Simple percutaneous pinning for management of unstable fifth metacarpal neck fractures

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Background
The purpose of this prospective study was to evaluate the clinical and radiographic outcomes of our new surgical technique, percutaneous antegrade intramedullary pinning, for the management of unstable displaced fifth metacarpal neck fractures.
Patients and methods
Between 2010 and 2014, 40 patients who met the inclusion criteria were invited for clinical and radiological follow-up. There were 38 males and two females. The mean age was 28 years. Clinical assessments included active range of motion of the injured fifth metacarpophalangeal (MP) joint; visual analog scale score for pain; grip strength; and disabilities of the arm, shoulder, and hand score. Radiological evaluation included angulation and shortening of the fifth metacarpal.
Results
The average follow-up duration was 18 months. Regarding clinical outcomes, the mean active range of motions of the fifth MP joints were 87°, the median visual analog scale scores were 0, the mean grip strengths were 95%, the mean disabilities of the arm, shoulder, and hand scores were 3, and mean period for return to work was 6 weeks. Regarding radiological outcomes, all fractures healed at a mean of 5.85 weeks, the mean residual angulation was 4°, and the mean postoperative shortening was 0.5 mm.
Conclusion
This technique is straightforward, and there is no incisional scar. The wires do not violate the MP joint that makes early joint motion possible. The operative time is relatively short compared with previous techniques. All patients in the study group had satisfactory clinical and radiographic outcomes.
Level of evidence: therapeutic level IV, case series.

Keywords:
antegrade intramedullary pinning, fracture fifth metacarpal neck, percutaneous pinning, surgical treatment

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Introduction

Metacarpal fractures are among the more common types of hand injuries, representing one-third of all fractures encountered by the hand surgeon [1]. Among these, fractures of the neck of the fifth metacarpal bone are the commonest, with an incidence ranging from 9.7 to 50 % [2,3]. The majority of these fractures are treated conservatively [4,5].

Surgical treatment is usually indicated when conservative treatment fails, in the presence of a shortening of more than 3 mm, or when the amount of volar angulation of the metacarpal head is judged important. However, the recommendations in the literature vary largely [6].

Many surgical techniques have been described to treat the unstable neck fractures of the fifth metacarpal to achieve reduction and obtain stability, such as percutaneous wire fixation, external fixation, lag screw fixation, and plate and screw fixation. Intramedullary Kirschner wire (K-wire) osteosynthesis of the metacarpal bones is preferred because of the simplicity of the method, and it has the least soft tissue injury [7].

In 1957, Lord [8] introduced intramedullary fixation of displaced metacarpal fractures, in which a pin was introduced percutaneously through the reduced metacarpal head. Since then, various wire fixation techniques involving a different entry point, number of wires, location of wire end, postoperative immobilization, and rehabilitation have been suggested [9]. Although acceptable outcomes have been reported regardless of the specific technique, there have been several problems, including the intraarticular location of the wire, which prohibits early rehabilitation [10].

In our new surgical technique of percutaneous antegrade intramedullary pinning, the K-wire was inserted through the metacarpal neck fracture, extracted proximally, and then inserted after fracture reduction to subchondral bone of metacarpal head without violating metacarpophalangeal (MP) joint. The purpose of this prospective study was to evaluate the clinical and radiographic outcomes of this new surgical technique for the treatment of unstable displaced fifth metacarpal neck fracture.

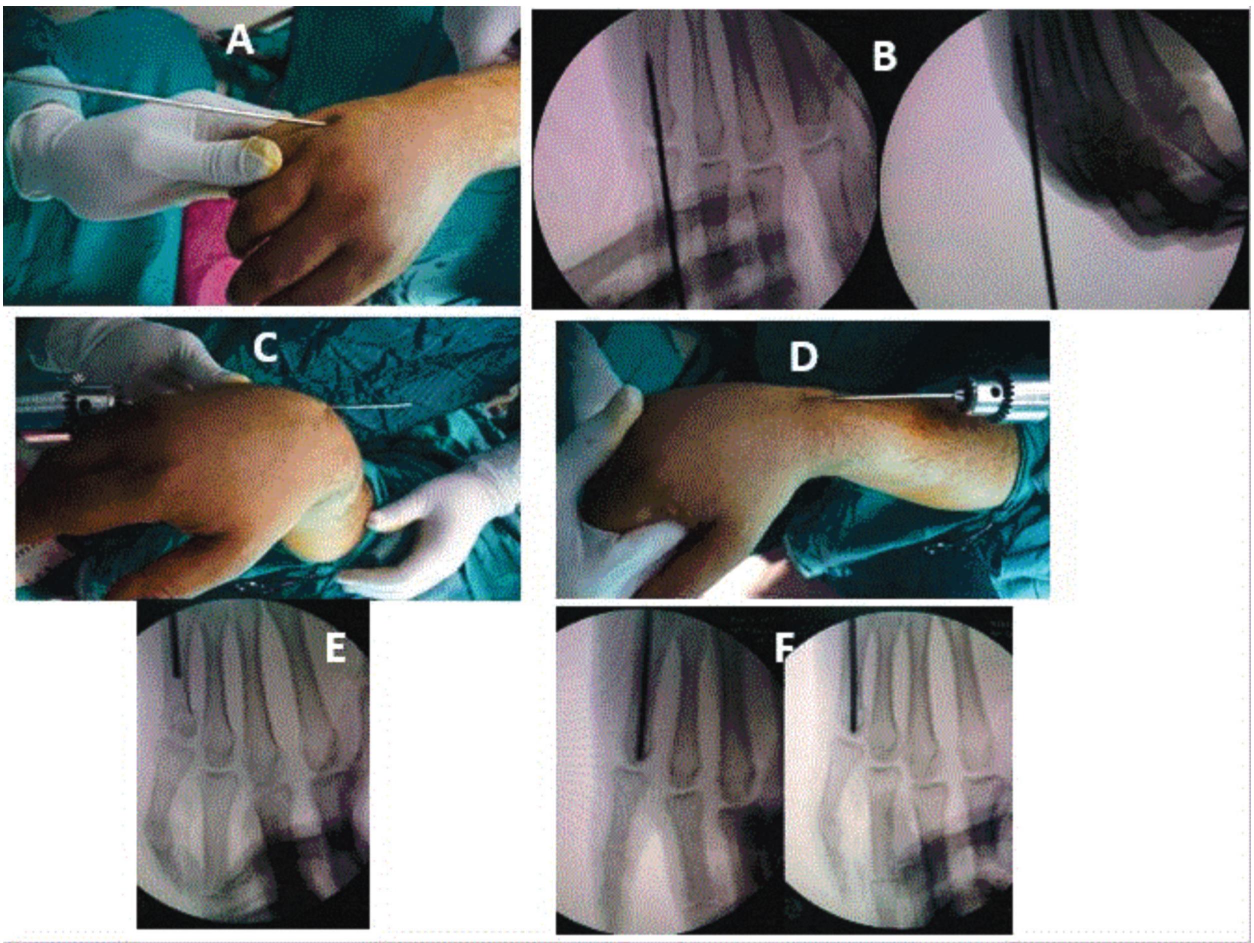
Patients and methods

Between 2010 and 2014, 70 patients with fractures of the fifth metacarpal neck were treated at El-Minia University Hospital. This prospective study was conducted after approval of the Ethics Committee of the University Hospital. The inclusion criteria in the present study were acute completely displaced or angulated (>40°) fracture neck of the fifth metacarpal. Open or intraarticular fractures were excluded.

Surgical technique

The operation was performed using intravenous regional anesthesia (Bier's block), with an upper arm tourniquet applied. All operations were performed under fluoroscopic guidance. Intramedullary K-wire was inserted through the metacarpal neck fracture in the retrograde direction (Fig. 1a). The thickness of the K-wire was selected to fit the intramedullary space well to supply maximum fracture stability. Then, after checking the location of the wire under an image intensifier, the wire was advanced into the medullary cavity of the proximal fragment. The wire was advanced in a dorsal and ulnar direction to emerge

Figure 1



Surgical technique. (a) Intramedullary Kirschner wire inserted through the metacarpal neck fracture in the retrograde direction. (b) The wire was advanced into the medullary cavity of the proximal fragment. (c) The wrist was maintained into a fully flexed position, and the wires were sequentially advanced farther through the base of the metacarpal bone, soft tissue overlying the carpal bone, and dorsal skin. (d) Once the proximal end of the wire penetrated and protruded through the dorsal skin, they were held with wire driver drill. (e) Now the wire was withdrawn into metacarpal shaft. (f) Anteroposterior and 30° pronation lateral radiographs showing the Kirschner wire inserted down to subchondral bone of the metacarpal head in the antegrade direction with good reduction.

at the periphery of the carpometacarpal joint without penetrating the carpal bone (Fig. 1b). This will prevent K-wire impingement on dorsal skin during wrist extension. Then, the wrist was maintained into a fully flexed position, and the wire was sequentially advanced farther through the base of the metacarpal bone, soft tissue overlying the carpal bone, and dorsal skin (Fig. 1c). Once the proximal end of the wire penetrated and protruded through the dorsal skin, it was held with wire driver drill (Fig. 1d). Now the wire was withdrawn into metacarpal shaft (Fig. 1e). The fracture was reduced using the closed method, described by Jahss [11], in which the MP and proximal interphalangeal joints are flexed to an angle of 90°, and upward pressure is applied on the flexed finger to correct dorsal angulation. This method has some advantages, including reduction in the fracture by causing the interosseous muscles to relax and the collateral ligaments to tighten, ease of handling of the distal fragment, and spontaneous resolution of any rotational malalignment. Once the fracture was reduced, a K-wire, mounted in a wire driver drill, was inserted down to subchondral bone of the metacarpal head in the antegrade direction, while reduction with the Jahss maneuver was maintained (Fig. 1f). The wire was bent back distally where it emerged from the skin.

Postoperative management
A well-moulded ulnar gutter short-arm splint was applied in all cases. The splint was positioned with the wrist in 20° extension, the MP joint at 60° flexion, and the interphalangeal joint in full extension. Patients were encouraged to begin full finger motion exercises of the unaffected fingers outside the splint the following day. One week after surgery, the splint was changed to a removable dorsal short-arm splint, and full wrist and finger motion exercises were encouraged. Immediate postoperative radiographs were obtained to assess reduction. At 4 weeks and weekly thereafter, radiographs were obtained to assess healing of the fracture. Once there were radiographic signs of bone healing, the wires were removed by drawing it proximally out of the metacarpal in the outpatient department, and patients were encouraged to perform wrist and finger motion exercises more vigorously without a splint.

Clinical evaluation
These assessments were done at 3-month interval for 1 year and every 6-month thereafter. It included range of motion (ROM) of the injured fifth MP joint, visual analog scale (VAS) score for pain, grip strength, and disabilities of the arm, shoulder, and hand (DASH) score.

Active ROM for patients with injured fifth MP joints was measured using a finger goniometer, and pain during daily activity was recorded using a VAS, in which zero indicated no pain and 10 indicated the most severe pain.

Grip strength was measured on both sides. Grip strength values are expressed as percentages of those of the contralateral hands, but assuming 10% greater strength of the dominant hand when the right hand was dominant, and similar hand strengths when the left hand was dominant [12].

DASH responses are scored from 0 to 100, and higher scores indicate greater patient disability.

Radiological evaluation
At follow-up, standardized AP and oblique pronated views of the fifth metacarpal of the injured hand were performed. The shortening of the fifth metacarpal was assessed using a method developed by Chautems (1990), which is a modification of the technique described by Poznan (1974) [13]. The first line was drawn tangential to the third and fourth metacarpals. The highest apex of the fifth metacarpal was then determined, and from this point, a straight line was drawn perpendicular to line 1. The distance between the apex of the fifth metacarpal and line 1 was measured (Fig. 2). After measuring shortening, the volar angulation of the fifth metacarpal was determined on the oblique pronated view using the conventional technique. For the conventional technique, line 1 was drawn intramedullary of the fifth metacarpal so that the line was parallel to the cortex of the shaft. Line 2, which denotes the volar angulation of the head, was drawn from the center of the metacarpal head to the fracture site (Fig. 2).

Statistical analysis
Statistical analysis was carried out using IBM SPSS Statistics for Windows version 22.0 (IBM Corp., Armonk, NY).

Descriptive statistics were done for parametric quantitative data by mean, SD, and minimum and maximum of the range, and for nonparametric data by median and interquartile range, whereas they were done for categorical data by number and percentage.

Analyses were done between preoperative and postoperative parameters using Wilcoxon signed-rank test for nonparametric quantitative data.

The level of significance was taken at P value less than 0.05.

Figure 2

Anteroposterior and 30° pronation lateral radiographs showing how to measure fifth metacarpal angulation and shortening.

Results

The average follow-up duration was 18 months (range, 12–36 months).

A total of 40 patients met the inclusion criteria and were invited for clinical and radiological follow-up. There were 38 males and two females. The age range was from 18 to 69 years, with a mean (SD) of 28 (11.95) years. Thirty-six injuries were on the dominant side (90%). The most common mechanisms of sustaining the fracture were punching injury (55%) or accidental fall (35%). More than 85% of injuries were operated within 24–48 h from the time of injury (range, 1–15 days). The average operative time was 15 min (range, 10–35 min). The K-wires size ranged from 1.6 to 2 mm. Single-ended wires were used to impinge in the subchondral bone of metacarpal head leaving it intact.

All patients in the study group had satisfactory clinical and radiographic outcomes, as shown in Tables 1 and 2.

Clinical outcomes

The mean (SD) active ROMs of the fifth MP joint were 87° (2.05°) (range, 80°–90°). The median VAS scores were 0 (range, 0–2). The mean (SD) grip strengths were 95% (8.24%) (range, 70–105%). The mean (SD) DASH scores were 3 (3.41) (range, 0–12). The mean (SD) period for return to work was 6 (1.08) weeks (range, 4–10 weeks).

Radiological outcomes

All fractures healed at a mean (SD) of 5.85 (1.23) weeks (range, 4–9 weeks), which was confirmed by clinical and radiological examinations (Fig. 3).

Preoperatively, the mean (SD) fifth metacarpal neck angle was 54.97° (7.31°) (range, 43–78°) for the injured side and 13° (2.16°) (range, 8–16°) for the uninjured side. The mean (SD) residual angulation (after subtraction of normal contralateral side angulation) was 4° (3.67°) (range, 0–12°). It showed significant postoperative improvement ($P<0.001$).

The mean (SD) preoperative shortening was 3 mm (1.06 mm) (range, 1–5 mm). The mean (SD) postoperative shortening was 0.5 mm (0.75 mm) (range, 0–2 mm), which also showed significant postoperative improvement ($P<0.001$).

Complications

There were two superficial pin-tract infection secondary to soft tissue irritation, which settled with a course of oral antibiotics and removal of the K-wire. Two cases of extensor tendon irritation resolved after K-wire removal.

Table 1 Patient demographic data and outcomes

Patients	Sex	Age	Side	DASH score		Postop VAS score	Angulations (°)		Shortening (mm)		MP joint ROM (°)	Union radiographs (weeks)	Grip (%)	Return to work (weeks)	Follow-up (months)
				Preoperative	Postoperative		Preoperative	Postoperative	Preoperative	Postoperative					
1	M	20	R	32	0	0	55	6	1	0	87	6	95	6	12
2	M	18	R	30	0	0	56	6	3	1	87	6	100	6	12
3	M	26	R	34	3	0	43	6	2	0	87	6	95	6	36
4	M	24	R	36	4	0	45	2	1	0	88	5	100	5	12
5	M	19	L	30	3	0	49	2	5	2	88	5	105	5	18
6	M	20	R	33	4	0	50	2	4	1	89	5	100	5	24
7	M	28	R	35	6	0	50	0	3	0	90	4	105	4	12
8	M	31	R	40	6	0	56	6	2	0	87	4	95	4	18
9	M	24	R	30	0	0	50	0	2	0	88	5	100	6	24
10	M	21	R	35	0	0	45	0	3	0	89	4	105	5	12
11	M	26	R	45	6	0	61	1	3	0	87	6	95	6	12
12	M	28	R	45	5	1	53	0	3	0	88	6	105	6	18
13	M	24	R	50	2	1	55	0	3	0	89	5	100	5	12
14	M	34	R	45	4	1	55	0	5	2	90	4	105	5	18
15	F	26	R	35	0	1	57	8	4	1	85	7	85	7	24
16	M	22	R	35	0	0	58	8	2	0	86	7	95	6	12
17	M	20	L	32	0	0	52	2	4	1	89	5	100	5	18
18	M	19	R	30	0	0	49	0	3	0	88	5	100	6	36
19	M	21	R	30	0	0	59	6	3	0	87	6	90	6	12
20	M	28	R	35	6	1	61	8	3	0	85	7	90	7	18
21	M	36	R	40	6	1	70	6	4	2	87	6	95	6	12
22	M	32	R	45	6	1	66	6	2	0	86	7	90	7	18
23	M	46	R	45	6	2	60	8	3	0	85	8	85	8	12
24	M	35	R	35	4	1	49	0	2	0	90	4	100	5	18
25	M	60	L	50	10	2	65	10	4	1	84	8	75	10	24
26	M	63	R	50	12	2	66	12	2	0	84	8	75	6	12
27	M	22	R	38	0	0	58	2	5	2	89	5	100	5	24
28	M	24	R	36	0	0	60	4	3	0	87	6	95	6	18
29	M	21	R	35	0	0	56	2	2	0	87	6	95	6	12
30	M	69	R	55	12	2	78	12	2	0	80	9	70	7	36
31	F	19	R	36	0	0	49	0	3	0	87	6	100	6	24
32	M	28	R	40	6	1	56	6	4	2	87	6	95	6	12
33	M	22	R	36	0	1	52	4	5	2	86	7	95	7	24
34	M	21	R	32	0	0	49	2	2	0	87	6	95	6	12
35	M	19	R	30	0	0	46	1	4	1	85	6	90	7	24

(*Continued*)

Table 1 (*Continued*)

Patients	Sex	Age	Side	DASH score		Postop VAS score	Angulations (°)		Shortening (mm)		MP joint ROM (°)	Union radiographs (weeks)	Grip (%)	Return to work (weeks)	Follow-up (months)
				Preoperative	Postoperative		Preoperative	Postoperative	Preoperative	Postoperative					
36	M	24	R	34	3	0	45	2	2	0	89	5	100	6	12
37	M	25	R	32	3	0	55	10	3	0	84	7	90	7	18
38	M	33	L	50	3	2	50	2	3	1	87	6	95	6	12
39	M	20	R	35	0	0	55	0	2	0	90	4	105	5	24
40	M	22	R	36	0	0	55	8	4	1	85	6	90	7	12

DASH, disabilities of the arm, shoulder, and hand; F, female; L, left; M, male; MP, metacarpophalangeal; R, right; ROM, range of motion; VAS, visual analog scale.

Table 2 Summary of the results

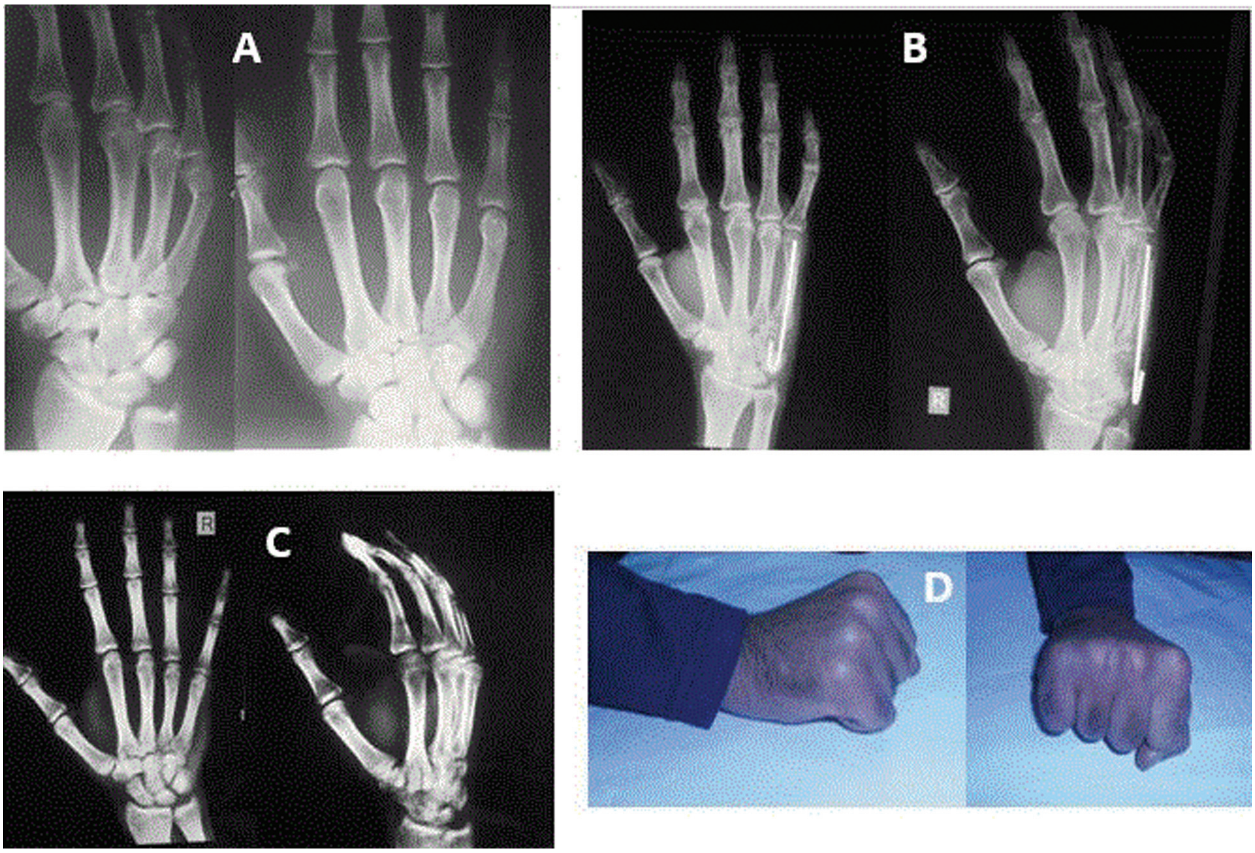
Patient number	40
Age	
Range	(18–69)
Mean (SD)	28 (11.95)
Sex (M/F)	38/2
Dominant side affection [*n* (%)]	36 (90)
Mechanism of injury [*n* (%)]	
Punch	22 (55)
Fall	14 (35)
Operative time (min)	Average 15 (range, 10–35)
Follow up duration (months)	Average 18 (range, 12–36)
Clinical outcomes	
ROMs	
Range	80–90
Mean (SD)	87 (2.05)
VAS scores	
Range	0–2
Median	0
Grip strengths	
Range	70–105%
Mean (SD)	95% (8.24%)
DASH scores	
Range	0–12
Mean (SD)	3 (3.41)
Return to work period	
Range	4–10
Mean (SD)	6 (1.08)
Radiological outcomes	
Fracture healing time	
Range	4–9
Mean (SD)	5.85 (1.23)
Fifth metacarpal neck angle	
Preoperative	
Range	43–78
Mean (SD)	54.97 (7.31)
Postoperative	
Range	0–12
Mean (SD)	4 (3.67)
P value	$<$0.001*
Fifth metacarpal shortening	
Preoperative	
Range	1–5
Mean (SD)	3 (1.06)
Postoperative	
Range	0–2
Mean (SD)	0.5 (0.75)
P value	$<$0.001*
Complications	
Superficial pin-tract infection	2
Extensor tendon irritation	2

Wilcoxon signed-rank test for nonparametric quantitative data. DASH, disabilities of the arm, shoulder, and hand; F, female; M, male; ROM, range of motion; VAS, visual analog scale.
*Significant difference at *P* value less than 0.05.

Discussion

Metacarpal neck fractures are better and more easily fixed with the use of intramedullary K-wires.

Figure 3



(a) Anteroposterior and 30° pronation lateral radiographs showing right fifth metacarpal neck fracture in a 21-year-old man. There is 45° angulation and 2 mm shortening. (b) Postoperative radiographs showing good alignment. (c) 18-month follow-up radiographs showing healing of the fracture and good alignment.

Compared with the other available surgical methods, intramedullary fixation is characterized by its simplicity, and the fact that the technique does not harm the soft tissue. For these reasons, it has become a commonly used technique [9,14].

In 2014, Yammine and Harvey [7] performed a meta-analysis of four studies involving a total of 163 patients. They concluded that antegrade intramedullary nailing (AIMN) had better pain scores, better grip strength, and significantly better results in terms of active ROM of the fifth finger, lesser residual angulation, and fewer complications.

Since Foucher *et al.* [15] described the 'bouquet' technique involving antegrade nailing of metacarpal fractures using multiple small prebent K-wires and had satisfactory results in 68 fractures in 66 patients, it has been widely used and produces reliable fracture reduction and excellent ROM of the fifth finger for patients with a fifth metacarpal neck fracture.

In the current prospective study, 40 patients were managed by our new technique of AIMN. All patients in the study group had satisfactory clinical and radiographic outcomes. The mean DASH score was 3. Radiographic union was achieved in all patients at a mean of 5.85 weeks. Radiographic assessment revealed a significant reduction in the mean dorsal angulation to 4°. The mean shortening was corrected significantly to 0.5 mm postoperatively.

We report four complications. Two patients developed a superficial pin-site infection. In these two cases, the K-wire removal was delayed for 8 and 9 weeks waiting for fracture union. Moreover, two patients experienced extensor tendon irritation, which resolved after K-wire removal.

Our prospective study had certain limitations. Being a case series, this method of fixation is not compared with other fixation modalities, such as plate fixation, transfixing wires, or multiple intramedullary wires. Future randomized control studies should be structured to compare these different methods of fixation to yield more definitive information. Although directing the wire in a dorsal and ulnar direction to emerge at the periphery of the carpometacarpal joint (CMCJ) without penetrating the carpal bone was difficult in obese patients, there was no clinical or radiological evidence of arthrosis in these joints. Delayed K-wire removal was associated with pin-tract infection.

Calder *et al.* [16] described excellent functional results without any limitations of movement or rotational deformity after intramedullary fixation of metacarpal fractures with one K-wire.

Facca *et al.* [17] found better functional results after intramedullary fixation of metacarpal fractures with a single K-wire and 6 weeks of immobilization (n=20) compared with a second series treated with locking plates and immediate mobilization (n=18). Active flexion and extension was significantly greater in the K-wire group. The wire group showed seven complications, including three cases of wire migration, three of lesions of the dorsal cutaneous branch of the ulnar nerve, and one of esthetic blemish.

Mohammed *et al.* [18] examined 20 patients with metacarpal neck or diaphyseal fractures treated with a single antegrade intramedullary K-wire. They observed four complications: a failed fixation and three superficial wound infections. All patients regained full flexion, but two patients had an extension deficit of about 15°.Venkatachalam and Harrison [19] achieve good functional results with antegrade locked flexible intramedullary nailing of metacarpal fractures. Twenty-six patients with fractures of metacarpal neck and shaft were included in this study. All fractures went on to union by an average of 6.3 weeks with full MP joint movement and grip strength.

Fujitani *et al.* [20] confirmed the results of Facca and colleagues; 30 patients with metacarpal neck fractures that had either been treated with two intramedullary K-wires or with a low profile plate, were examined. They had better functional result after intramedullary K-wires and comparable radiological outcome. Complications occurred in two patients with intramedullary fixation; tendon rupture was seen in one case and transient neuritis was seen in other case.

In 2013, Lee *et al.* [21] described a modified retrograde percutaneous intramedullary multiple K-wire fixation for treatment of unstable displaced metacarpal neck and shaft fractures which was very close to our technique. However, they introduced the wire through the metacarpal head violating the MP joint. Although they had no radiographic evidence of arthrosis in the MP joint associated with cartilage damage caused by transarticular wire penetration during the follow-up period, they recommend careful drilling at the right location in the optimal direction, and unnecessary repetitive drilling should be avoided to minimize potential cartilage damage. They managed 56 consecutive patients with 65 metacarpal fractures by this technique. The average DASH score was 8.7 (range, 0–21). Radiographic union was achieved in all patients at a mean of 5.2 weeks. Radiographic assessment revealed a significant reduction in the average dorsal angulation to 8°. The average shortening was corrected significantly to 1 mm postoperatively.

Compared with the previously reported antegrade intramedullary wire fixation techniques, there are several advantages of our procedure. Antegrade intramedullary insertion of K-wires through the metacarpal shaft can be difficult because of poor control of the tip and the angle of introduction. Such a technique also requires a dorsal skin incision, which usually leads to bad-looking dorsal scar.

Conclusion

This technique is straightforward, and there is no incision scar. The wires do not violate the MP joint that makes early joint motion possible. It provides easy access to the medullary canal through the fracture, and the operation time is relatively short compared with previous techniques. K-wires can be removed easily in the outpatient setting without anesthesia. All patients in the study group had satisfactory clinical and radiographic outcomes. Our results fit into the context of current practice as many hand surgeons consider the AIMN technique their preferred method to treat neck fractures of the fifth metacarpal.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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