The Egyptian Journal of Hospital Medicine (October 2022) Vol. 89 (2), Page 6160- 6166

Intramedullary Fixation of Metacarpal Fractures Using Headless Compression Screws

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ABSTRACT

Background: Metacarpal fractures represent about 1/3 of hand fracture, which represent 10% of all fractures, mostly in the second and third decades of life. The purpose of this study was to evaluate the functional, radiological outcomes and reducing rate of complications in patients suffering of metacarpal fractures, treated by closed reduction and internal fixation by using headless compression screws.

Patients and methods: This prospective one-arm clinical trial included 18 patients presented by a total of 20 metacarpal shaft fractures, who were managed surgically at Zagazig University Hospital (ZUH), Egypt. They were managed by intra medullary headless compression screws (IMHS).

Results: No cases had malunion and 3 cases had superficial skin infection by 16.6%. Regarding Total Active Motion (TAM) score, 83.4% of cases had satisfactory level, and 16.6% had unsatisfactory level.

Conclusion: Intramedullary screw fixation of metacarpal fractures is an efficient and safe procedure with a low incidence of complications. The IMH screws appeared to require less casting and provide a quicker return to work.

Keywords: Metacarpal fracture, Intramedullary fixation, Headless compression screw.

INTRODUCTION

The metacarpal bones are the longest, closest bones to the hand, and they give the phalanges a secure foundation. Its head is cam-shaped and articulates as a condylar joint with the base of the proximal phalanx to allow for flexion, extension, and radial and ulnar deviation. Its base articulates with the distal carpal row [(1)].

Hand fractures, which make up 10% of all fractures and are most common in the second and third decades of life, account for around one-third of all metacarpal fractures. It typically happens as a result of a direct blow to the hand's dorsum, as in an assault, a boxing match, a fall, a car accident, crush injuries, and workplace trauma. The most frequent metacarpal fractures were ring-finger shaft fractures and little finger neck fractures (Boxer's fractures) [(2)].

The majority of metacarpal fracture consequences are stiffness at the carpometacarpal and metacarpo-phalangeal joints and malunion, with surgery being an effective treatment for malunion that includes angulation, rotation, and shortening [(3)].

There is a potential of shorting in numerous metacarpal fractures, which could lead to instability. Since the latter are linked to both sides of the metacarpal head, instability is more frequently noted in the second and fifth metacarpals than the third and fourth. Compared to a single metacarpal fracture, multiple metacarpal fractures are typically accompanied by soft tissue damage [(4,5)].

Fixation of metacarpal fractures by intramedullary headless screws has many advantages as it placed percutaneously so minimal incision needed which reduce the infection risk, headless compression screws also offer stable fixation. They can be placed through the articular surface and, because of their small size and headless nature it can be buried in a sub-chondral location without interfering with joint motion. Also it provide a good results as **Beck *et al.*** [(6)] reported 100% of patients achieved full radiological union with minor complication rate and full range of motion and early return to work with average 96% of grip strength [(7,8)].

The purpose of this study was to evaluate the functional, radiological outcomes and reducing rate of complications in patients suffering of metacarpal fractures, treated by closed reduction and internal fixation by using headless compression screws.

PATIENTS AND METHODS

This prospective one-arm clinical trial included 18 patients presented by a total of 20 metacarpal shaft fractures, who were managed surgically at Zagazig University Hospital (ZUH) Egypt. They were managed by intra medullary headless compression screws (IMHS).

Inclusion criteria: Closed metacarpal fracture. Multiple metacarpal fractures in the same hand considered as single case.

Exclusion criteria included: Infection at site of operation. Sever osteoporotic. Sever comminuted fracture. Intra articular fracture. Skeletal immaturity. Neurovascular injuries.

Pre-operative:

All patients underwent Full history taking, Proper clinical examination, Routine plain radiographic images were obtained for all patients, which include anteroposterior (AP), and oblique views of the hand. In cases of phalangeal trauma, additional lateral views were obtained. X ray images were used to identify the site and shape of fractures and to evaluate their displacement and angulation. Metacarpal fracture was classified according to the morphological character.

Received: 30/06/2022
Accepted: 06/09/2022

Surgical technique:

All patients operated in supine position with the involved hand on a side table. Surgical operations in this study were carried out for 9 patients (50 %) undergoes to general anesthesia and 9 patients (50 %) had regional anesthesia by supra scapular nerve block. Intraoperative fluoroscopy (C- arm), (image intensifier guided) was used in all surgical operations in this study to confirm reduction and fixation of the fractures during surgery. The method of fixation were used in fixation of fractures in this study is a Retrograde IMHS.

Post-operative follow up:

- Patients left without cast.
- The wound was inspected regularly, sutures removed if the wound healed and physiotherapy commenced. Active motion of the entire hand was encouraged as soon as the postoperative splintage was removed.
- All patients followed every week during the first month.
- The use of the injured hand in activities of daily living was encouraged within the limits of pain. Heavy work was avoided until progress toward union was sufficient by radiological evidence.
- Activities started according to the situation.
- Total Active Motion (TAM) Score: Range of motion was evaluated using TAM score which is defined as the total range of motion achieved when all three joints metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) of a digit are actively flexed or extended simultaneously, minus any extension deficit at any of the three joints (Table 1).

Table (1): Total active movement (TAM) score normal values [9].

Normal		
Active	**Flexion**	**Extension lag**
Metacarpophalangeal (MCP) Proximal interphalangeal (PIP) Distal interphalangeal (DIP)	85º 110º 65º	0º 0º 0º
Totals	260º	0º
Total active motion (TAM) 260º – 0º = 260º		

Range of motion (ROM) of fingers with metacarpal treated by open reduction and internal fixation by mini- plates and screws, were assessed using goniometer six weeks after surgery and at final follow up (Figure 1).

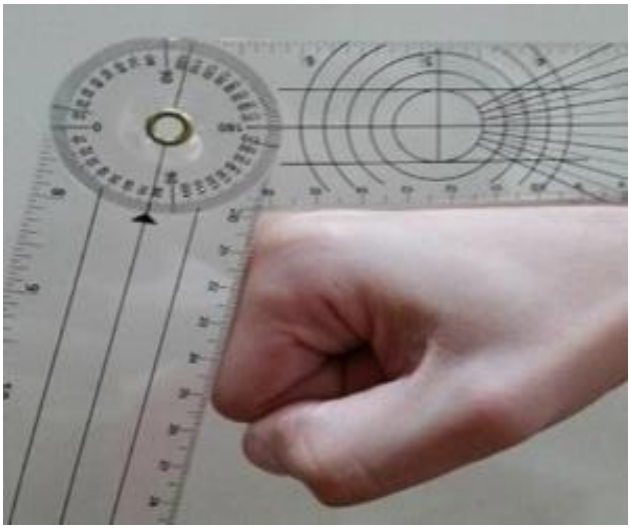

Figure (1): Goniometer used to measure part of range of motion at MCP joint.

- Quick DASH Score: Functional outcome was evaluated using Quick DASH score. The Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) is a thirty-item questionnaire that quantifies physical function and symptoms in persons with any or multiple musculoskeletal disorders of the upper limb. Quick DASH contains eleven items and is similar with regard to scores and properties to the full DASH (Figure 2).

- Functional outcome of the studied group of metacarpal fractures treated by either K wires or IMHS fixation, were assessed using a questionnaire six weeks after surgery and at final follow up. The assigned values for all completed responses are simply summed and averaged, producing a score out of five. This value is then transformed to a score out of 100 by subtracting one and multiplying by 25. This transformation is done to make the score easier to compare to other measures scaled on a 0-100 scale. A higher score indicates greater disability.

QuickDASH

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE
1. Open a tight or new jar.	1	2	3	4	5
2. Do heavy household chores (e.g., wash walls, floors).	1	2	3	4	5
3. Carry a shopping bag or briefcase.	1	2	3	4	5
4. Wash your back.	1	2	3	4	5
5. Use a knife to cut food.	1	2	3	4	5
6. Recreational activities in which you take some force or impact through your arm, shoulder or hand (e.g., golf, hammering, tennis, etc.).	1	2	3	4	5

	NOT AT ALL	SLIGHTLY	MODERATELY	QUITE A BIT	EXTREMELY
7. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
8. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	1	2	3	4	5

Please rate the severity of the following symptoms in the last week. *(circle number)*	NONE	MILD	MODERATE	SEVERE	EXTREME
9. Arm, shoulder or hand pain.	1	2	3	4	5
10. Tingling (pins and needles) in your arm, shoulder or hand.	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
11. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)*	1	2	3	4	5

QuickDASH DISABILITY/SYMPTOM SCORE = $\left(\left[\frac{\text{(sum of n responses)}}{n}\right] - 1\right) \times 25$, where n is equal to the number of completed responses.

A QuickDASH score may not be calculated if there is greater than 1 missing item.

Figure (2): Quick DASH questionnaire [(10)].

Ethical consent:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data collected and encoded using Microsoft Excel software. Data were then imported into Statistical Package for Social Sciences (SPSS version 20.0) software for analysis. Qualitative variables were presented in the form of frequencies and percentages, quantitative variables were presented in the form of means and standard deviations. Shapiro-Wilk test was used to determine if the data had a normal distribution. The normal distributed quantitative data were compared using Student's t-test. In contrast, the non-parametric data were analyzed by using Mann-Whitney. The Qualitative categorical variables were compared using Chi-square test. P value ≤ 0.05 was considered significant and <0.001 for high significant result.

RESULTS

Table 2 showed that all age groups are equal, as each age group had 6 patients. Most patients included in this study were males (77.8%) with only 2 (22.2%) females. Only 2 patients were diabetes and other patients had no comorbidities.

Table (2): Sociodemographic characteristics and past medical history of participants.

Variable	**The studied group (N 18) Mean ± SD (Range)**	
Mean Age (years):	34.88 ± 11.31	
(Range)	(20 - 65)	
Variable	**N. (18)**	**%**
Age grouping		
15-29 years	6	33.3%
30-39 years	6	33.3%
40-65 years	6	33.4%
Gender Male Female	 14 4	 77.7 % 22.3 %
Comorbidity Diabetes mellitus No comorbidity	 2 16	 88.2 % 11.8 %

Preoperative data:

Table 3 shows that 10 of patients affected in the right hand. Also 14 of the 18 fractures occurred in the dominant hand.

Table (3): Affected side among the studied patients.

Variable		**N. (18)**	**%**
Side of fracture	Right Left	10 8	55.5% 44.6%
Dominancy	Dominant hand Non-dominant hand	14 4	77.7% 23.3%

Table 4 summarizes the causes of fracture.

Table (4): Mechanism of injury distribution among the studied patients.

Variable	N. (18)	%
Mechanism of injury		
Direct trauma	8	44.4%
FOOSH	6	33.3%
Road Traffic Accident	4	22.2%

FOOSH: Fall On Out Stretched Hand

Table (5) shows that only one case needed 14 weeks after the fracture to return to work. While rest of patients 94.4% returned to work between 6 -8 weeks.

Table (5): Time to return to work among the studied group

Variable	NO(18)	t/ X^2	P
Period to return work in days	23.22±3.96	2.670	0.017*
Variable	**NO(18)**		**%**
Time to return to work (weeks)			
6 - 8 weeks	17		94.4%
11-14 weeks	1		5.5%

Table 6 shows that most of patients (83.4%) were satisfied according to TAM score, while 16.6% of the patients were unsatisfied according to TAM score at the end of follow-up.

Table (6): Outcome according to TAM and Quick DASH score among the studied patients.

Final outcome	The studied group (N. 18) Mean ± SD (Range)		
TAM score	230.3 ± 39.1 (125 - 255)		
Quick DASH score	17.5 ± 3.8 (10 - 39)		
Final outcome	Variables	N. (18)	%
TAM score	Satisfactory	15	83.4%
	Unsatisfactory	3	16.6%
Quick DASH score	10-11 (No difficulty)	9	50%
	12-22 (Mild difficulty)	5	25%
	23-33 (Moderate difficulty)	4	16.7%

Table 7 shows that only 6 patients of the studied group had complications including Stiffness, and superficial skin infection.

Table (7): Complications distribution among the studied group.

Complications	N. (18)	%
Malunion	0	0.0%
Stiffness	3	16.6%
Superficial infection	3	16.6%
No	12	66.6%
Total	18	100

DISCUSSION

This one-arm clinical trial aimed to evaluate the functional, radiological outcomes and reducing rate of complications in patients suffering of metacarpal fractures, treated by closed reduction and internal fixation by using headless compression screws.

Regarding the demographic data, the current results showed that the mean age was distributed as 34.88 (SD 11.31) in the participants; Males were majority.

Kibar *et al.* [11], reported in their study on 34 cases undergone intramedullary headless screws (IMHS) use for fixation of metacarpal fractures that the mean age was 33 years, 28 cases were males, and 6 cases were females.

Warrender *et al.*[12], in their study on 150 cases undergone intramedullary headless compression screw fixation of metacarpal fractures reported that the mean age was 29 years, 123 cases were males, and 27 cases were females.

Regarding a preoperative data the IMHS group, the mean trauma surgery interval days was 1.33±0.45 days, while 8 cases had left hand fractures. 77.7% of fractures were in the dominant hand. As for the site of metacarpal bone, 4 cases for each 2nd and 4th metacarpus, 2 case with 3rd, 7 cases with 5th, and one cases had fracture in the 2nd, 3rd, and 4th. So, 17 cases had single bone fracture, and one case had three bones fracture. With respect to the type of fracture, 55.5% of cases had transverse fractures, and both oblique and spiral were represented equally in 22.2%. Respecting the cause of trauma, 8 cases had direct trauma, 6 cases had fall down, 4 cases had RTA. All cases did not have other skeletal injury.

Kibar *et al.* [11], reported in their study on 34 cases undergone intramedullary headless screws (IMHS) use for fixation of metacarpal fractures that regarding the involved digit, 17 cases with the small digit, 10 cases with ring digit, 6 cases with the middle digit, 3 cases with multiple metacarpal fractures, and 4 cases with index digit. 21 cases had fractures in the dominant hand, 23 cases had fractures in the right hand, and 11 cases had fractures in the left hand. The mechanism of injury was fall in 16 cases, punch and external force in one case for each, road accident in 4 cases, sport injury in 5 cases, and work accident in 7 cases. Concerning the fracture configuration, 7 cases had transverse fracture, 25 cases with spiral/oblique **[11].**

Warrender *et al.*[12], in their study on 150 cases undergone intramedullary headless compression screw fixation of metacarpal fractures reported that regarding the metacarpal injury site, 131 cases with the small digit, 25 cases with ring digit, 2 cases with the middle digit, and 2 cases with index digit. 130 cases had fractures in the dominant hand, 121 cases had fractures in the right hand, and 29 cases had fractures in the left hand.

Tobert *et al.* [13], in their study on 16 cases with IMHS treatment of metacarpal fracture reported that 13 cases with the small digit, 3 cases with ring digit, 1 case with the middle digit, and 1 case with index digit. Regarding the complications, the current study found that there was no cases with malunion, 3 cases had superficial skin infection by 16.6%, and 16.6% had stiffness.

Regarding postoperative data The IMHS group had mean follow-up of 2.11±0.33 months, and mean physiotherapy duration of 1.33±0.41, and mean period for work return of 23.22±3.96 days. Regarding IMHS group, all cases had union during 6 weeks, and all cases did not have splint age postoperative.

Ruchelsman *et al.*[14], in their study on 39 cases with IMHS treatment of metacarpal fracture reported that all cases had achieved union by 6 weeks.

Couceiro *et al.* [15], found that he mean return to work time was 0.92 months for the IMHS group (0.5–1.5). They did find differences in terms of postoperative splinting time; this was not surprising, as they only applied splinting for a very brief time on some of the patients on the screw group for comfort purposes. The mean return to work time or time back to their regular activities appeared to be shorter on the screw group.

Since the screws we used were non-compressive and fully threaded with the same thread pitch along the whole screw, and compression and shortening of the fracture lines were not seen during surgery, we can say that the IMHS acts as an internal splint and can be applied to all fracture patterns.

Elmaraghy *et al.* [16], revealed that 5.7% of case had postoperative infection, and 2.9% of cases had malunions.

Kibar *et al.* [11], fount that regarding case subjected to IMHS for metacarpal fractures fixation, there was no case reported for complications during the follow-up period (Infection, loss of fixation, nonunion, malunion, hardware failure, metal allergy and extensor tendon disruption) **[9]**.

Warrender *et al.* [12], in their study on 150 cases with 160 fractures undergone intramedullary headless compression screw fixation of metacarpal fractures revealed that four complications (2.5%) were identified through the review of 160 total metacarpal fractures. One complication was a nickel allergy, one was a broken screw after repeat trauma, and 2 patients had bent intramedullary screws.

Couceiro *et al.* [13], reported three minor complications in their study on IMHS for metacarpal treatment, including one patient with extension lag who did not experience any issues with daily living and reported a Quick DASH score of 9.1, and two patients with stiffness who had Quick DASH scores of 22.7 and 4.5, respectively. All of the fractures were united successfully; they did not register any cases of malunion on either of the groups. Two of the patients on the screw group developed some degree of stiffness; their respective Quick DASH was 22.7 and 4.5, respectively.

Regarding the outcome, the present findings reported that with regard of TAM score, 83.4% of cases

had satisfactory level, and 16.6% had unsatisfactory level.

Tobert *et al.* [15], in their study on 16 cases with IMHS treatment of metacarpal fracture reported that Functional outcome was considered excellent in all patients with total active motion in excess of 240 degrees. Active motion was initiated within 1 week of surgery. No secondary surgeries were performed related to a complication of IMHS fixation.

Couceiro *et al.* [15], found the mean satisfaction was 9.4 (7–10) for the screw group and 9.1 (6–10) for the Kirschner wire group; and the mean Quick DASH score was 4.7 (0–22.7) for the screw group and 5.2 (0–34.1) for the Kirschner wire group. None of these differences reached statistical significance (the respective *p* values were 0.861, and 0.613).

In conclusion, intramedullary screw fixation of metacarpal fractures is an efficient and safe procedure with a low incidence of complications. The IMH screws appeared to require less casting and provide a quicker return to work.

Financial support and sponsorship: Nil.
Conflict of interest: Nil.

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