

*Research Article***Biodegradable plates versus Titanium miniplates fixation of phalangeal and metacarpal fractures****Ahmed M. Mohamed, Khaled M. Hassan and Hesham A. Eissa**

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Introduction

Hand fractures account for about 1.5% of all emergency room visits and 40% of upper extremity fractures⁽¹⁾. Most metacarpal and phalangeal fractures are treated conservatively, Oblique and spiral fractures are prone to malrotation so operative fixation could be necessary⁽²⁾. The most effective method for fixation of metacarpal and phalangeal fractures has not been established. Commonly used surgical techniques are Kirschner-wire, miniplate, and screw fixations⁽³⁾. Bioresorbable polymers such as PLA, poly glycolic acid (PGA) and poly caprolactone (PCL) are well known biocompatible materials, which could be tailored to lose their mechanical strength gradually, resorbing completely in the body after a period varying from a few months for PGA to a few years (1–3) for PCL⁽⁴⁾.

Patient & method

This study was a prospective randomized clinical study that was conducted in The Plastic Surgery department at El Minia University Hospital from March 2016 till December 2016. The study involved twenty patients who presented with metacarpal and phalangeal fractures, they were managed after approval of the faculty ethical committee. Both open & closed, metacarpal & phalangeal fractures were included in this study. Extremes of ages, associated neurovascular injury & severe comminuted fractures were excluded from our research. Patients were classified into 2 groups:

Group A: Hand fractures that will be managed by open reduction internal fixation by Titanium mini plates and screws, this group included 10 patients their age range from 26 to 69 years old.

Group B: Hand fractures that will be managed by open reduction internal fixation by biodegradable mini plates and

screws, this group included 10 patients their age range from 21 to 65 years old.

Operative technique:

- **Position**

We put the patient in the supine position on operating table with the arm extended over radio-lucent arm piece.

- **Anaesthesia**

All cases operated by local intravenous anaesthesia with local anesthetic agent (Lidocaine 2%) with double level tourniquet technique, with an additional mild sedation for few cases as they were irritable.

Pneumatic tourniquet after sleeve application

- **Approach and Incision**

They were exposed through a direct incision made on the radial border of the first and second metacarpals and ulnar border of the fifth metacarpal. The third and fourth metacarpals were exposed through a dorsal longitudinal incision between these bones.

- In general, it's better to expose the adjacent metacarpal fractures through a single approach through interdigital space aiming to decrease soft tissue dissection and so decrease incidence of adhesions.

Phalangeal fractures:

Phalanx was exposed through Dorsal midline or Dorso-Lateral skin incision.

Deep dissection was done either through tendon sparing (by retract tendon to one side or through tendon splitting (through the tendon)

The implant:

- a) **Low profile titanium mini-plates**

A 2mm titanium mini-plate was used in metacarpal fractures & 1.5 mm plate was used for phalangeal fractures.

- b) **Biodegradable implants**

After reduction of the fracture, an absorbable plate was put in warm water and

adopted over the fracture site, screw holes were created by an appropriate drill bit, the screws were then sonic inserted inside the holes that has been made in the bones.

After plate implantation, the extensor tendons were put back into place and the wound was closed in layers. A volar slab was applied postoperatively, with the metacarpophalangeal joints flexed at 70 and the interphalangeal joints at 0 (hand safe position). The patients were sent for examination by post-operative radiographs. The slab was maintained for 2 weeks until suture removal. Afterward, the patients were encouraged to commence active motions of the carpus, metacarpus, and fingers, but minimal loadbearing was delayed for another 2 weeks.

Intravenous antibiotics were used for 48 hours, followed by short course (3-4 days) of oral antibiotics. Plain x-ray done in the 1st and 3rd months to assess union. all patients were functionally evaluated according to Total active range of motion (TROM).

The patients were followed up till they achieved complete fracture healing and useful ROM of hand joint. Early active joints mobility was allowed as patient can tolerate pain.

Methods of statistical analysis:

Data were collected, revised, verified, coded, then entered PC for statistical analysis done by using SPSS statistical package version 20.

The following had been done:

Descriptive statistics:

- For qualitative data: number (N) and percentage (%)
- For quantitative data: mean (\bar{X}) and standard deviation (SD).
- Kolmogorov- Smirnov for normality test was used to differentiate between parametric data and non-parametric data.

Analytical statistics:

Normally distributed variables (parametric) between two study groups were analyzed using:

- Independent sample (t) test for analysis of quantitative variables.
- Chi-square (χ^2) for analysis of qualitative data.
- For all tests probability (p) was considered:
- Non-significant if ≥ 0.05
- Significant if < 0.05

Results

This study was a comparative study between 2 groups: group A which was managed by open reduction internal fixation by Titanium mini plates and screws while group B which was managed by open reduction internal fixation by biodegradable mini plates and screws.

Age:

This study included 20 patients. Age ranged between 21 and 69 years old with mean age = 38.9 ± 14.9 and 35.7 ± 13.1 years old for group A and B respectively.

Mechanism of injury

Mechanism of injury was fall on hand in 5 patients (50%), traffic accident in 4 patients (40%) and only one patient direct blow in group A while in group B, the mechanism was: fall on hand in 2 patients (20%), traffic accident in 4 patients (40%) and direct blow in 4 patients (40%).

Affected ray

In group A, second ray was affected in 3 patients (30%), 3rd ray in 2 patients (20%), 4th ray in 2 patients (20%) and 5th ray in 3 patients (30%) while in group B first ray was affected in 2 patients (20%), 2nd ray in one patient only (10%), 3rd ray in 2 patients (20%), 4th ray in patient (10%) and 4 patients (40%) with 5th ray affection .

Site of fracture

Group A included 7 patients (70%) with metacarpal bone fractures and 3 patients (30%) with proximal phalanx fracture while group B included 8 patients (80%) with metacarpal bone fractures and 2 patients (20%) with proximal phalanx fracture.

Type of fracture

Oblique fracture (occurred) in most cases (5 patients) 50% in group A then transverse fracture in 4 patients (40%) and only one

patient with spiral fracture (10%) in group A while in group B oblique fracture occurred in 2 patients (20%), transverse fracture in 4 patients (40%), spiral fracture in 2 patients (20%) and comminuted fracture in 2 patients (20%).

Operative time

Operative time in group A was 55 ± 19.4 minutes while in group B, it was 84.5 ± 21.2 minutes.

Post-operative total range of motion (TROM)

In group A, total range of motion was 234 ± 15.05 while in group B, it was 133 ± 17.02 degree measured by goniometer.

Reduction of fracture

Group A included 6 patients (60%) with anatomic reduction of fracture and 4 patients (40%) with satisfactory reduction while group B included 7 patients (70%) with anatomic reduction and 3 patients (30%) with satisfactory reduction.

Callus formation

Callus formation was normal in 7 patients (70%) in group A and abundant in 3 patients (30%) while in group B, there was no patients with normal callus formation and all 10 patients had abundant callus formation.

Percentage of total range of motion (TROM)

In group A, the mean TROM was 234 ± 15.05 while in group B, it was 133 ± 17.02 .

In group A, percentage of TROM was $89.6 \pm 6.02\%$ while in group B, it was $50.7 \pm 6.3\%$.

Time till union

In group A, time for union = 7.5 ± 1.7 weeks while in group B no union occurred.

Complications

In group A, one case (10% of cases) was complicated with delayed union and another case of infection (10% of cases), while in group B all cases were complicated with non-union and fracture displacement which forced us to replace with K-wire fixation.

Case 1

Male patient 25 years old presented with fall on hand. Fracture 2nd metacarpal was managed by ORIF by Titanium plates and screws



Pre-operative x-ray



Post-operative x-ray



Follow up photo and x-ray 6 months later

Discussion

This study compares between 2 groups: group A was managed by open reduction internal fixation by Titanium mini plates and screws while group B was managed by open reduction internal fixation by biodegradable mini plates and screws.

This study included 20 patients. The relatively small number of patients could be considered a limitation of this study this was because of the limited availability of biodegradable plates and their very expensive prices. Age ranged between 21 and 69 years old with mean age = 38.9 ± 14.9 and 35.7 ± 13.1 years old for group A and B respectively. Group A included 7 male patients (70%) and 3 female (30%) patients while group B included 6 male patients (60%) and 4 female patients (40%).

Lee, Kim & Choy, 2013 evaluated the use of retrograde percutaneous intramedullary multiple Kirschner wire (K-wire) fixation, for the treatment of unstable displaced metacarpal neck or shaft fractures.

The study included 56 patients (65 metacarpal fractures) comprising 48 men and 8 women, with a mean age of 24 years (range 15–74 years), and all were right handed. The little finger was the most commonly affected (31 cases), followed by the ring finger (17 cases), middle finger (11 cases), and index finger (6 cases). The dominant hand was affected in 48 patients.

Mechanism of injury in Group A was fall on hand in 5 patients (50%), traffic accident in 4 patients (40%) and direct blow in only 1 patient (10%) while in Group B included

fall on hand in 2 patients (20%), traffic accident in 4 patients (40%) and direct blow in 4 patients (40%).

Type of fracture in Group A was oblique 5 in patients (50%), transverse fracture 4 patients (40%), spiral fracture in 1 patient (10%) and no comminuted fracture while in group B oblique fracture in 2 patients (20%), transverse fracture in 4 patients (40%), spiral fracture in 2 patients (20%) and comminuted fracture in 2 patients (20%).

Group A included 3 patients with affected 2nd ray fracture (20%), 2 patients with 3rd ray fracture (30%), 2 patients with 4th ray fracture (40%) and 3 patients with 5th ray fracture (30%) while group B included 2 patients with affected 1st ray fracture (10%), 1 patient with 2nd ray fracture (10%), 2 patients with 3rd ray fracture (20%), 1 patient with 4th ray (10%) and 4 patients with 5th ray fracture (40%)

Group A included 7 patients (70%) with metacarpal bone fractures and 3 patients (30%) with proximal phalanx fracture while group B included 8 patients (80%) with metacarpal bone fractures and 2 patients (20%) with proximal phalanx fracture

Operative time in this study was: in group A = 50 ± 15.4 minutes while in group B = 42.5 ± 7.9 minutes. The total tourniquet time (for hand fracture fixation) in group A, ranged from 30 to 70 minutes (with mean 49 ± 15.7 minutes) while in group B, it ranged from 35 to 55 minutes (with mean 41.5 ± 6.6 minutes).

Comparison between this study and Xiong et al.,

	(Xiong et al., 2015)	Group B in this study
No. of patients	5	10
Age	24.1 ± 2.7	35.7 ± 13.1
Mechanism of injury	Direct blow, fall on hand and motor accident	The same
Affected ray	4 th and 5 th	All
Time from injury till operation time	10.6 ± 6.9	2.5 ± 1.5
Follow up time (months)	4.2 ± 0.8	4.4 ± 0.5
Bone healing time (weeks)	7.6 ± 0.8	Non union
Post-operative TROM	84.4 ± 8.5	133 ± 17.02

Compare this results with other published articles, Berman et al, 1999, study included 16 patient with 16 phalangeal fractures with TROM (180° - $>220^\circ$), 15 patient (93.7%) had excellent to good range of motion, and one had poor result, without assessment of functional outcome by any method and the study include only phalangeal fractures with small sample number.

The current study recommends low profile implant over the other implants to decrease the complications. Pun et al., 1991 using stainless steel miniplates with high profile in 69 patients, had poor results TROM $<180^\circ$, 47% of phalangeal fractures and 75% of metacarpal fractures most probably this type of implant affect gliding tendon mechanism and more prominent.

The use of screws or screws and plates in metacarpal and phalange fractures provides a rigid, secure and reliable fixation. Biomechanical studies by Massengil et al., Vanik et al., and Mann et al., showed that Kirschner-wire fixation methods produced weaker fixation than did miniature plates and screws.

Because the K-wire technique was best suited for a transverse fracture, we decided to study the clinical applicability of miniplate for a more diverse group of fractures. The initial concern was that the anatomical dissection would involve too much tissue and that gliding layers would be adversely affected.

Conclusion

In conclusion, this series of metacarpal and phalangeal fractures treated with titanium vs. biodegradable plates and screws (group A), favorable outcomes should be expected, and this type of fixation could be a good indication for this

subgroup of fractures. The stable bony construct achievable by using titanium plates and screws (group A) is the key to good functional results but the results was bad by using biodegradable plates and screws (group B). Further work is required on biodegradable plating system. Alternative biodegradable system may be tried in a later study.

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