Percutaneous transverse intermetacarpal pinning for displaced metacarpal fracture: a functional and radiological outcomes

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Introduction
Metacarpal fractures represent 36% of hand and wrist fractures and may have a negative impact on hand function. Numerous surgical techniques have been outlined to manage these fractures, but there has been no consensus on the most suitable method or technique. This study aimed to assess the advantages of using the transverse intermetacarpal Kirschner wires fixation [percutaneous transverse intermetacarpal pinning (PTIP technique)] using the normal adjacent metacarpal bone as an internal-external fixator for the fractured one, also the functional and radiological outcomes and the postoperative complication rates.
Patients and methods
Between January 2023 and January 2024, 20 patients with 23 unstable ulnar and four metacarpal fractures undergoing PTIP were prospectively recruited. We investigated clinical and functional outcomes in terms of total active range of motion, grip strength, and quick disability arm shoulder hand score.
Results
The mean age was 36±10.32 years, and the time of healing (weeks) was 6.59±1.01. At the final follow-up, the total active of motion was 258.95±11.97, grip strength (%) compared with the normal side was 100.37±5.89, and quick disability arm shoulder hand score was 2.75±2.9.
Conclusion
The PTIP technique is an acceptable and effective method for managing acute, unstable metacarpal fractures with satisfactory results with low complication rate.

Keywords:
k-wires, metacarpal fracture, percutaneous, pinning, transverse

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Introduction

Metacarpal fractures represent 36% of hand and wrist fractures [1]. The peak incidence of metacarpal shaft fractures is observed between the ages of 20 and 40 years [2]. Fractures of the metacarpal shaft and neck rarely show complications. For instance, malunion is one common complication, with persistent dorsal apex angulation or rotational deformity causing more functional affection, loss of dorsal contour of the hand, prominent metacarpal head in the palm, and reduced power gripping [3]. Most metacarpal fractures are often stable and treatable with conservative management [4]. However, stiffness, skin soreness, and compartment syndrome may be the consequences of prolonged immobilization [5]. It is reported that 8% of all metacarpal fractures, including some unstable fracture patterns and displaced, angulated, open, or irreducible fractures, may require surgery to restore function and appearance [4]. The aims of treatment encompass early diagnosis, correction of rotational deformities and angulation, preservation of soft tissue, together with the longitudinal and transverse arches, and maintenance of the length of the metacarpals as shortening and malunion of the metacarpal fractures may result in critical limitations of the hand range of motion (ROM) [6]. Researchers have employed diverse techniques for the operative treatment of metacarpal fractures, including mini plate and screws fixation, external fixation [7,8], intramedullary Kirschner wires (K-wires), Cerclage [9], and transverse K-wire [10]. K-wire fixation is a prevalent method that offers several advantages, such as being minimally invasive with less soft tissue disruption and easy removal [11]. After the fixation of the fracture, rehabilitation is considered the primary component of treatment. Prompt mobilization following the repair of hand fractures is essential, as tendon gliding, and joint mobility are vital for optimal hand use [12].

So we hypothesized that percutaneous transverse intermetacarpal pinning (PTIP) is an advantageous method for fixation of the metacarpal fractures that allows rigid fixation, early ROM, and low complication rates.

This study aimed to assess the advantages of using the transverse intermetacarpal K-wires fixation (PTIP technique) using the normal adjacent metacarpal bone as an internal external fixator for the fractured one, also the functional and radiological outcomes and the postoperative complication rates were reported.

Patients and methods

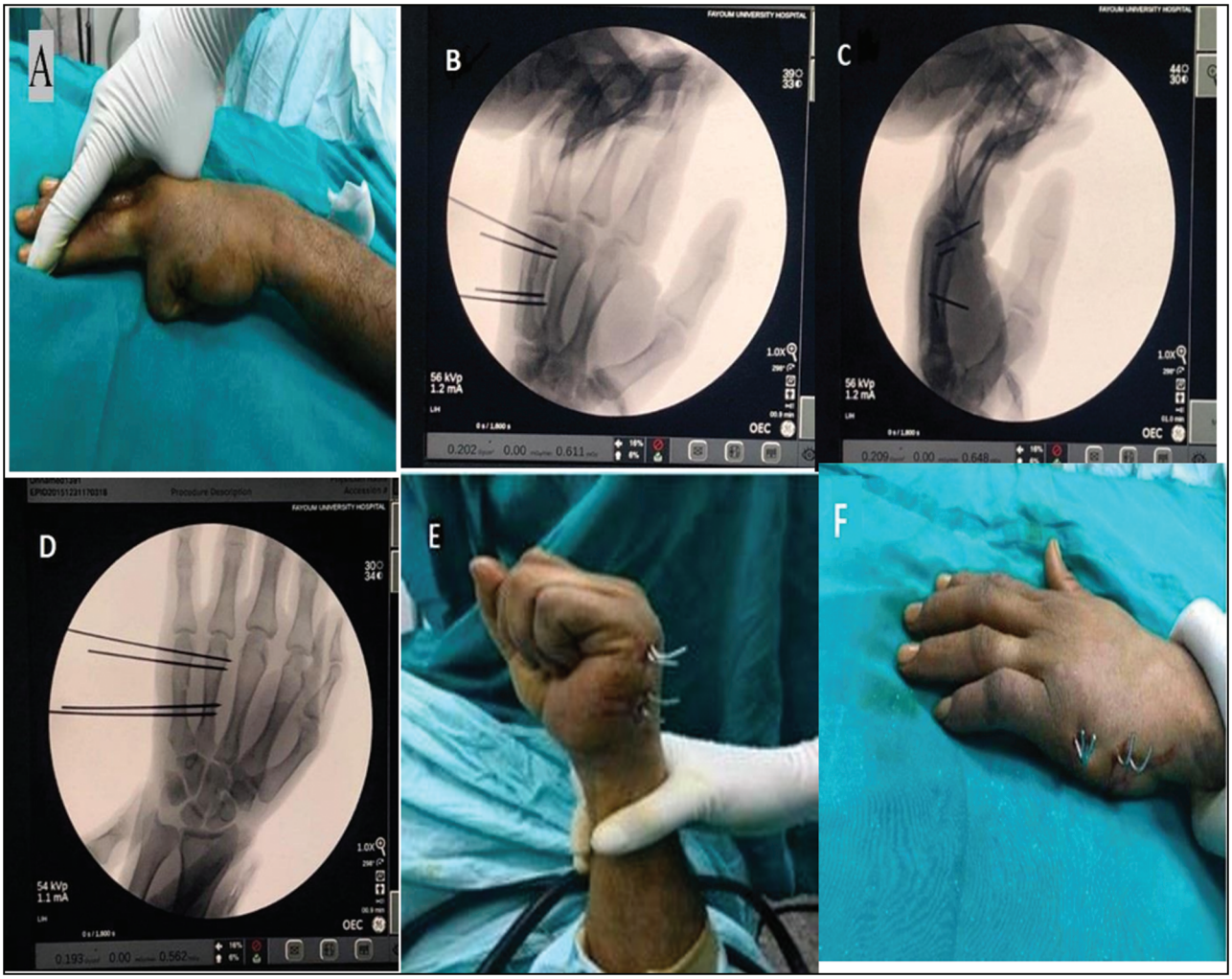
Study design

In this prospective case series study, from January 2023 to January 2024, 20 patients with 23 metacarpal fractures were treated by closed reduction and fixation using transverse intermetacarpal K-wires and followed-up for 6 months. Patients with any unstable metacarpal fractures with intact adjacent metacarpal bone were included and allowing the use of at least two pins distal to the fracture site. In contrast, patients with first metacarpal bone fractures, intra-articular fractures, metacarpal neck (can not accommodate at least two pins), and nonunited fractures were excluded. Before inclusion in the study, written consent was obtained, and the patients were informed about the surgical procedure; radiographic and functional outcomes were recorded.

Surgical technique

Under regional or general anesthesia with a radiolucent hand table and image intensifier, the fracture was manipulated under fluoroscopy for closed reduction, which was carried out by flexing the metacarpophalangeal (MCP) and proximal interphalangeal joints and using the proximal phalanx to push up the metacarpal head (Jahs maneuver) (Fig. 1a). If not properly reduced, a dorsal mini-incision may be performed.

Figure 1



A (reduction of fracture) B, C, D (intraoperative transverse pinning fluoroscopy) E, F(clinical check of rotation).

Fixation was performed with 2–3 k-wires (1.4–1.6 mm) distally to avoid pivoting and dorsal angulation, and 1–2 K- wires proximally. K-wires were advanced transversely from the medial side of the fifth metacarpal or the lateral side of the second metacarpal up to the far cortex of the adjacent metacarpal (Fig. 1b, c, and d). The finger rotation was checked clinically in an extended and flexed position (Fig. 1e and f). Then, the K-wires were cut and bent over the skin. After that, a short forearm volar splint was used to control pain.

Post-operative care

This procedure is a 1-day surgery. The active protected range of motion of MCP and IP joints was started immediately postoperatively with the daily care of the k-wire entry site. The patients were instructed to visit the outpatient clinic weekly to evaluate finger movement and inspect the K-wires entry site. After that, the splint was removed in the 4th week. Radiological evaluation with a hand radiography was performed in 3, 6, and 9 weeks after surgery. Plain radiography were done in anteroposterior, lateral, and oblique views. Finally, K-wires were removed in the outpatient clinic when satisfactory fracture healing was reached.

Follow-up

Clinical and functional evaluation were performed postoperatively in the 3rd and 6th months. The functional evaluation consisted of measuring the range of motion by total active motion score (TAM) [13], measuring hand grip strength percentage from the normal side using a sphygmomanometer (the patient applied maximum pressure to 20 mmHg inflated cuff. Patients who have regained hand function should achieve a value that is at least equal to that of their uninjured hand, considering the dominance of the injured hand) and limitation of daily activities using quick disability arm shoulder hand score (Quick DASH Score) [14].

Statistical analysis

After data collection and coding, they were analyzed using SPSS (Statistical Package of Social Science) V.22 in Windows 7 (SPSS Inc., Chicago, Illinois, USA). we used simple descriptive analysis in the form of numerical values and percentages of qualitative data, alongside arithmetic means as central tendency measurement and standard deviations as a measure of the dispersion of quantitative parametric data. The following step was the Paired *t*-test, which was employed to make comparisons of two dependent quantitative data. The Mann–Whitney test was used to compare two independent groups. The χ^2 test was used to compare between two of more than two qualitative groups.

Results

This prospective case series study was conducted on 20 patients with 23 metacarpal fractures treated by transverse K-wire fixation. It included 17 (85%) males and three (15%) females. The patients' ages ranged from 19 to 56 years, with a mean of 36±10.32 years (Table 1).

It was observed that most of the patients achieved complete union in 6 weeks, i.e., 12 (60%) patients with 14 (60.7%) metacarpal fractures, while three (20%) patients with five (21.7%) metacarpal fractures healed in 7 weeks, and two (10%) cases with two (8.7%) metacarpal fractures healed in 8 weeks (Table 2).

Regarding the clinical outcome in the 6-month follow-up, (Fig. 2) the grip strength (%) compared with the normal side showed a mean of 100.37±5.89, and the TAM mean was 258.95±11.97, TAM % mean was 97.76±2.7, while the Quick DASH score had a mean of 2.75±2.9 (Table 3).

Table 1 Patient demographics

			Significance	
Item	**Males *N* (%)**	**Females *N* (%)**	**χ^2**	***P***
Total *N* (20)	17 (85.0)	3 (15.0)	2.162	0.009*
	Right	Left		
Dominant hand	18 (90.0)	2 (10.0)	5.084	0.003*
Injured side	13 (65.0)	7 (35.0)	1.836	0.012*
	Range	Mean±SD		
Age (years)	19–56	36.0±10.32		
Radiation exposure (s)	15–65	26.5±13.77		
Mode of trauma	Punching injury	direct trauma	Others	
N, %	9 (45)	8 (40)	3 (15)	
Fractured metacarpal	The 5th metacarpal	The 2nd metacarpal	The 3rd +4th metacarpal	The 3rd and 4th metacarpal
N, %	10 (50)	3 (15)	3 (15)	2 (10)

χ^2: Chi-square.
*$P < 0.05$: statistically significant.

A significant correlation was observed between the age of the patients and the Quick DASH score, but a nonsignificant correlation was found between the age of the patients and the grip strength, TAM, and healing time.

One patient was complicated by nonunion and treated by miniplate fixation; one patient had a fracture of the adjacent metacarpal at the site of the K-wire entry. No other complications were reported.

Discussion

The choice of the most suitable treatment approach for metacarpal shaft fractures relies on various considerations, such as the fracture location (intra-articular or extra-articular), the fracture pattern (transverse, spiral, oblique, or comminuted), the presence of any deformities (angular, rotational, shortening), the stability of the fracture, and any accompanying injuries to the bones and soft tissues. Regardless of the preferred treatment method, the ultimate aim should be the prompt and complete restoration of function [15]. The consensus in most of the literature aligns with considering any degree of rotational deformity, angulation exceeding 30º, or shortening exceeding 5 mm as indications for surgical intervention [16].

In this study, after six months of follow-up, TAM was 258.95˚±11.97 (240–270˚). The mean Quick DASH score was 2.75±2.90 (0–9.1), the mean TAM % compared with the normal side was 97.76%±2.70 (92–100%), the mean grip strength % in comparison to the normal side was 100.37%±5.89 (90–110%). None of the patients had any clinically detectable rotational deformity. These results were comparable to Sletten *et al.* [17] in a transverse K-wiring group (45 patients), the comparative study of Wong and Yueng *et al.* [16] on 29 patients treated with transverse wiring, and the

Table 2 Radiological outcomes of the studied patients

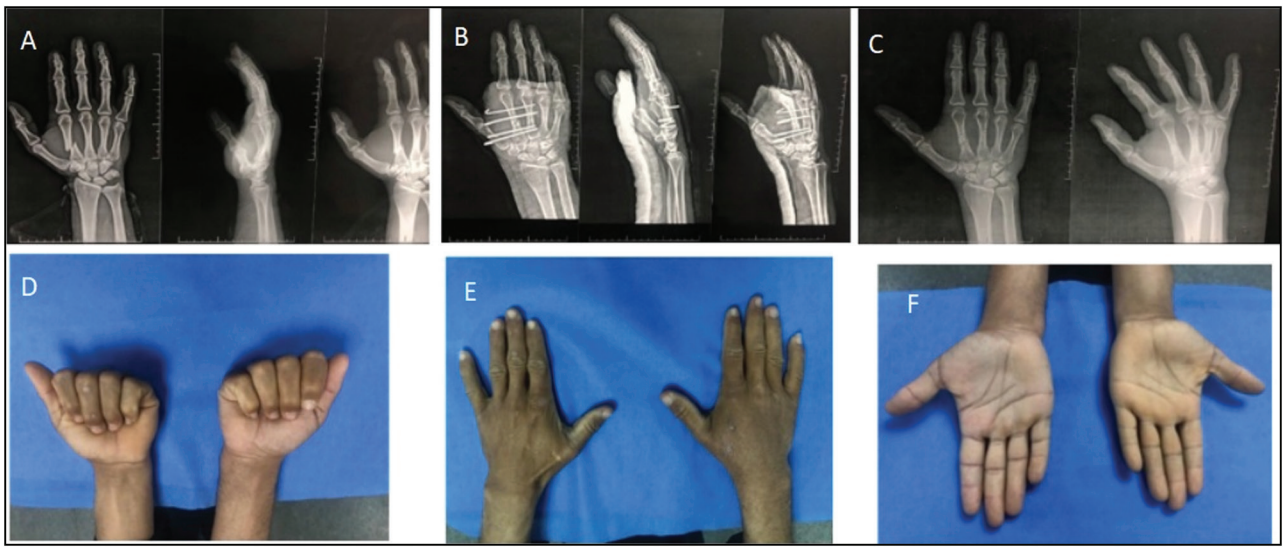
Union time	*N* of patients (%)		*N* of metacarpals (%)	
6 weeks	12 (60.0)		14 (60.7)	
7 weeks	4 (20.0)		5 (21.7)	
8 weeks	2 (10.0)		2 (8.7)	
10 weeks	1 (5.00)		1 (4.35)	
Failed (nonunion)	1 (5.00)		1 (4.35)	
Total	**20** (**100**)		**23** (**100**)	
	Range	Mean±SD	Range	Mean±SD
Time for union (weeks)	6–10	6.63±1.07	6–10	6.59±1.01

Table 3 Clinical outcomes of the studied patients

In 3-month follow-up	Min	Max	Mean±SD
Grip strength (%) compared with normal	21.43	106.67	86.54±17.68
TAM	160	270	243.25±24.72
TAM (%) compared with normal side (o)	59.26	100	91.95±8.65
Quick DASH score	4.5	54.5	12.38±10.70
In 6-month follow-up			
Grip strength (%) compared with normal	90	110	100.37±5.89
TAM	240	270	258.95±±11.97
TAM (%) compared with the normal side	92	100	97.76±2.70
Quick DASH score	0	9.1	2.75±2.90

Max, maximum value; Min, minimum value; SD, standard deviation; TAM, total active motion.

Figure 2



A Second metacarpal fracture in Rt dominant hand. B transverse K-wiring. C after removal of k- wires. D, E, F clinical outcome and range of motion.

prospective study of Essawy *et al.* [18] on 25 patients. Choi and Song [19] concluded that transverse K-wire pinning can provide a full range of motion and achieve excellent clinical results.

In the study of Galanakis *et al.*, [15] 25 metacarpal fractures underwent transverse K-wire percutaneous pinning; in their final follow-up of three months, TAM results were higher than ours in three months follow-up. This difference could be because, in our study, the below elbow slab was removed four weeks postoperatively; however, Galanakis *et al.*[15] had removed the slab after one week postoperatively. Conversely, Pintore *et al.* [20] only applied a soft bandage immediately after transverse K-wire fixation to allow immediate free movement of MCP and IP joints.

One patient experienced an iatrogenic fracture of an adjacent metacarpal at the previous K-wire tract in the 8th week postoperatively; this complication may be related to the use of relatively thick K-wire or repeated K-wire penetration. There was one patient with non-union in this study that was comparable with the study of Choi and Song [19] who had also one case of non-union. There were no cases of pin tract infection in this study although Choi and Song [19] in their study had experienced five cases with pin tract infections and Sletten *et al.* [17] in their study had experienced eight patients with pin tract infections, this could be explained by using the daily dressing and care of K-wire entry site protocol in our study.

We recommend to use at least two K-wires distal to the fracture site to control the fracture sagittal angulation and allow stable fixation that was also recommended by Paul *et al.* [21] in their study. Also we recommend to use at least one K-wire proximal to the fracture site if one of the ulnar two metacarpal bones was the fractured one due to their relative range of motion at the carpometacarpal joints but no K-wires could be used if the case was the second or the third metacarpal bone fracture because there is no ROM at their carpometacarpal joints.

It is essential to acknowledge the limitations of our study. For instance, the relatively small sample size urges further research to be conducted on a larger scale. Additionally, the follow-up period was short, and there was no direct comparison with other methods and techniques of fixation.

Conclusion

Although there are various fixation methods to choose from, the PTIP technique remains an acceptable alternative for managing acute, displaced, unstable metacarpal fractures. It is both biologically sound and technically straightforward, offering a safe, cost-effective, and efficient approach with favorable functional outcomes and with low complication rate.

Ethical Approval

Approval was obtained from the ethics committee of the faculty of medicine, Fayoum University (No: M635).

Consent to Participate

Informed consent was obtained from all individual participants included in the study.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by A.R.F., M.S.E., M.E.E.L., A.B.A.B. and H.A.K. The first draft of the manuscript was written by M.S.E. and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Consent to Publish

Patients signed informed consent regarding publishing their data and photographs.

Availability of data and materials

The corresponding author has the data available to him.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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