

## Plate and Screw Versus Intramedullary K Wire for Fixation of Unstable Metacarpal and Phalangeal Fractures

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### ABSTRACT

**Background:** Unstable metacarpal and phalangeal fractures represent more than one third fractures of the hand. The severe the trauma, the more grave the fracture that herald perfect management is needed.

**Objective:** Assessment of the clinical and radiological outcomes of metacarpal and proximal phalangeal fractures in patients who underwent open anatomic reduction and fixation with plate and screws or by intramedullary K wire fixation.

**Patients and Methods:** Twenty five patients with unstable metacarpal and phalangeal fractures were treated; in group I 12 male patients operated by plate and screw fixation and group II 13 male patients operated by intramedullary K wire fixation. For the two groups total active motion "TAM, DASH score, postoperative lateral angulation, loss of reduction and radiological healing were assessed.

**Results:** There was a non-significant difference between group I (Plate and screw fixation) and group II (Intramedullary nail fixation) as regard the follow-up period or association between loss of reduction and removal of hard ware ( $p>0.05$ ). Group I showed a significant increase in the mean values of surgery duration and TAM ( $p<0.05$ ), accompanied by a significant reduction in the mean values of DASH score, post-operative lateral angulation and radiological healing in comparison to those group II ( $p<0.01$ ).

**Conclusion:** The operative duration of plates and screws fixation was longer than that of K wire fixation, but it had perfect stability with early mobilization, therefore, when possible it is preferred to be the first line of choice in management of unstable metacarpal and proximal phalangeal bone fractures.

**Key Words:** Metacarpal – Phalangeal – Plate – Screw – K wire.

### INTRODUCTION

The fractures of the metacarpal and proximal phalangeal bones represent about 10% of all fractures, and more than one third of all hand fractures [1,2]. Metacarpal fracture may affect head, neck, shaft, and base of the metacarpal bone. The most common causes of these fractures are road traffic injury or machinery related trauma. In other way, fall, crush injury especially during sports, or twist-

ing injuries may result in these fractures [3-6]. Fracture of distal and middle phalangeal bones occurs less frequently than proximal phalanx [7].

The prognosis of metacarpal and proximal phalangeal fractures is dependent on the severity of injuries, and the perfection of the management [8]. It's reported that every 2mm shortening of metacarpal bones may lead to 8% loss of the power grip, and digital overlap during fist formation may be resulted from a trivial malrotation of metacarpals [3,9,10].

Conservative management of the stable hand fractures can be applied in most of these fractures. In the reverse way, the application of non-operative techniques can lead to unsatisfactory results in unstable hand fractures [5,6,11-13].

The management of unstable metacarpal and proximal phalangeal fractures varies greatly worldwide, due to resources unavailability, geographical, and social factors [7,14-16].

It's not uncommon for operative reduction and internal fixation of hand fractures [17]. These indications may be unstable fractures, displaced intraarticular fractures, compound fractures with tendons, nerves, vessels, ligaments injuries, fractures with segment loss, malunion/or nonunion with disability, during replantations, some cases of oblique or spiral hand fractures, comminuted hand fractures with or without segment loss of the bone, and closed multiple metacarpal fractures [18]. A lot of procedures may be applied like intramedullary K wires, or plate and screws, and external fixators [3,5,6,12,19].

The targets of management of these fractures are; 1- Maintaining of proper reduction, 2- Inhibition of malrotation, 3- Regaining of bone length, 4- Proper soft tissue handling, 5- and early starting of mobilization [3,7,12,19-21].

Finally, the reduction should be evaluated both in flexion and extension with assuring reduction stability. These will permit early movement that keep intrinsic muscles active [6,22,23].

The aim of this study was to assess the clinical and radiologic outcomes of patients with metacarpal, and proximal phalangeal fractures, who underwent open anatomic reduction and fixation with plate and screws in group I, and intramedullary K wire fixation in group II.

### PATIENTS AND METHODS

From April 2012 to July 2016, a total number of 25 patients with unstable metacarpal and phalangeal fractures were treated. Group I (Plate and screw fixation) consisted of 12 male patients with age ranged from 18 to 52 years, and the mean age was  $32 \pm 9.37$  year. The preoperative lateral angulation was  $52.5 \pm 16.15^\circ$ ; the shortening was  $1.67 \pm 2.42$ mm. The injury to surgery interval ranged from the same day (day one) to the day 22 with mean value of  $9.58 \pm 7.72$  days, ten cases with unstable metacarpal fractures in group I, and two cases with unstable proximal phalangeal fractures were included in this group. Regarding group II (Intramedullary K wire fixation) consisted of 13 male patients with age ranged from 20 to 50 years, and the mean age was  $34.9 \pm 10.65$  year. The preoperative lateral angulation was  $51.15 \pm 15.96^\circ$ ; the shortening was  $2.15 \pm 2.19$ mm. The injury to surgery interval ranged from the same day (day one) to the day 22 with mean value of  $7.54 \pm 7.43$  days, eleven cases with unstable metacarpal fractures included in group II, and two cases with unstable fracture proximal phalanx.

#### Methods:

This retrospective study design was approved by ethical committee of institutional review board (IRB) of Faculty of Medicine, Zagazig University. Written consents containing the details of operative and postoperative interventions with permission for pre and post-operative photography were taken from all patients included in this study.

#### Operative technique:

The operations were done under regional nerve block (infraclavicular, or interscalene), some cases were operated under general anesthesia. The use of tourniquet on the upper arm was routinely followed. In group I: The operative approach was through an incision on the radial edge of the first radial two metacarpals and ulnar rim of the ulnar (fifth) metacarpal. The third and fourth metacarpal bones were exposed by a longitudinal dorsal inci-

sion, after that, dissection, and retraction of the extensors was done. As regard fractures of proximal phalanges, dorsolateral incision was used to expose the fracture site, without aggressive dissection of soft tissues, and minimal periosteal elevation if needed to expose fracture site. Proper Reduction of the fracture was achieved and maintained using a reduction forceps or small K-wire. Next, internal fixation was carried out using appropriate Fixation of the fractured bones with a suitable plate according to the configuration of the fracture. Confirmation of the reduction and accuracy of the plate and screw sizes were assured through image intensifier. Skin and soft tissue closure without any drains was done. Elevation of the hand with complete rest with plaster of Paris splint was applied for 48 hours. Depending on the overall state of the patient, kind of fracture and fixation technique, active finger and metacarpophalangeal joint mobilization was started on the Third day postoperatively, or later.

In group II; closed reduction of the fractures was achieved in most of cases, then fixation with intramedullary K wires. Also Reduction of the fracture was confirmed under Image intensifier. In some cases of unstable metacarpal fractures, especially in open fracture, intramedullary K wire from the fracture site to pass through metacarpophalangeal joint, then reduction of the fracture was done. After that, introduction of the K wire through distal segment of the bone to pass the fracture site, to the proximal segment of the metacarpal bone, to be extruded at carpometacarpal joints to appear from the skin. This technique will preserve MP joint; with the part of the K wire outside the skin is at carpometacarpal junction [24].

Monitoring of the union of the fracture was confirmed by repeated X-rays, during the visits of follow-up. Other parameters like range of motion recorded in degrees and occurrence of complications. Physical therapy was carried out on an out-patient basis. The patients were evaluated clinically and radiologically. Active ROMs of all the joints of each finger in the involved hand were measured. Based on these same factors, the patients were allowed to use their hands in daily activities after the fourth postoperative week and in activities requiring force after the sixth week. DASH scoring was performed in all patients. The assessment of functional results was made on the basis of the criteria of the American Society for Surgery of the Hand, in which total active movement (TAM) of the digit (other than the thumb) is measured. TAM is defined as the total active 3 flexion range of metacarpophalangeal (MCP) and interphalangeal (IP) joints. The results were graded as follows:

TAM  $\geq 210^\circ$  as good, TAM of  $210-180^\circ$  as fair and TAM of  $<180^\circ$  as poor (normal TAM for fingers =  $260^\circ$ ). The complications were noted.

*Statistical analysis:*

Data were represented as mean  $\pm$  standard deviation (SD). Statistical analysis was performed using the 20.0 version of SPSS statistical software for windows. Independent student *t*-test was used in the comparison between two groups of patient. Pearson correlation was done to detect the association between the injury to surgery interval and each of DASH score, total active motion and radiological healing. Chi-Square tests were done to detect any association between the removal of hard ware and loss of reduction or dominant side lesion. *p*-values less than 0.05 were considered significant.

**RESULTS**

There was a non-significant difference between group I (Plate and screw fixation) and group II (Intramedullary nail fixation) regarding the mean values of follow-up period ( $13.33 \pm 5.28$ ,  $12.61 \pm 4.19$ ,  $p > 0.05$ ). Concerning plate and screw fixation (group I) (Figs. 1-4), showed a significant increase in the mean values of surgery duration ( $43.08 \pm 12.60$  min) and total active motion "TAM" ( $148.5 \pm 8.05^\circ$ ) when compared with that of intramedullary nail fixation (Figs. 5-7) "group II"

( $27.77 \pm 7.30$ ,  $p < 0.01$ ,  $137.64 \pm 12.38^\circ$   $p < 0.05$ , respectively), accompanied by a significant reduction in the mean values of DASH score ( $13.25 \pm 3.11$ ), postoperative lateral angulation ( $2.58 \pm 3.34^\circ$ ) and radiological healing ( $4.958 \pm 0.69$  week) in comparison to those of intramedullary nail fixation "group II" ( $27.77 \pm 7.30$ ,  $p < 0.05$ ,  $9.23 \pm 8.12^\circ$ ;  $p < 0.05$  and  $6.50 \pm 1.43$ ;  $p < 0.01$  respectively) (Table 1).

In both groups there was no significant association between loss of reduction and removal of hard ware ( $p > 0.05$ ), or between dominant side lesion and removal of hard ware ( $p > 0.05$ ). Moreover, no significant association could be detected between loss of reduction and dominant side lesion ( $p > 0.05$ ).

Table (1): Statistical analysis of Follow-up period (weeks), Surgery duration (min), DASH score, total active motion (TAM), postoperative lateral angulation (POLA), and radiological healing (weeks) in group I (Plate and screw fixation) and group II (intramedullary K wire fixation).

	Group I	Group II	<i>p</i> -value of tt
Follow-up period	$13.33 \pm 5.28$	$12.61 \pm 4.19$	0.709
Surgery duration	$43.08 \pm 12.60$	$27.77 \pm 7.30$	0.001
DASH score	$13.25 \pm 3.11$	$18.15 \pm 7.65$	0.049
TAM	$148.5 \pm 8.05$	$137.64 \pm 12.38$	0.017
POLA	$2.58 \pm 3.34$	$9.23 \pm 8.12$	0.015
Radiological healing (week)	$4.958 \pm 0.69$	$6.50 \pm 1.43$	0.003



Fig. (1): Preoperative, proximal phalangeal fracture of the 4<sup>th</sup> figure of left hand.



Fig. (2): Preoperative, X-ray of proximal phalangeal fracture of the 4<sup>th</sup> figure of left hand (2 views).



Fig. (3): Intraoperative, incision with plate and screws fixation of proximal phalangeal fracture of the 4<sup>th</sup> figure of left hand.



Fig. (4): Intensifier photo, Plate and screws fixation of proximal phalangeal fracture of the 4<sup>th</sup> figure of left hand.



Fig. (5): Post operative view of proximal phalangeal fracture of the 4<sup>th</sup> figure of left hand.



Fig. (6): Multiple fractures of metacarpal bone were fixed by intramedullary K wires.



Fig. (7): K wire fixation of the 5<sup>th</sup> metacarpal bone of the left hand.



Fig. (8): Intramedullary K wire fixation of the 4<sup>th</sup> and 5<sup>th</sup> metacarpal after anatomical reduction.



Fig. (9): Postoperative X-ray of 2 K wires fixation of fracture of 1<sup>st</sup> metacarpal of right hand.

## DISCUSSION

Metacarpal bones and phalanges are small bones; in spite of that the improper management of their unstable fractures is of bad impact on the whole patient satisfaction, quality of life, and daily patient's activity [25]. Strauch et al. [26] declared

by cadaveric study, that lag by about 7° of extensor tendon with each 2mm of shortening of metacarpals, and the angulation also affects the power grip and flexor digitorum function.

Closed reduction of the metacarpal and proximal phalangeal bones can be applied in the majority of cases, and then wrist and finger plaster immobilization would be attained in the intrinsic-plus or "clam-digger" situation (extended wrist in 30-40°, metacarpophalangeal joints is flexed in 80-90°, and full extension of interphalangeal joints) [3,5,6,27]. The drawbacks of these conservative policies are also serious, including poor stability, long recovery time, fracture displacement, and stiff joints [28,29].

The goal of management of fractures of metacarpal and proximal phalangeal bones is to attain painless range of motion in the affected finger in the shortest possible time. As well known, any elongation of the time of restriction of mobility of joints next to the deal with these fractures leads to stiffness of joints and loss of pliability of soft tissues [30,31].

Barr et al. [32] stated functional loss in approximately 77% of fingers with unstable metacarpal

and phalangeal fractures treated by closed reduction means.

A lot of open reduction and fixation procedures are available; nevertheless appropriate early physical therapy is the corner stone for achieving perfect outcomes [33]. Unfortunately, Intramedullary Kirschner wires are used more commonly in fixation of these fractures [6,11] due to simplicity of the procedure, easily availability in field of the operation, minimal time of consuming the operating room, and the lowest association with soft tissue trauma as it can be inserted percutaneously [5,34,35]. Percutaneous insertion of the K wire in a transverse, cross, or insertion intramedullary can be done easily. However, adhesions of the extensor tendons or even tendon ruptures can be happened [27]. Moreover, K wires cannot maintain acceptable biomechanical solidity and associated with complications like restricted joints motion and their stiffness [27].

Pin track infection and loosening of K wire, or migration of the pin can occur, because the end of the wires is kept outside the skin [36]. The delayed beginning of movement in the affected fingers can lead to stiff hand [6,37].

K-wire can maintain stability of the fractures if soft tissue is unharmed. Osteosynthesis by plates and screws in these unstable metacarpal and proximal phalangeal fractures provides proper anatomical reduction and stabilization with early active mobilization of nearby joints, and also reduction of edema, fibrosis and scar formation [38]. A lot of researches proved that, mini-plates and screws are superior in biomechanical stability over other manners of internal fixation in unstable hand fractures [39,40]. Plate and screws fixation can be used in comminuted metacarpal and phalangeal fractures [5,6,34,41].

Surgical fixation by single K-wire is very simple, however cannot avoid rotation and applies no proper impaction between both fracture ends, thus delaying fracture union. Besides, fixation by K-wire requires immobilization in plaster for a while with limitations of early mobilization [42]. In reverse way, plate fixation can prevent malrotation and fixation disruption with improvement of initial beginning of functional mobilization [43,44]. Early active and passive mobility can avoid intrinsic muscle stiffness. Material disappointment and irritation, nonunion, and infection also can be avoided with the merits of plate fixation [45,46].

Fujitani et al. [47] presented another idea in a comparative research between intramedullary nail

and plate fixation for unstable fractures neck of metacarpals and stated according to them, that the active range of motion of finger with intramedullary K wire fixation group was better than those in the plate group. They explained that results due to more fibrosis nearby the metacarpophalangeal joint, after a lot of soft tissue dissection during fixation of these fractures by plate and screws.

In a comparative study done by Ozer et al. [34] between intramedullary K wiring and fixation with plate and screw, they stated that, in spite of the similarity between the two groups in the clinical consequences, the shorter operative times, and no need for other surgery to remove the plates in the group of intramedullary K wires are of great value.

Agarwal and Pickfoed [43] studied the fixation of hand fractures with plate and screw of 11 metacarpal bones, 9 phalanges. They proved satisfactory results, with no failure of plate fixation. In the present study, only one case from 12 patients operated for fixation of metacarpal and proximal phalangeal fractures by plate and screws showed loss of reduction (success rate 91.6%). Only one case required hard ware removal, the time of fracture union was significantly lower than the union with K wire fixation, mean total active motion in affected fingers was  $148.5 \pm 8.05^\circ$ , with lower mean DASH score  $13.25 \pm 3.11$  points, and minimal postoperative angulation  $2.58 \pm 3.34^\circ$ .

As regard the management of transverse and oblique fractures of the shaft of metacarpal bones by percutaneous K wire intramedullary, this work was done by Yammine and Harvey, [48] they proved a good results, with good union power in spite of slight malunion with mean DASH score of 5.55 points (range 0.83-11.67 points). In this present study in 13 cases with intramedullary K wire fixation, the achieved results were (TAM of the affected fingers was  $137.64 \pm 12.38^\circ$ , DASH score was  $27.77 \pm 7.30$ , postoperative lateral angulation was  $9.23 \pm 8.12^\circ$ , time for union in weeks was  $6.50 \pm 1.43$ ).

Another study on forty cases of metacarpal fractures treated with plate and screws, revealed good stability with early permission of free mobility, all their patients returned to their preoperative activities, except one case required revision surgery. Minimal irritation of fixation material with dorsal application of the plates necessitates hard ware removal [49].

In other words, the disadvantages of the use of plate and screws may be tendon and other soft tissue irritation, or tendon rupture, and if stiffness

of fingers and nonunion occurred it will be so difficult to solve [50].

There is no agreement about the treatment of the fractures of metacarpal bone and proximal phalangeal bones, due to the nature of most studies being retrospective, and mixing between these 2 fractures in the same study. The solution may be with prospective multicenter researches with comparative studies and wide data base [5].

Other limitations were the narrow number of patients, without randomization, inclusion of different fractures of the metacarpals and proximal phalanges, the choice of the surgical procedure was dependent on the self-preference of the surgeon range, and finally the assessment of union radiologically was uneasy [51].

In conclusion, although the operative duration of plates and screws fixation was longer and being expensive than that of K wire fixation, it had perfect stability with early mobilization, So, it is preferred to be the first line of choice in management of unstable metacarpal and proximal phalangeal bone fractures.

*Conflict of interests:* The authors declare no Conflict of interests.

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