Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://doi.org/10.21608/zumj.2022.133339.2552 Volume 30, Issue 2, March 2024
Manuscript ID ZUMJ-2204-2552 (R1)
DOI 10.21608/ZUMJ.2022.133339.2552

ORIGINAL ARTICLE

Functional and Radiological Outcome of Osteosynthesis with Mini-plate and Screws in Metacarpal Fractures

Tarek A. EL-Hewala[1] , Omar A. Kelani [1], Haron O. Mosbah[2] , Mohammed A. Abdelrazek[1]
Orthopedic Surgery Department, Faculty of Medicine, Zagazig University, Egypt[1]
Orthopedic Surgery Department, Faculty of Medicine, Gharyan University, Libya[2]

Corresponding author:
Haron O. Mosbah

Email:
dr.haroon1982hom@gmail.com

Submit Date	**2022-04-13**
Revise Date	**2022-05-09**
Accept Date	**2022-05-10**

ABSTRACT

Background: Metacarpal fractures represent about one-third of all hand fractures. The principles of fracture management are to restore full hand function and minimizing additional soft tissue injury. Our study aimed to evaluate the functional and radiological outcome of metacarpal fractures, treated by open reduction and internal fixation using mini-plate and screws.

Methods: A prospective cohort study included 12 patients with metacarpal fracture were operated at Orthopedic Surgery Department, Zagazig University Hospitals. All patients were managed by open reduction internal fixation (ORIF) and fixed using mini-plates and mini-screws and were evaluated both clinically and radiologically. The functional outcome was evaluated by TAM score and Quick DASH score.

Results: The mean patient's age was 35.67 ±10.16 years ranged from 27-69 years. According to AO/OTA classification the most common fractures were 77.3.4.2C followed by 77.1.1C and 77.4.2A by 16.7% for each one. The mean TAM score was 230.3 ± 39.1 ranged from 125 to 255. 83.4% of patients were satisfied. According to Quick DASH score, 25% of patients (3 patients) were unsatisfied, two of three were had fair and one had poor satisfaction, while about 75% were satisfied. Most of the studied group had grip strength between 80 and 89% in compare to the contra-lateral side. While 4 patients had grip strength more than 90% in compare to the normal hand and one patient had grip strength < 70%.

Conclusion: Plate osteosynthesis is an excellent choice for treatment of metacarpal bone fractures. Fixation of metacarpal fractures by mini-plate and screws lead to anatomical reduction of fractures with stabilization that is rigid enough to allow early mobilization and preventing stiffness with good functional outcome.

Keywords: Metacarpal Fractures, Plate osteosynthesis, Screws

INTRODUCTION

Hand fractures represent 10% of all fractures and fracture metacarpals represent about 1/3 of hand fractures [1]. Most metacarpal fractures occur in active working population, and young adults. These fractures usually result from direct hit over the dorsum of the hand as in assault, boxing, fall, road traffic accident, crouch injuries and industrial trauma [2]. Metacarpal shaft fractures can be described as transvers, short oblique, spiral and comminuted. The correction of shortening dorsal angulation and rotation are the main objectives for treatment of displaced metacarpal shaft fractures [3].

Metacarpal fractures usually are presented by pain, swelling, bruises at trauma site, restriction of movement of carpometacarpal and metacarpophalangeal joints, proper management of metacarpal fractures is of utmost important as any complication can result in functional handicap [4].

Metacarpal fractures can be treated by various methods that range from conservative treatment by close reduction and casting/slap, to closed reduction and percutaneous pinning to external fixation or open reduction and internal fixation with plate and screws or with screws alone [5].

Open reduction and internal fixation is indicated in displaced intraarticular fractures, polytrauma, unstable fracture pattern, rotational deformity, segmental bone loss and multiple hand or wrist fractures [6].

In multiple metacarpal fractures there are chances of shorting causing instability [7]. Instability is more commonly seen in second and fifth metacarpal than in third and fourth metacarpal, as

the later are attached to both the sides of metacarpal head [8]. Multiple metacarpal fractures are usually associated with soft tissue injuries, compared with single metacarpal fracture, hence mini-plate ostheosynthesis will help in anatomical reduction and stable fixation to prevent stiffness and early return to work [9]. This study aimed to evaluate the functional and radiological outcome of metacarpal fractures, treated by open reduction and internal fixation by using mini-plate and screws.

METHODS

This prospective cohort study included 12 patients with metacarpal fracture operated at Orthopedic Surgery Department of Zagazig University Hospitals from February 2021 to August 2021. Patients were surgically managed by open reduction internal fixation (ORIF) using mini-plates and mini-screws and evaluated both clinically and radiologically. Institutional Review Board (IRB) approval and also informed written consent was taken from all patient**s.** This Work was performed according to the code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria: Adult patients with single and multiple closed metacarpal fracture according to AO/OTA classification 77. Intra articular metacarpal fractures were include in the study.

Exclusion criteria: Infection at site of operation, pathological fracture, osteoporotic and rheumatoid hand and open fracture were excluded.

Clinical data and examination:

Full history taking including personal data and fracture data as mode of trauma, duration from injury, presence of wounds, associated injuries, first aid and any medications received. The patients were examined for associated injuries. Documentation of sensory affection by pin prick test and vascularity refill test was done.

Clinical Investigations:

Laboratory data including complete blood count (CBC), pro-thrombin time (PT), pro-thrombin concentration (PC), INR, kidney function tests and liver function tests were done for all patients preoperatively. X rays of the hand (AP lateral and oblique views) were done for all metacarpal fractures. CT scan was done for intra-articular fractures.

Operative data:

The operations were carried out under general anesthesia**.** All patients received a single shot of a 3rd generation cephalosporin (Cefotriaxone 1 gm I.v.) during induction of anesthesia before application of the tourniquet. All patients were operated in a supine position with the injured upper limb placed on a side table perpendicular to the patient's body. Skin preparation and draping with sterile cloth and betadine was done. Well-padded tourniquet was applied to the arm to clear the field of surgery. The tourniquet was inflated after draping of the hand 100 mmHg above the systolic blood pressure of the patient. All surgeries were done under fluoroscopic guidance.

Surgical technique:

For fracture of the shaft of the first metacarpal, a dorso-lateral incision was done to expose the fracture while for fractures of the second and fifth Metacarpals, dorso-radial and dorso-ulnar longitudinal incisions were done respectively with a curve at the distal or proximal end. For fractures of the third and fourth metacarpals, a longitudinal incision for these two bones was done, and also for internal fixation of combination of metacarpals when several bones were involved. Incision was placed between the metacarpal rays and extended distally or proximally by a Y-shaped prolongation. After bone exposure the fracture was opened, and the fracture bone ends were reduced to anatomical position and maintained by reduction clamps or towel forceps.

Drilling and tapping using 1.5mm drill bit and 2mm tap were done. The fracture was then internally fixed with mini-set plate and 2mm screws. 2.00 mm mini-fragment plates; plate configuration was chosen according to the fracture pattern (straight plate for shaft fractures, T and L configured for peri-articular fractures) and then was fixed with mini screws. Mal-rotation was excluded by closing fingers to make a fist as the fingers should point towards the scaphoid tubercle, whilst in extension; the nails should be almost parallel.

The implant was covered with the periosteum as far as possible; this helps to minimize contact between the extensor tendons and the implant. Wounds were closed in layers. Vicryl 2/0 was used for subcutaneous tissues and prolene or monocryl 2/0 was used for skin closure.

Postoperative measures:

The hand was kept elevated for 24-48 hours postoperatively to minimize edema. A single shot of a 3rd generation cephalosporin (Cefotriaxone 1 gm i.v.)Was given to all patients postoperatively then shifted to an oral broad spectrum antibiotic for 1 week and analgesic were given. Volar splint was used postoperatively with the wrist in slight extension and metacarpo-phalangeal joint and interphalangeal joints in slight flexion for 2 weeks.

Follow-up:

The follow up period was 6 months. The patients were followed up at Orthopedic Surgery Department of Zagazig University Hospitals and

in Burn and Plastic surgery Hospital Tripoli - Libya outpatient clinic at 2weeks, 4 weeks, 6 weeks, 8weeks, 3 months and 6 months postoperative for:

Total Active Motion (TAM) Score:

TAM values were established by using a hand goniometer. In order to do so, the ranges of motion of the fractured phalanges in the metacarpophalangeal joint (normal range: 0-85 °), proximal interphalangeal joint (normal range: 0-110 °) and distal interphalangeal joint (normal range: 0-65 °) were measured and added up. A sum between 260-220° was classified as excellent; one between 219-180° as good; one between 179-130° as moderate, and one below 130° as poor [10].

Quick DASH score:

Quick DASH scoring was utilized for the subjective assessment of the patients. It directs 11 questions to the patients about difficulties in daily activities, limitations in work and social life, and pain. Similar to the DASH, each item has five response options: 1 = no difficulty, 2 = mild difficulty, 3 = moderate difficulty, 4 = sever difficulty, 5 = unable. The responses are scored, with a higher overall score indicating a worse outcome [11].

Grip strength:

The grip strength had been measured using a dynamometer (Jamar, Preston, USA). Technique of grip strength measurement is to hold the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer is adjusted, and the base should rest on first metacarpal (heel of the palm) while the handle should rest on middle of four fingers. When ready the patient squeezes the dynamometer with the maximum isometric force which is maintained for about 5 seconds. Three attempts were made, fifteen seconds apart between each trial. The mean of these attempts was calculated. Before each trial the dynamometer was adjusted to zero to get the actual reading. The other hand was tested with the same technique [12].

Statistical analysis:

Data analyzed using Microsoft Excel software then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance; difference and association of qualitative variable by Chi square test (X2). Differences between quantitative independent groups by t test. P value was set at <0.05 for significant results & <0.001 for high significant result.

RESULTS

The mean patient's age was 35.67 ±10.16, years ranged from 27-69 years. Male represented 83.3% of the patients. Most of the patients (66.7%) had right side injury. And 75% of patients had the injury on the dominant hand. The leading cause of fracture was RTA by (41.6%), followed by heavy object trauma (25%), while fight and fall on out stretched hand (FOOSH) each one had cause fracture in 16.7% of patients. 66.7% of patients had fracture in single metacarpal bone and the most affected MCB was the 4th, followed by 5th MCB **(Table 1)**. About 58.6% of patient's fractures united within 6 weeks, while only 2 patients have complete union within 9 to 10 weeks. Only one case needed 14 weeks after the fracture to return to work. While rest of patients 58.4% returned to work between 8-10 weeks **(Table 2)**.

Most of the studied group had grip power between 80 and 89% (58.3%) in compare to the contra-lateral side. While 4 patients (33.4%) had grip strength more than 90% in comparison to the normal hand, while one patient (8.3%) had grip strength < 70% **(Table 3)**.

The mean of TAM score was 230.3 ± 39.1 with most of patients (83.4%) were satisfied at the end of follow-up. The mean of Quick DASH score was 17.5 ± 9.7 with half of patients had no difficulty, mild (25%), moderate (16.7%) and sever difficulty (8.3%) **(Table 4)**. Only 3 patients of the studied group had complications including chronic pain, stiffness and SSI **(Table 5)**.

Table (1): Demographic distribution among the studied group

Variable	The studied group (12)	
Mean Age(years): mean ± SD (Range)	**35.67±10.16 (27-69)**	
Variable	**NO(12)**	**%**
Age grouping		
20-29 years	**4**	**33.3%**
30-39 years	**4**	**33.3%**
40-60 years	**4**	**33.4%**

Variable		The studied group (12)	
Gender Male Female		10 2	83.3% 16.7%
Side affected	Right Left	8 4	66.7% 33.3%
Dominancy	Dominant hand Non-dominant hand	9 3	75% 25%
Mechanism of injury Heavy object RTA Fight FOOSH		3 5 2 2	25% 41.6% 16.7% 16.7%
The affected MCB 1st 2nd 3rd 4th 5th		2 3 2 3 2	16.7% 25% 16.7% 41.6% 33.3%
Site of fracture Single MCB Multiple MCB		8 4	66.7% 33.3%

Table (2): Union time and time to return to work among the studied group

Variable	NO(12)	%
Union time (weeks) 5-6 weeks 7-8 weeks 9-10 weeks	 7 3 2	 58.4% 25% 16.7%
Time to return to work (weeks) 8-10 weeks 11-14 weeks	 11 1	 91.7% 8.3%

Table (3): Grip power measurements among the studied group

Variable	NO(12)	%
Grip Power(compared to the contra-lateral side) 90-100% 80-89% <70%	4 7 1	33.4% 58.3% 8.3%

Table (4): Final outcome according to TAM and Quick DASH score among the studied group

Final outcome	The studied group(18) Mean ± SD (Range)		
TAM score	230.3 ± 39.1 (125-255)		
Quick DASH score	17.5 ± 9.7 (10-39)		
Final outcome	Variables	NO(12)	%
TAM score	Satisfactory	10	83.4%
	Unsatisfactory	2	16.6%
The Quick DASH score	10-11 (No difficulty)	6	50%

Final outcome	The studied group(18) Mean ± SD (Range)		
	12-22(mild difficulty)	3	25%
	23-33(moderate difficulty)	2	16.7%
	34-44(sever difficulty)	1	8.3%

Table (5): Complication distribution among the studied group

Complications	NO (12)	%
Chronic pain	1	8.34%
Stiffness	1	8.34%
SSI	1	8.34%
Non- Complicated	9	75%
Total	12	100

(a)

(b)

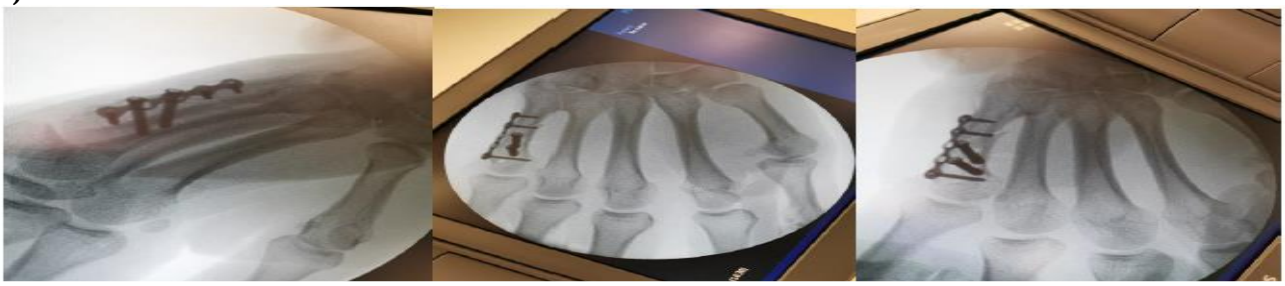

Figure (1): A case of 39 years old male, patient presented with fracture 5th metacarpal. AO Classification: 77.5.2A. History of trauma by Heavy object in his right hand. The patient was treated by open reduction and internal fixation by mini-fragment plates and screws. (a) Preoperative x-rays showing fracture of 5th metacarpal, (b): Intra-operative x-rays showing fracture 5th metacarpal

(a)

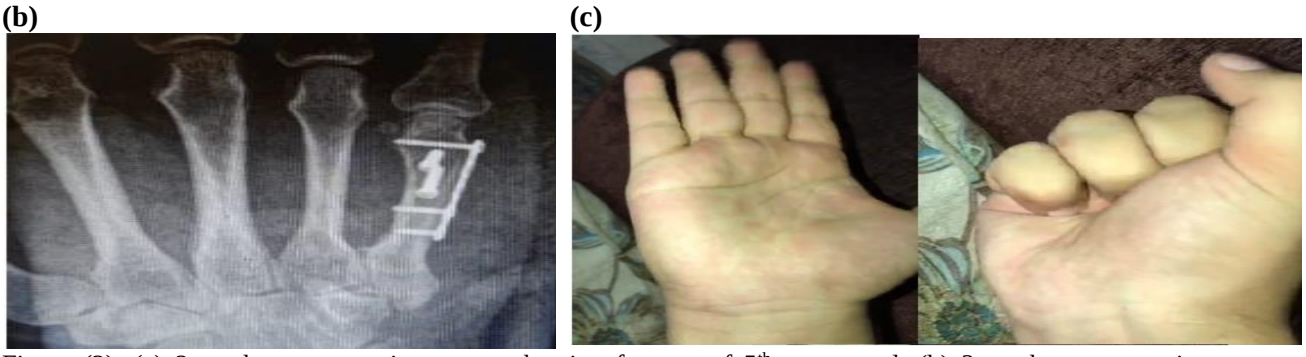

Figure (2): (a) 2 weeks postoperative x-rays showing fracture of 5th metacarpal, (b) 3months postoperative x-rays showing fracture of 5th metacarpal with complete union, (c) 3months follow up showing excellent outcomes.

DISCUSSION

Fracture fixation of long bones has been changed to the point where there is an emphasis on rigid fixation with early functional use without external cast immobilization. A corresponding shift arose in the treatment of fractures of the small bones of the hand **[13]**.

The main management of metacarpal shaft fractures depends largely on the stability and fracture configuration **[14]**. Non-displaced fractures with any configuration can be managed by conservative method with a slab or splint immobilizing the wrist in extension and metacarpo-phalangeal joint in flexion more than 70 degrees, allowing early interphalangeal mobilization, thus minimizing hand stiffness **[15]**.

Many surgical options have been described to treat unstable and displaced metacarpal shaft fractures **[16].** Options include; open reduction internal fixation, Kirschner (K-) wire fixation, tension band suture fixation, external fixators and cerclage wiring **[17].** Described methods for percutaneous pinning (PCP) with K-wires include antegrade and retrograde intramedullary placement, locking techniques, the bouquet osteosynthesis (multiple intramedullary pinning) and transverse pinning to adjacent metacarpals **[18].**

In this study the age ranged from 27-69 years, with mean age 35.67 ±10.16, years. 66.7% of them were below age of 40 years.This was comparable with **Abdelhady et al.** who had the same mean age (35 years) and according to TAM score only 10% (2 patients had unsatisfactory outcome, while 90% of the patients has satisfactory results **[19]**.

Also **Bissar et al** observed that among the plate fixation group the age range was the same of this study (19 to 55 years) and documented that the Quick DASH score was excellent in 10 cases, good in 3 cases, fair in 1 case and poor in 1 case **[20].**

In this study the mean union time was 7 weeks ranged from 5 to 10 weeks. It has been noted that 58.3% of patient's fractures united before the end of the 6th week, while only 2 patients have fractures need more than eight weeks for complete union **[21].** This was comparable with **Elnaffad et al.** who documented that the mean union time of the internal fixation group was 6.43 weeks **[22].** Also, **Shah et al.** reported that 7 patients (23.3%) showed union in 6 weeks. 18 Patients (60%) had union in 4 weeks. 3 patients (10%) had at five weeks and 2 patients had union at 6 weeks **[23]. Kastanisg et al.** also reported that average union time was 5.8 weeks (range from 4,2 to 8,5 weeks) **[24].**

In the current study, only 3 patients of the studied group had complications including chronic pain, stiffness and SSI.

This was comparable with **Soni et al.** who treated 21 patients with MCB fractures and documented that the complications was occurred in 5 patients (23.8%) the complications were deep infection in two patients and Superficial infection was seen in three patients **[7].** Also **Sundaram et al.** noted that three cases with delayed union and two cases of infection, one had superficial infection while the other had deep infection **[9]. Abdelhady et al.** documented that only one patient had wound complication (keloid) without any affection on hand functions **[19].**

CONCLUSION

Plate osteosynthesis is an excellent choice for treatment of in metacarpal bone fractures. Fixation of metacarpal fractures by mini-plate and screws lead to anatomical reduction of fractures with stabilization that is rigid enough to allow early mobilization and preventing stiffness with good functional outcome.

REFERENCES

1. McNemar TB, Howell JW, Chang E. Management of metacarpal fractures. J Hand Ther. 2003; 16(2):143–51.

2. Souer JS, Mudgal CS. Plate fixation in closed ipsilateral multiple metacarpal fractures. J Hand Surg. (European Vol. 2008; 33(6):740–4.
3. Al-Madawy AM, Abou Elatta MM, Hasanin MM, Al-Nahal AAE-K. The use of minilocked plate for management of unstable metacarpal fractures. J Hand Microsurg. 2016;8(3):159.
4. James JIP. Fractures of the proximal and middle phalanges of the fingers. Acta Orthop Scand. 1962; 32(1–4):401–12.
5. Black D, Mann RJ, Constine R, Daniels AU. Comparison of internal fixation techniques in metacarpal fractures. J Hand Surg Am. 1985;10(4):466–72.
6. Stern PJ. Management of fractures of the hand over the last 25 years. J Hand Surg [Am]. 2000;25:817–23.
7. Meunier MJ, Hentzen E, Ryan M, Shin AY, Lieber RL. Predicted effects of metacarpal shortening on interosseous muscle function. J Hand Surg Am. 2004;29(4):689–93.
8. Freeland AE, Orbay JL. Extraarticular hand fractures in adults: a review of new developments. Clin Orthop Relat Res. 2006;445:133–45.
9. Sundaram GT. Functional outcome of min implants in closed metacarpal fractures. Int J Orthop. 2019;5(02):300–6.
10. Duncan RW, Freeland AE, Jabaley ME, Meydrech EF. Open hand fractures: an analysis of the recovery of active motion and of complications. J Hand Surg [Am] 1993; 18:387-94.
11. Barton NJ. Fractures of the shafts of the phalanges of the hand. Hand 1979; 11:119-133.
12. Bloem JJ. The treatment and prognosis of uncomplicated dislocated fractures of the metacarpals and phalanges. Arch chir neer landicum 1971; 23: 55-65.
13. Trampisch US, Franke J, Jedamzik N, Hinrichs T, Platen P. Optimal Jamar dynamometer handle position to assess maximal isometric hand grip strength in epidemiological studies. J Hand Surg. 2012, 37.11: 2368-73.
14. Meals C, Meals R. Hand fractures: a review of current treatment strategies. J hand surg. 2013; 38(5), 1021-31.
15. Al Shahat OA, Ismail YH, Kaseer A, Hasan M, El Genidy AS. Management of Metacarpal and Phalangeal Bone Fractures of the Hand. Egyp J Plast Reconstr Surg. 2018; 42(2), 405-9.
16. Meinberg EG, Agel J, Roberts CS, Karam MD, Kellam JF. Fracture and Dislocation Classification Compendium-2018. J Orthop Trauma. 32, S1-S10.
17. Kozin SH, Thoder JJ, Lieberman G. Operative treatment of metacarpal and phalangeal shaft fractures. J Am Acad Orthop Surg. 2000; 8 (2): 111-21.
18. Laugharne E, Bhavsar D, Rajaratnam V. The distribution of hand fractures: a British perspective. Eur J Plast Surg 2013; 36: 367-70.
19. Abdelhady Hossam, Zayed Faisal, Salah M. Functional results of osteosynthesis with mini-plate and screws in metacarpal shaft fractures. Al-Azhar Int Med J. 2020;1(2):280–3.
20. Bissar MM, Abulsoud MI, Mbbch MMA, Abdul-rahman MM. OPEN ORIGINAL Comparative Study Between Intramedullary K Wires Versus Mini-plates and. 2021;299–305.
21. Pearson RG, Clement RGE, Edwards KL, Scammell BE. Do smokers have greater risk of delayed and non-union after fracture, osteotomy and arthrodesis? A systematic review with meta-analysis. BMJ Open. 2016;6(11) e010303.
22. Elnaffad EE, Shouman OO, Salem AS, Zeina AM. Comparative study between different modalities for the management of metacarpal bone fractures. 2020;1(15):75–90.
23. Shah G, KC BR, Chand P, Sah DN. Functional outcome of Metacarpal Fracture managed with Miniplate and Screws. Janaki Med Coll J Med Sci. 2018;6(1):43–8.
24. Kastanis G. Fixation of unstable diaphyseal metacarpal fractures with low profile locking plates: Case series-Current concepts. J Med Sci Clin Res. 2021;09(10).

To cite

Mosbah, H., Elhewala, T., Kelany, O., Abdelrazek, M. Functional and Radiological Outcome of Osteosynthesis with Mini-plate and Screws in Metacarpal Fractures. *Zagazig University Medical Journal*, 2024; (506-512): -. doi: 10.21608/zumj.2022.133339.2552