0.0%)	1(3.33%)	
superficial infection	1(3.33%)	0(0.0%)	
Stiffness	3(10.0%)	1(3.33%)	

Data are presented as frequency (%).

Figure 1: Male patient 37 years old with fall on left hand; (A): preoperative *X*-Ray A/P and oblique view show oblique fracture of fifth metacarpal, follow up *X*-Ray A/P and oblique view; (B): After 3 months show union of fracture; (C): After 6 months Show complete union of fracture; (D): Intraoperative (reduction, plate fixation) via dorsal approach; (E): Full range of motion after 2 months of intensive physical therapy.

Figure 2: Male patient 33 years old exposed to direct trauma by a heavy metal object to his right hand; (A): Preoperative *X*-Ray A/P and oblique view show of transverse fracture of the fifth metacarpal; (B): Post-operative *X*-Ray A/P and oblique view show fixation of fracture by K-wires; (C): Follow-up 4 months post-operative with full active range of motion.

DISCUSSION

Undisplaced and impacted fractures of the hand, without rotation or angulation at the fracture site, are classified as stable. Conversely, fractures that cannot be adequately aligned through manipulation or maintained with a cast or splint are considered unstable. Conservative treatment of such unstable fractures has been associated with less favorable outcomes in reported cases [10].

Over time, the treatment of long bone fractures has shifted toward rigid fixation methods that allow for early functional mobilization without reliance on external cast immobilization. This shift has also influenced the approach to fractures of the smaller bones of the hand, emphasizing stable internal fixation and early rehabilitation [11].

Milford L. *et al.,* [12] stated that satisfactory findings were 76% in closed reduction and percutaneous intramedullary Kirschner wire fixation, while in managing hand fractures with plate and screws, 63.3% satisfactory results were obtained. The most robust implant presently readily accessible for the management of hand fractures is the plate and screws method.

In the present study, it was suggested that The fixation of metacarpal bones using K-wires yielded outcomes comparable to those achieved with open reduction and internal fixation employing mini-plates and screws without statistical significance except in number of C- arm images and time of union.

Labler L. [13] reported that in comparison between intramedullary K-wires versus plate-screw fixation of extra-articular metacarpal fractures, a significant variation existed in the clinical findings utilizing either technique.

The present investigation indicated that no significant variation in outcomes between the two examined groups.

Lee SM. [14] reported that the effect of the fracture pattern on the results is many; spiral fractures gave satisfactory findings, and oblique fractures yielded less favorable outcomes. Transverse fractures gave more satisfactory results than comminuted fractures.

Böstman OM. [15] says that The combining of open reduction and plaster immobilization is detrimental, as surgical trauma and adjacent implants may compromise tendon gliding performance.

In the present study, a short time of splint immobilization (two weeks) was applied to all cases.

Schuind F. *et al.,* [16] found that the technique at operation has largely affected the results of treatment. The

incidence of excellent results was higher in fractures with simple techniques at operation (e.g. closed pinning) than in fractures in which the technique was difficult.

Freeland AE *et al*., [17] reported that in managing fractures with open reduction and internal fixation, as well as the resulting scar, injury of soft tissues is increased.

In the present study, non-union with refracture and breakdown of the plate was encountered in one patient that had been managed by plate and screws. The patient was exposed to severe trauma early postoperatively, the patient was old, a fracture was comminuted, and poor bone quality. Planning was to be revised with plating and bone graft, but the patient refused.

Black D. *et al*., [18] reported that the primary drawback of plate fixation is the requisite rise in soft tissue dissection due to the plate's size, which further compromises the vitality of the bone adjacent to the fracture on both sides.

Lewis RC Jr. *et al*., [19] determined that precise surgical approach and prophylactic broad-spectrum antibiotics appeared to be crucial in preventing infections.

In the present study, there was one case of superficial infection, fixed with K-wires and treated with strong antibiotics.

Krein R. [20] found that K-wire fixation may be made percutaneously in an intramedullary manner. K-wires are readily accessible in operating rooms and can be applied with ease.

Diaz-Garcia R, Waljee JF. [21] asserted that the key aspect is for the surgeon to select the fixation strategy with which they are most proficient.

In the present study union time is significantly lower in K-wires group compared to mini-plates group, shows that in group I, time of union ranged between 6-8 with a mean of 6.67±0.28 weeks, while in group II it ranged between 5-16 with a mean of 6.89±2.20 weeks. However, there is no significant difference between the groups regarding hand grip, DASH, and TAM score thorough the period of 6 months follow up.

There was also statistical significant difference in number of C-arm images between the two studied groups; in group I, number of C-arm images ranged between 12-21 with a mean of 18.15±2.53 images, while in group II it ranged between 7-15 with a mean of 12.2±2.41 images.

Limitations of the work involved that the sample size was relatively small. The work had been in a single center.

There was no significant difference between the groups regarding hand grip strength, DASH and TAM scores.

We recommend the use of Kirschner wires over miniplates for the management of unstable metacarpal shaft fractures. This preference is due to several advantages associated with K-wires, including their simpler and more straightforward surgical technique, significantly lower cost, and shorter operative time. Additionally, K-wires demonstrate faster time to union, making them a more reliable and efficient option in ensuring prompt recovery. While both methods are effective, the practicality and cost-effectiveness of K-wires make them particularly suitable for managing unstable metacarpal fractures, especially in resource-limited settings or when minimizing surgical complexity is essential.

CONCLUSION

Percutaneous intramedullary K-wires or open reduction internal fixation utilizing mini-plates and screws are viable methods for addressing unstable metacarpal fractures, as they facilitate reduction and fixation, enabling mobility of adjacent joints and promoting satisfactory functional outcomes.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCE

1. Hunt TJ., Powlan FJ., Renfro KN., Polmear M., Macias RA., Dunn JC., *et al.*, (2024). Common finger injuries: treatment guidelines for emergency and primary care providers. Mil Med; 189:988-94. https://pubmed.ncbi.nlm.nih.gov/36734106/.
2. Barton NJ. (1984). Fractures of the hand. J Bone Joint Surg Br; 66:159-67. https://pubmed.ncbi.nlm.nih.gov/6707048/.
3. Barton NJ. (1979). Fractures of the shafts of the phalanges of the hand.Hand; 11:119-33. https://pubmed.ncbi.nlm.nih.gov/488787/.
4. James JI. (1962). Fractures of the proximal and middle phalanges of the fingers.Acta Orthop Scand; 32:401-12. https://pubmed.ncbi.nlm.nih.gov/13957247/.
5. Czerniecki S, Mishu M, Schmucker R. (2024). Metacarpal and Phalangeal Nonunions. Hand Clin. Feb; 40(1):129-139. doi: 10.1016/j.hcl.2023.09.003. PMID: 37979984.
6. Wong CR., Zhu A., Baltzer HL. (2024). The accuracy of artificial intelligence models in hand/wrist fracture and dislocation diagnosis: A systematic review and meta-analysis. JBJS reviews; 12:24-32. https://pubmed.ncbi.nlm.nih.gov/39236148/.
7. Boccolari P., Tedeschi R., Platano D., Donati D. (2024). Review of contemporary non-surgical management techniques for metacarpal fractures: Anatomy and rehabilitation strategies.

Elsevier; p.22-30. https://www.sciencedirect.com/science/article/pii/S2666769X24000058.

8. Gomes YJV., Lócio LC., Furtado-Filho WRS., Casimiro LM., Silva JJDL. (2024). Epidemiological analysis of hand fractures in a tertiary hospital.Rev Bras Parasitol Vet; 39:58-65. https://www.rbcp.org.br/details/3394/analise-epidemiologica-das-fraturas-de-mao-em-um-hospital-terciario.
9. Pritsch M., Engel J., Farin I. (1981). Manipulation and external fixation of metacarpal fractures. J Bone Joint Surg Am; 63:1289-91. https://pubmed.ncbi.nlm.nih.gov/7287799/.
10. Labler L., Bonaccio M., Oehy K. (2003). Die intramedulläre Kirschner-Drahtosteosynthese zur Behandlung distaler Metakarpalfrakturen [Intramedullary Kirschner wire osteosynthesis in treatment of distal metacarpal fractures]. Swiss Surg; 9(2):69-75. German. doi: 10.1024/1023-9332.9.2.69. PMID: 12723286. https://pubmed.ncbi.nlm.nih.gov/12723286/.
11. Kamath JB., Harshvardhan, Naik DM., Bansal A. (2011). Current concepts in managing fractures of metacarpal and phalangess. Indian J Plast Surg. 2011 May; 44(2):203-11. doi: 10.4103/0970-0358.85341. PMID: 22022030; PMCID: PMC3193632. https://pmc.ncbi.nlm.nih.gov/articles/PMC3193632/.
12. Milford L. Lamb DW., Abernethy PA., Raine PA. (1973). Unstable fractures of the metacarpals: a method of treatment by transverse wire fixation to intact metacarpals. Hand; 5: 43-8. https://www.sciencedirect.com/science/article/abs/pii/0072968X73900089.
13. Labler L. (2018). Open reduction and internal fixation for fractures at the proximal interphalangeal joint. Hand Clin; 10: 239-50. https://www.sciencedirect.com/science/article/abs/pii/0072968X73900089.
14. Lee SM., Orlinsky M., Chan LS. (1994). Safety and effectiveness of portable fluoroscopy in the emergency department for the management of distal extremity fractures. Ann Emerg Med. 1994 Oct; 24(4):725-30. doi: 10.1016/s0196-0644(94)70284-5. PMID: 8092602. https://pubmed.ncbi.nlm.nih.gov/8092602/.
15. Böstman OM. (1991). Absorbable implants for the fixation of fractures. J Bone Joint Surg Am. 1991 Jan;73(1):148-53. PMID: 1985987. https://pubmed.ncbi.nlm.nih.gov/1985987/.
16. Schuind F., Cooney WP 3rd, Burny F., An KN. (1993). Small external fixation devices for the hand and wrist. Clin Orthop Relat Res. 1993 Aug;(293):77-82. PMID: 8339512. https://pubmed.ncbi.nlm.nih.gov/8339512/.
17. Freeland AE., Roberts TS. (1991). Percutaneous screw treatment of spiral oblique finger proximal phalangeal fractures. Orthopedics. 1991 Mar; 14(3):384, 386, 388. PMID: 2020638. https://pubmed.ncbi.nlm.nih.gov/2020638/.
18. Black D., Mann RJ., Constine R., Daniels AU. (1985). Comparison of internal fixation techniques in metacarpal fractures. J Hand Surg Am. 1985 Jul;10(4):466-72. doi: 10.1016/s0363-5023(85)80067-8. PMID: 4020056. https://pubmed.ncbi.nlm.nih.gov/4020056/.
19. Lewis RC Jr., Nordyke M., Duncan K. (1987). Expandable intramedullary device for treatment of fractures in the hand. Clin Orthop Relat Res. 1987 Jan; (214):85-92. PMID: 3791765. https://pubmed.ncbi.nlm.nih.gov/3791765/.
20. Krein R., Richter M., Brüser P. (2000). Osteosynthesen mit resorbierbaren Hemizerklagen bei Metakarpalfrakturen [Osteosynthesis with resorbable hemi-cerclage in metacarpal fractures]. Handchir Mikrochir Plast Chir. 2000 Mar; 32(2):102-6. German. doi: 10.1055/s-2000-19256. PMID: 10857063. https://pubmed.ncbi.nlm.nih.gov/10857063/.
21. Diaz-Garcia R., Waljee JF. (2013). Current management of metacarpal fractures. Hand Clin. 2013 Nov; 29(4):507-18. doi: 10.1016/j.hcl.2013.09.004. PMID: 24209950. https://pubmed.ncbi.nlm.nih.gov/24209950.