Management of unstable metacarpal shaft fractures by k-wires versus mini-plate fixation

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Objective To compare the clinical and functional outcome of treatment of unstable metacarpal shaft fracture by K-wires versus open reduction and mini-plate fixation prospectively.

Place and duration The study was conducted at the Department of Orthopedic, Al-Zahraa Hospital, Faculty of Medicine for Girls, Al Azhar University, for a duration of 1 year from 1st January 2019 to 30th December 2019.

Patients and methods A total of 20 patients with unstable metacarpal shaft fracture were divided into two groups. Group A included 10 patients who were fixed by mini-plate and screws. Group B included 10 patients who were fixed by K-wires. Hand function was assessed 3 months postoperatively and when the patients finish physiotherapy by using Quick DASH score.

Results Union occurred in all cases. In group A, only one (5%) case reported tendon adherence. In group B, three (15%) cases reported joint stiffness.

Conclusion The mini-plate fixation is superior to K-wire fixation in the treatment of unstable metacarpal shaft fractures.

Keywords: fracture, hand injuries, K-wiring, metacarpals, plating

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Introduction Fractures of the hand occur in active working young adults. They are documented to have a large economic effect not only in terms of cost of treatment and disability but also in terms of loss of days of work and permanent disability [1]. It represent 10% of all fractures of the human body; metacarpal fractures account for up to 40% of hand fractures [2].

The mechanism of injury is owing to direct trauma (tapping, crushing, and penetrating fractures) or indirect trauma (traction, angulation, compression, and rotation fractures) [2].

Fractures of the metacarpal bones can involve the base, the shaft, the neck, or the head of the bone. The metacarpal shaft fractures are categorized according to site (proximal, middle, and distal third) of the shaft, shape of the fracture line (transverse, oblique, spiral, or comminuted), and whether the fracture is open or closed [3].

Moreover, metacarpal shaft fractures can be classified into stable (nondisplaced, impacted transverse fracture) and unstable (cannot be reduced by closed manipulation, spiral, short oblique, and comminuted) [4].

Treatment of metacarpal fractures depends on stability of the fracture, aiming for anatomical reduction, bone union, early use of the hand, and functional restoration, which ranges from nonsurgical treatment in most cases to minimally invasive techniques with K-wires or plates and screws [5].

The indications of internal fixation include unstable fractures, severely displaced fractures with interposition of soft tissue, multiple fractures that need rigid fixation, open fractures associated with soft tissue injury, metacarpal shaft fractures with rotational deformity, displacement greater than 25%, shortening more than 2 mm, or unacceptable angulation [6].

Aim This comparative study showed the clinical and functional outcomes of treatment of unstable metacarpal shaft fracture by K-wires versus open reduction and mini-plate fixation prospectively.

Patients and methods This study was carried out on 20 patients with unstable metacarpal shaft fracture who were divided into two groups: group A included 10 patients with 13 fractured metacarpals who were fixed by mini-plate and screws, and group B included 10 patients who were fixed by K-wires. Hand function was assessed 3 months postoperatively and when the patients finish physiotherapy by using Quick DASH score.

Conclusion The mini-plate fixation is superior to K-wire fixation in the treatment of unstable metacarpal shaft fractures.
and group B included 10 patients with 18 fractured metacarpals who were fixed by K-wires. The study was conducted at the Department of Orthopedics, Al-Zahraa Hospital, Faculty of Medicine for Girls, Al Azhar University, for a duration of 1 year from 1st January 2019 to 30th December 2019. The inclusion criteria were adult patients with unstable metacarpal shaft fracture, closed and open fractures, relevant methods of fixation with K-wires and mini-plates, and single or multiple metacarpal shaft fracture in one hand or both. Children, other types of metacarpal fractures like head, neck, and base, and pathological fractures were excluded from the study.

The mean age in group A was 37.11±16.01 years (17–62 years) and in group B was 37.91±12.82 years (18–63 years). We had 15 male and five female patients: in group A, seven (35%) males and three (15%) females, and in group B, eight (40%) males and two (10%) females. The mechanism of injury in this study in group A cases was one case of twisting, three road traffic accident, four falling, and two direct injury, whereas in group B cases, one case of road traffic accident, four falling, and five direct injury.

According to skin and soft tissue condition, in group A, all ten (50%) cases were closed fractures. In group B, seven (30%) cases were closed and three (20%) cases were open (Gustillo 1). There were no cases of associated injuries in group A, whereas in group B, four (20%) cases had associated fractures: one had ipsilateral proximal humerus fracture and fracture mid shaft left radius managed operatively, one had ipsilateral open distal tibia fracture, one had dislocation of proximal inter-phalangeal (PIP) joint of right middle finger, and one had right distal radius fractures.

Regarding affected hand dominance, in group A, six (30%) cases were left nondominant and four (20%) cases were right dominant, whereas in group B, six (30%) cases were left nondominant and four (20%) cases were right dominant.

All patients were subjected to full history taking, clinical examination, routine laboratory investigations. Pre/postoperative anteroposterior, lateral, and oblique radiographs of the whole hand were obtained in all cases. In open fractures, a prophylactic broad-spectrum antibiotic and anti-titanic serum were administered. We have taken a written informed consent from all patients preoperatively. All patients were anesthetized by general anesthesia.

Surgical techniques

Open reduction and internal fixation by mini-plate and screws

The patients were placed supine on the table. The involved limb is prepared, draped, and placed on a side table. Tourniquet was used. A direct dorsal longitudinal incision was done over the injured ray, followed by dissection of subcutaneous tissue and retraction of the extensor tendon. If more than one metacarpal bone was injured, it was better to do a single incision in between each two adjacent bones. The periosteum was also opened longitudinally, and the bone was exposed subperiosteally to visualize the fracture. The fracture was reduced by traction on the digit and reduction was held in compression by a reduction clamp. Application of the plate and placement of the screws were done, followed by closure of surgical incision in layers. Sterile dressings and creep bandage were applied. Postoperative check radiograph was taken to assess the reduction (Fig. 1a–e).

Closed reduction and internal fixation by K-wires

The patients were placed supine with the involved limb placed on the cassette of image intensifier. With the metacarpo-phalangeal (MCP) joint acutely flexed, a K-wire was introduced into the metacarpal head and drilled it to the level of the fracture. By manual pressure and manipulation of the wire and with the aid of an image intensifier, reduction of the fracture was done. Checking of the reduction by radiographs was done; if it was accurate, the wire was cut near the skin. Sterile dressings and extended below-elbow splint was applied in functional position. Postoperative check radiograph was taken to assess the reduction (Fig. 2a–f).

Postoperative treatment

For all patients, parenteral antibiotics were given for 2 days followed by oral antibiotics depending upon the condition of the wound and pin site. Regular wound dressings were done. In case of satisfactory alignment and stable fixation, we allowed the patient for protected active ROM immediately postoperatively to avoid stiffness of MCP and inter-palangeal (IP) joints.

Follow up

For all patients, we needed a series of radiograph follow-ups every 2 weeks for the first 6 weeks postoperative and then every 1 month till radiographic union occurs. In group A patients, sutures were removed after 2 weeks. In group B patients, the K-wires were removed after 6–8 weeks. Telephonic contact and address of patients were kept to ensure follow-up. We continued physiotherapy for 2 months and till the patient gets satisfactory hand
Figure 1

Surgical technique of mini-plate fixation. A-Skin incision and dissection B-reduction and lag screw C-application of plate and screws D-closure of incision in layers E-skin closure.

Figure 2

Surgical technique of K-wire fixation. A-introduction of the wire B-reduction under image intensifier and enter from the head of fractured metacarpal C-drill the wire to a level just above the CMC joint D-reduction and fixation of the other fractured metacarpal E-cut all wires near the skin F-splint in functional position.
function. The period of follow-up for all patients in this study ranged from 4 to 6 months.

Clinical evaluation
We assessed the hand function 3 months postoperatively and when the patient finish physiotherapy by using Quick DASH score. Higher scores indicate a greater level of disability and severity, whereas lower scores indicate a lower level of disability. The score ranges from 0 (no disability) to 100 (most severe disability).

Results
Fracture union was achieved in all cases of this study in a period ranged from 6 to 10 weeks as follows: in group A, five (25%) patients achieved union in 6 weeks, four (20%) patients in 8 weeks, and one (5%) patient in 10 weeks; whereas in group B, four (20%) patients achieved union in 6 weeks, five (25%) patients in 8 weeks, and one (5%) patient in 10 weeks. According to the complications that occurred in this study, in group A, one (5%) case recorded as tendon adherence, which caused painful limited flexion. The patient was advised to do intensive physical therapy and symptoms improved 2 months following the treatment, and full range of movement was restored, whereas in group B, three (15%) cases recorded joint stiffness.

We analyzed the patients for the functional outcome using Quick DASH disability score. The mean score in group A was 3.184. A total of seven patients recorded score 0, with sound union and no deformity normal function; one patient recorded score 18.18 owing to tendon adherence, which caused painful flexion of MCP joint; one patient recorded score 2.27; and one patient recorded score 4.54. However, in group B, the mean score was 13.406. A total of four patients recorded score 0, two patients recorded score 9.09, one patient recorded score 75 owing to associated ipsilateral proximal humeral and radius fractures, one patient recorded score 22.72, one patient recorded score 11.36, and one patient recorded score 6.8. All higher scores occurred in group B, which was fixed by K-wires (Table 1).

Table 1 Data of mean DASH score in group A compared with group B in this study

<table>
<thead>
<tr>
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<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>Significance</th>
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<tr>
<td>Group A</td>
<td>3.184</td>
<td>5.778</td>
<td>2.872</td>
<td>0.0431</td>
</tr>
<tr>
<td>Group B</td>
<td>13.406</td>
<td>22.814</td>
<td></td>
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P value less than 0.05, significant. P value more than 0.05, nonsignificant.

Discussion
The hand fracture frequency among other fractures is between 12.3 and 30%. Isolated fractures of the MC and phalanges are the commonest injuries affecting upper extremity, which account for ~10% of skeletal fractures in general [7]. They occur most frequently in young age between 10 and 40 years [8].

This study was carried out on 20 patients with unstable metacarpal shaft fracture who were divided into two groups: group A included 10 patients with 13 fractured metacarpals who were fixed by mini-plate and screws, and group B included 10 patients with 18 fractured metacarpals who were fixed by K-wires.

Age of patients
The mean age in group A was 37.11±16.01 years (17–62 years) and in group B was 37.91±12.82 years (18–63 years). In the study by Sahin et al. [8], the highest frequency was seen between 10- and 40-year age group.

Mechanism of injury
In group A, falling was the causative injury in four (20%) patients, twisting in one (5%) patient, road traffic accident (RTA) in three (15%) patients, and direct injury was seen in two (10%) patients. However, in group B, falling was the causative injury in four (20%) patients, RTA was the cause in one (5%) patient, and direct injury was seen in five (25%) patients. These finding are similar to that reported by Barton [9] who stated that comminuted fractures are commonly owing to crushing injuries.

Skin condition
All patients in group A had closed metacarpal shaft fracture with intact skin and no soft tissue injuries, which was an indication of open reduction and internal fixation by mini-plate and screws, to prevent and minimize infection. However, in group B, seven patients had closed metacarpal shaft fracture and three patients had open (Gustillo 1) metacarpal shaft fracture, which were owing to direct injury.

Associated fractures
In group A, there were no cases with associated fractures, whereas in group B, four (20%) cases had associated fractures: one of them had ipsilateral proximal humeral fracture and fracture mid shaft left radius managed operatively, one had ipsilateral open distal tibia fracture managed by closed reduction and internal fixation by interlocking nail, one had dislocation of PIP joint of right middle finger, and one had right distal radius fracture.
Affected hand dominance
In this study, 12 patients had fractures in the left nondominant hand and eight patients had fractures in the right dominant hand.

These findings correlate with those of Absoud and Harrop [10], who reported that the nondominant hand was found to be injured slightly more frequently than the dominant one.

Regarding the number of fractured rays
In group A, seven (35%) patients had a single fractured metacarpal bone and three (15%) patients had multiple fractured metacarpals, with a total number of 13 fractured rays (mean±SD, 1.32±0.453).

In group B, four (20%) patients had a single fractured metacarpal bone and six (30%) patients had multiple fractured metacarpals, with a total number of 18 fractured rays (mean±SD, 1.83±0.736).

Fracture union
In this study, union was achieved in all cases in a period ranged from 6 weeks in young age patients with no associated comorbidities to 10 weeks in old patients as follows: in group A (mini-plate), where rigid fixation and early active motion and no associated fractures, five (25%) patients achieved union in 6 weeks, four (20%) patients in 8 weeks, and one (5%) patient in 10 weeks, who had diabetes and hypertension.

However, in group B (K-wires), there was no compression on the fracture and four cases had associated fractures: four (20%) patients achieved union in 6 weeks, five (25%) patients in 8 weeks, and one (5%) patient in 10 weeks. There were no cases reported with nonunion or malunion.

According to DASH score
We assessed the hand function 3 months postoperatively and when the patients finish physiotherapy by using Quick DASH score. Higher scores indicate a greater level of disability and severity, whereas lower scores indicate a lower level of disability. The mean score in group A was 3.184. A total of seven patients recorded score 0, with sound union and no deformity normal function; one patient recorded score 18.18 owing to tendon adherence which caused painful flexion of MCP joint; one patient recorded score 2.27; and one patient recorded score 4.54. However, in group B, the mean score was 13.406, four patients recorded score 0, two patients recorded score 9.09, one patient recorded score 75 owing to associated ipsilateral fracture proximal humerus and mid shaft radius, one patient recorded score 22.72, one patient recorded score 11.36, and one patient recorded score 6.8. All higher scores occurred in group B, which was fixed by K-wires owing to associated injuries and delayed active motion and hand exercises.

Regarding complications
In group A, only one (5%) case reported with tendon adherence which cause painful limited flexion. This patient was a 62-year-old female, who had a history of uncontrolled diabetes and hypertension. She was uncooperative in doing hand exercises immediate postoperatively and was advised to do intensive physical therapy with simple analgesic when needed. Her symptoms improved 2 months following the treatment, and full range of movement was restored.

In group B, three (15%) cases reported with joint stiffness. There were no cases reported with nonunion or malunion or serious complications like neurovascular injury, implant failure/plate breakage, deep seated infections, and heterotopic ossification.

Similar studies reported relatively high incidence of delayed union and nonunion with mini-plate fixation. Puckett et al. [11] reported a 4% incidence of delayed union and a 8% nonunion rate, whereas Page and Stern [12] reported a 4% incidence of delayed union and a 2% nonunion rate. In the study done by Puckett et al. [11], incidence of nonunion possibly related to extensive periosteal stripping.

Fusetti et al. [13] performed their research on complication rates after metacarpal plate fixation, and they reported that 15% of their patients had difficulty with fracture healing, 10% had stiffness, whereas 8% had plate loosening or breakage. Moreover, two patients had complex regional pain syndrome, and one patient developed deep infection.

The functional outcome of this method seems to be quite satisfactory. The results of mini-plate fixation for metacarpal fractures have been said to be favorable because of early hand exercises and active range of motion, as there was no need of postoperative splint, but in K-wires, patients need a postoperative splint and more time till full union and removal of the wires and then start rehabilitation.

In Pavlopoulos et al. [14], up to 90% of normal range of motion has been achieved in their study of treatment of
metacarpal and phalangeal fractures using K-wiring, and their method is simple, minimally invasive, well tolerated, and stable. It is low cost and does not obstruct joint mobility. K-wires can be removed easily.

Conclusion
Mini-plate fixation was more stable and allows the straightaway motion of the finger, which was conducive to reduce the complications and help fracture healing, whereas K-wire fixation was simple to manipulate and without or with little damage on fracture blood supply, and has been used more frequently nowadays. In K-wire fixation, there was no compression on the fracture, and it was difficult to control the motions of the fingers. This was not conducive to the early motions of the hand joints and is prone to cause complications such as stiffness, and malunion, as well as delay of fracture healing. In the present study, mini-plate showed advantages of lower infection rate, lower complication incidence, and shorter healing time compared with the K-wire. However, the mini-plate also showed disadvantage of relatively difficult procedure and high costs and invasiveness. In addition, longer surgery time with mini-plate fixation than K-wire.

The mini-plate fixation is superior to K-wire fixation in the treatment of unstable metacarpal shaft fractures.

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Conflicts of interest
There are no conflicts of interest.

References