90/90 Bicortical, double-loop, interosseous wiring for fixation of transverse and short oblique metacarpal shaft fractures

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ABSTRACT

Background:
The purpose of this study was to determine the effectiveness of 90/90 interosseous wiring for fixation of transverse and short oblique metacarpal shaft fractures on early motion.

Methods:
This prospective study was conducted at an academic Level 1 trauma Center from 2015 to 2017. The study included 20 patients (16 males and 4 females). The mean age was 27.3 yr (range, 12 to 44 yr). The dominant hand was affected in 10 patients, and the nondominant hand was affected in the other 10 patients. Regarding the fracture pattern, 17 were transverse and three were short oblique fractures. The mean follow-up period was 6 mo (range, 4 to 8 mo). Patients were assessed for union (clinically and radiographically), range of motion (total active motion [TAM] and total active flexion [TAF]), hand grip strength, and patient-reported outcome using the quick-Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.

Results:
All patients achieved union after a mean of 7 wk (range, 6 to 8 wk). The mean TAF was 246 degrees (range, 150 to 260 degrees). TAM was excellent in 13 digits and good in seven digits. The mean grip strength was 90.20% (range, 61.53% to 100%) of the unaffected side. The mean quick-DASH score was 2.72 (range, 0 to 20.45).

Conclusions:
The interosseous wiring technique is an effective method of fixation that can be used alone for transverse or short oblique fractures of the metacarpal and can permit early hand mobilization postoperatively without loss of reduction.

Key Words
metacarpal, fracture, fixation, interosseous, wiring

INTRODUCTION

There are many options for fixation of transverse and short oblique metacarpal shaft fractures which include: Kirschner wires (cross wires, intramedullary wires, or transverse wires); composite wiring; plates and screws; interosseous wiring; and a combination of interosseous wiring and Kirschner wires.[1] The choice of a proper rigid method of fixation for hand fractures is essential to allow early motion. Rigid methods include mini-plates and composite (tension band) wiring, but mini-plates are quite expensive, and composite wiring is technically demanding. Our hypothesis was that perpendicular interosseous wiring could be a rather rigid, cost effective, and less technically demanding option that can allow early hand motion.

Lister[2] reported the use of interosseous wiring in phalangeal fractures and interphalangeal joint arthrodesis. He used an interosseous loop wire parallel to the fracture site to control rotation and lateral angulation with a supplementary Kirschner wire to control anteroposterior angulation. Gingrass *et al.*[3] used an interosseous wiring technique in 51 patients with various metacarpal and phalangeal fractures with good results. Hoffmann and Buck-Gramcko[4] compared the results of interosseous wiring and Kirschner-wire fixation in 90 replanted fingers of 68 patients and found that interosseous wiring was better regarding rigidity of fixation and early hand motion. These studies were conducted on heterogenous groups of patients. AL-Qattan[1] used both double and single interosseous loops for fixation of transverse and short oblique metacarpal fractures. The literature is, however, deficient in studies about the use of double-loop, bicortical, interosseous wiring alone in transverse and short oblique metacarpal fractures.

The purpose of this study was to assess the rigidity of perpendicular interosseous wiring in patients with transverse and short oblique metacarpal shaft fractures and the possibility of early, active hand motion.

MATERIALS AND METHODS

We prospectively included 20 patients with transverse and short oblique metacarpal shaft fractures treated by the senior author using 90/90 interosseous wiring between 2015 and 2017. Informed consent was obtained from the patients. All procedures performed in this study were in accordance with

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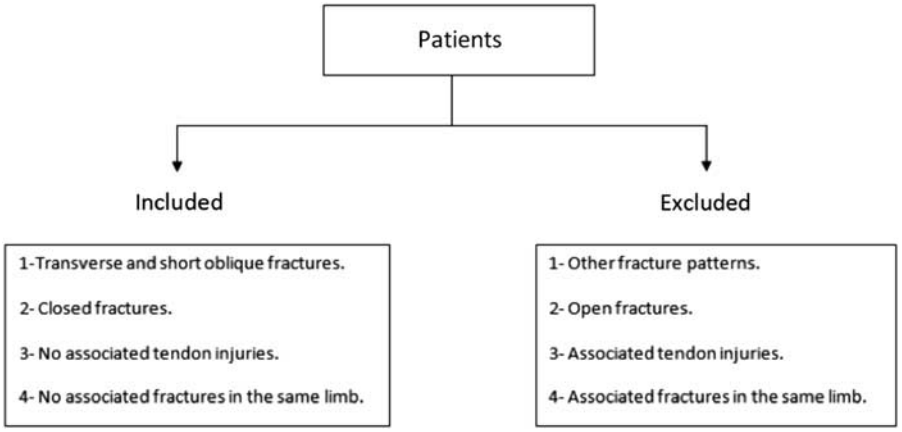

FIGURE 1. Inclusion and exclusion criteria.

the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Closed fractures only were included, and we defined the short oblique fracture as *an oblique fracture* line with a length less than twice the transverse diameter of the affected metacarpal. Patients with open fractures, other fracture patterns, associated tendon injuries or crushing hand injuries were excluded (Figure 1).There were 16 male patients and four female patients, with a mean age of 27.3 yr (range, 12 to 44 yr). The dominant hand was affected in 10 patients, and the nondominant hand was affected in 10 patients (Table 1). The mean follow-up period was 6 mo (range, 4 to 8 mo).

Surgical Technique

The procedure was carried out under either general or brachial plexus block anesthesia. A well-padded upper arm tourniquet was used. A dorsal skin incision was made over the fractured metacarpal. Subcutaneous dissection is completed in the same line. The extensor tendons were retracted away from the field, then the dissection was completed to expose the fracture site. The periosteum was elevated proximally and distally for only 3 mm. The fracture site was cleaned of hematoma, and both ends were anatomically reduced. A 1- to 1.2-mm Kirschner wire was used to make two perpendicular bone tunnels for cerclage passage through both cortices on either side of the fracture (Figure 2A and B). Tunnels were made at least 3-4 mm from the fracture site to avoid cutting through the bone ends while tightening of the cerclage wire. Then, 0.8-mm cerclage wires were passed through these tunnels in 90/90 fashion starting with the less mobile fracture end (Figure 2C). After confirming the reduction, the wires were tightened and bent to the surface of the bone to avoid impingement on the extensor tendons (Figure 2D). Reduction was confirmed intraoperatively aided by the C-arm (Figure 3). The wound was closed in layers. A wrist splint in 15 degrees extension and not extending beyond the distal palmer crease was applied for 2 wk to allow early finger motion.

TABLE 1. Patients included in the study

Serial	Age	Sex	Side	Hand dominance	Fracture pattern
1	24	Male	Left	Dominant	Transverse
2	21	Male	Left	Nondominant	Short oblique
3	26	Male	Right	Dominant	Transverse
4	21	Male	Left	Nondominant	Transverse
5	38	Male	Right	Nondominant	Transverse
6	30	Male	Right	Dominant	Transverse
7	29	Female	Left	Nondominant	Transverse
8	25	Male	Left	Nondominant	Short oblique
9	25	Male	Right	Dominant	Transverse
10	12	Male	Right	Dominant	Transverse
11	44	Female	Left	Nondominant	Transverse
12	24	Male	Left	Nondominant	Transverse
13	22	Male	Right	Nondominant	Transverse
14	19	Male	Right	Dominant	Transverse
15	28	Female	Left	Nondominant	Transverse
16	31	Male	Right	Dominant	Transverse
17	40	Female	Right	Dominant	Transverse
18	27	Male	Left	Nondominant	Transverse
19	28	Male	Left	Dominant	Transverse
20	32	Male	Right	Dominant	Short oblique

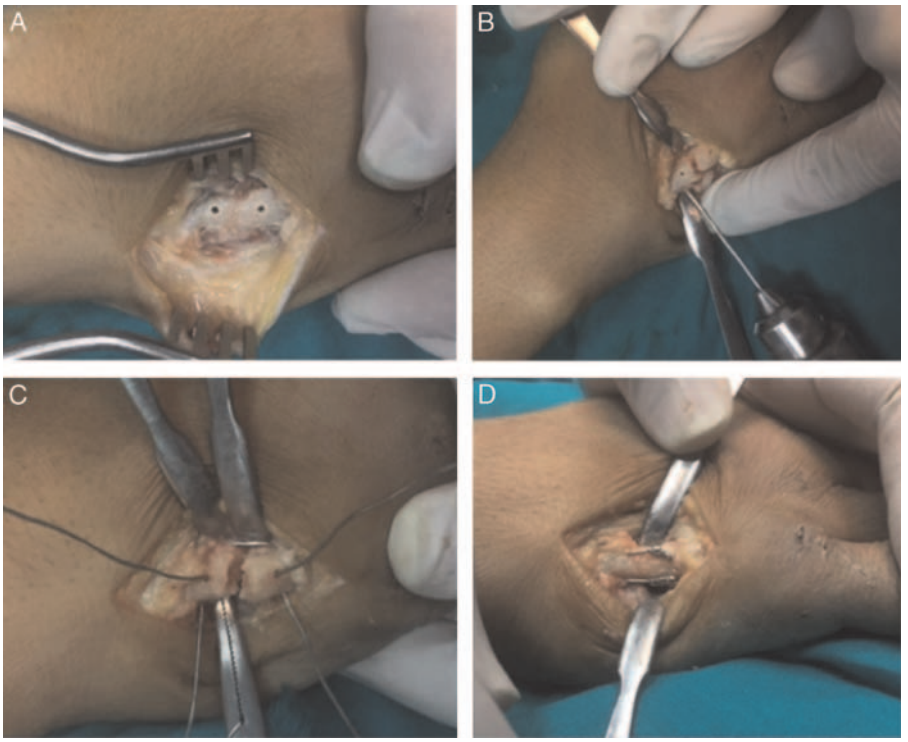

FIGURE 2. (A and B) Bone tunnels. (C) Passing the wire loops. (D) After wire tightening and cutting the ends of the wire loops.

Postoperative Evaluation

Radiographic evaluation was done at 2, 4, and 6 wk and at 3 mo. At the final follow-up period, patients were evaluated for total active flexion (TAF) (Table 2), total active motion (TAM) (Table 3), hand grip strength, and functional scoring by using the Quick-DASH score.[5–8]

RESULTS

No patients were lost to follow-up, which was for a mean of 6 mo (range, 4 to 8 mo). Regarding time to union, radiographic union occurred at a mean of 7 wk (range, 6 to 8 wk). All fractures united in proper alignment except in the first patient in the study who had a second metacarpal fracture that was fixed with 0.5-mm cerclage wire (Figure 4). It united in varus in the coronal plane with a little rotation (not evident clinically), but the patient's hand function was not affected, with excellent TAF of 260 degrees and TAM. The authors thought this malalignment occurred due to improper technical points regarding the size of the cerclage wire (0.5 mm) and the sites of bone tunnels, which were corrected in rest of the patients (Figures 5 and 6).

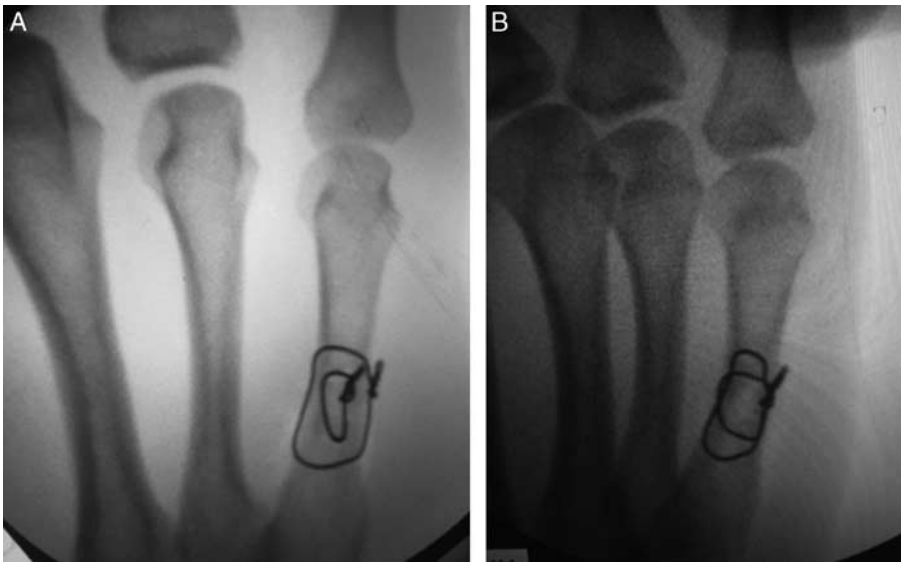

FIGURE 3. (A and B) Intraoperative C-arm images.

TABLE 2. Total active flexion

Score	Total active flexion (degrees)
Excellent	> 221
Good	121-220
Poor	< 120

Total active flexion = the sum of active flexion at metacarpophalangeal, proximal interphalangeal and distal interphalangeal joints.

TABLE 3. Total active motion

Percentage	Score
Normal	Excellent
> 75%	Good
50-75%	Fair
< 50%	Poor
< Preoperative	Worst

Total active motion = the sum of the degrees of active metacarphophalangeal, proximal interphalangeal, and distal interphalangeal joint flexion minus the degrees from full extension divided by the norm (either contralateral total or 260 degrees), and the result is the percentage of normal.[6]

TAM and TAF for all involved digits were measured using a goniometer at the final follow-up period. The mean TAF was 246 degrees (range, 150 to 260 degrees). TAF was excellent in 18 digits and good in two digits (Table 4). TAM was excellent in 13 digits and good in seven digits (Table 5). The mean grip strength was 90.20% (range, 61.53% to 100%) of the unaffected side. The mean quick-DASH score was 2.72 (range, 0 to 20.45). Only one patient complained of prominent hardware, which was removed upon his request.

DISCUSSION

Obtaining early active hand motion is the main concern after fixation of metacarpal fractures. Different fixation modalities are used with different degrees of rigidity and different costs. Interosseous wiring is a well-known method of fixation of hand fractures in the literature with different techniques (single or double loop, unicortical or bicortical, parallel or perpendicular). A 90/90 bicortical double-loop interosseous wiring technique offers an alternative cost-effective method of fixation. Our study is the first study to use a single technique of interosseous wiring (90/90 bicortical double loop) in specific patterns of metacarpal fractures (transverse and short oblique only).

Lister[2] described two techniques of wiring in his series: fixation of transverse fractures and arthrodesis of digits with a cerclage wire and oblique Kirschner wire, which is a type of tension band fixation. In the other technique, the cerclage wire is passed perpendicular to the fracture line to achieve compression in avulsion fractures. He had a 100% union rate in all 47 fractures, and only five out of 53 arthrodeses failed mostly due to failure to observe the essential elements of the technique, namely the need to obtain congruous bone ends and to maintain all internal fixation until there is clinical evidence of union. Overall, 83.2% of the maximal attainable TAM was achieved in the 100 patients. However, his study included two techniques for various indications and included only three metacarpal fractures.[2]

Gingrass *et al.*[3] used different techniques of interosseous wiring in fixation of metacarpal and phalangeal fractures. He supported the use of an additional Kirschner wire if there is any suspicion about fixation rigidity. He reported a mean TAM of 227 degrees in nine metacarpal fractures (in six patients).[3]

Al-Qattan[1] used single and double interosseous loop wiring in a series of 36 patients with metacarpal fractures with a mean follow-up of 8 wk. Twenty-six patients had transverse fracture (double loop wires were used in 24 patients and single loop was used in two patients). Ten patients had oblique fractures (double loop wires were used in nine patients and a single loop was used in one patient only). He started early finger motion in a wrist splint for 3 wk with excellent TAM at the final follow-up.

FIGURE 4. (A) A 24-year-old male patient with short oblique fracture of the second metacarpal of the left hand. (B) Immediate postoperative radiograph. (C) Complete union with mild varus.

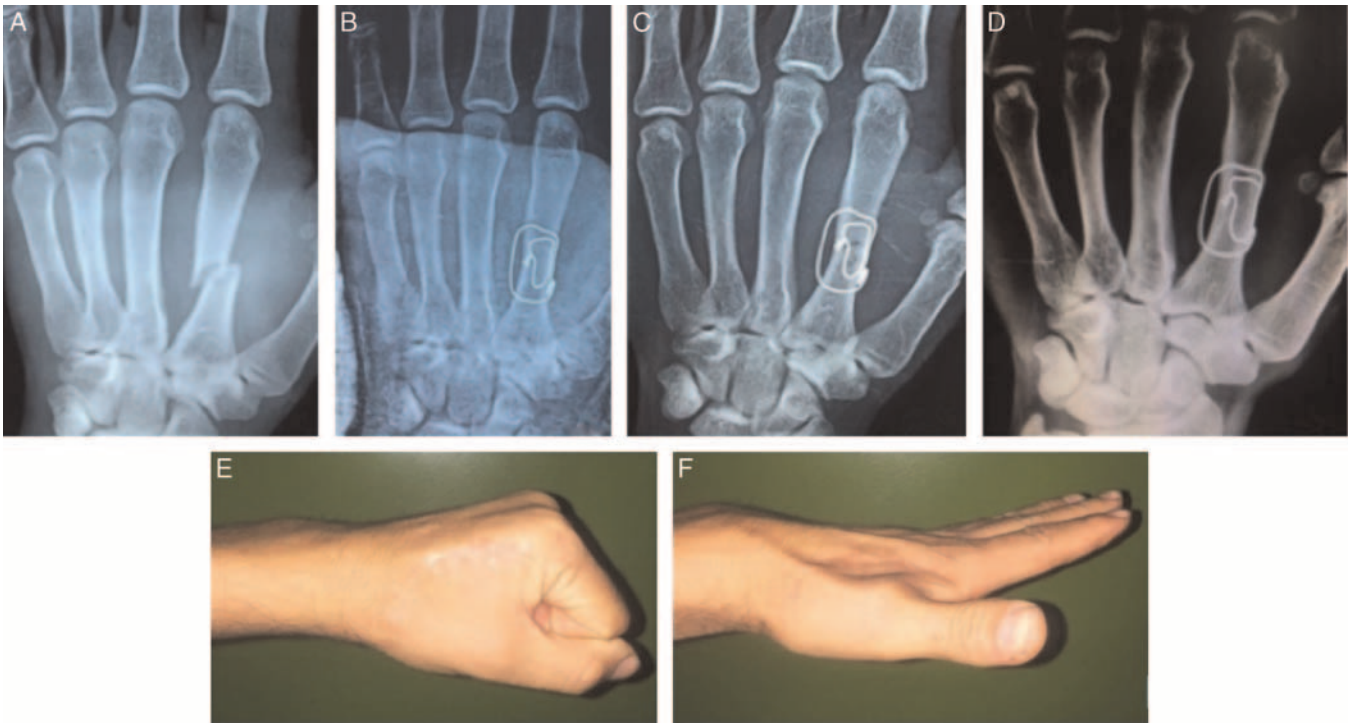

FIGURE 5. (A) A 21-year-old male patient with short oblique fracture of the second metacarpal of the left (nondominant) hand. (B) Immediate postoperative radiograph. (C and D) Follow-up radiograph after 6 wk. (E and F) Range of hand motion.

We believe that the use of a single interosseous loop may lead to rotation at the fracture site and loss of reduction. In our study, we used two interosseous loops in all patients to avoid this complication. Other advantages of this technique are the simplicity, the low cost, and the ability to revise reduction easily by

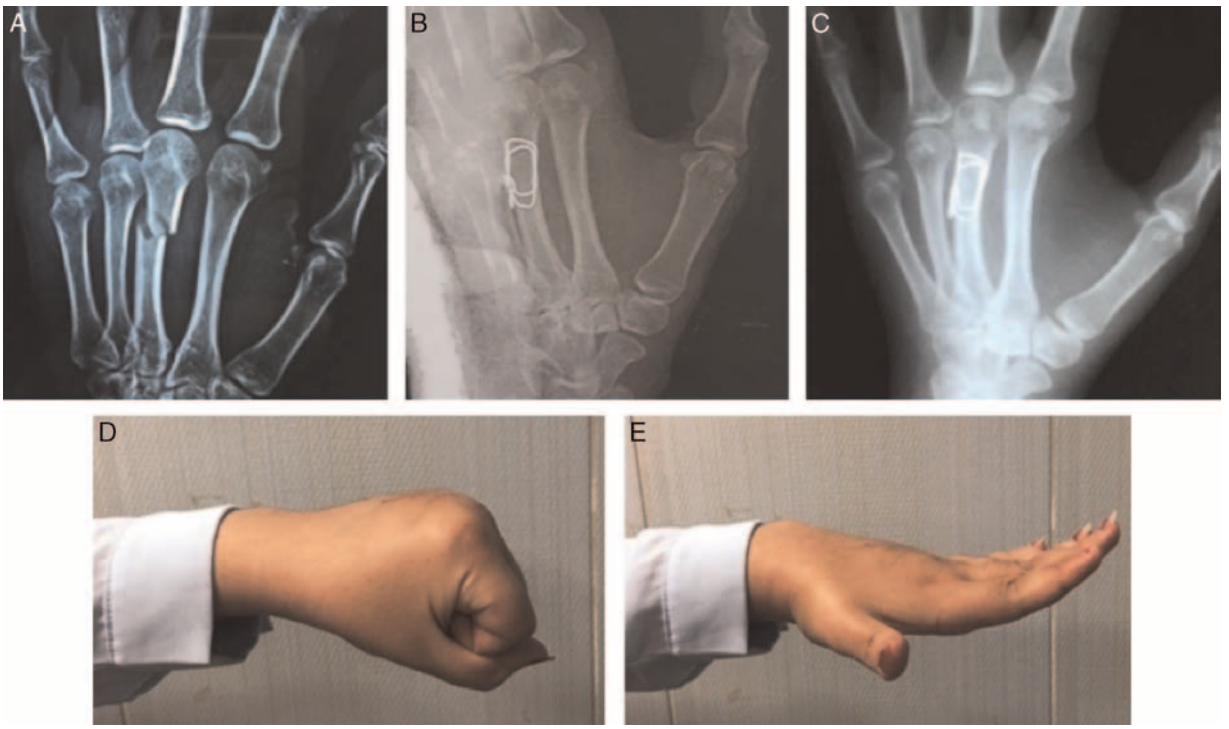

FIGURE 6. (A): A 25-year-old female patient with short oblique fracture of the third metacarpal of the left (nondominant) hand. (B) Immediate postoperative radiograph. (C) Follow-up radiograph after 8 wk showing complete union. (D and E) Range of hand motion.

TABLE 4. Total active flexion of the affected digits

Total active flexion	Number	Percentage
Excellent	18	90%
Good	2	10%

untwisting and re-twisting the loops if the fracture is not perfectly reduced.

In conclusion, the 90/90 bicortical, double-loop, interosseous wiring technique is an effective method of fixation that can be used alone for transverse and short oblique fractures of the metacarpals and can permit early hand mobilization postoperatively in a wrist splint for 2 wk. Moreover, this technique is cost-effective, but we recommend further comparative studies with other methods of fixation such as miniplates.

TABLE 5. Total active motion of the affected digits

Total active motion	Number	Percentage
Excellent	13	65%
Good	7	35%

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