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The Role of Intramedullary Nailing in Metacarpal Fractures

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Original Article

Summary

Background: The metacarpal bone fractures are the second common fracture of hand. Management of metacarpal fractures is mainly conservative. However, intramedullary nailing is required for better reconstruction of fractured bones and in fastening of healing. Objective: To evaluate the functional and radiological outcomes of intramedullary nailing in metacarpal fractures in adults. Methodology: This study was a clinical prospective follow up study implemented in public and private hospitals in Erbil city-Kurdistan region/Iraq during the period of two years from 1st of November 2019, to 31st of October 2021 on convenient sample of twenty two adult patients with metacarpal fractures. The metacarpal fracture cases were diagnosed by the orthopedic surgeon through examination and plain radiographs. The anatomical and functional outcomes were assessed by researchers through following up the patients. Results: Mean nail removal duration of metacarpal bone fractures after intramedullary nailing was (3.7 months), while mean Disabilities of the Arm, Shoulder, and Hand (DASH) score of metacarpal bone fractures after intramedullary nailing was (1.8) and mean range of motion (ROM) score at 6th week of metacarpal bone fractures after intramedullary nailing was (88.9). The mean union duration of metacarpal bone fractures after intramedullary nailing was (5.6 weeks); 63.6% of patients had union duration of 6 weeks and more. The postoperative complications of metacarpal bone fractures after intramedullary nailing was present in 7 (31.8%) patients; commonly skin irritation at entry site (57.1%). The metacarpal neck fractures are related commonly with shorter duration between injury and surgical operation, 5th metacarpal bone, transverse pattern and longer duration of nail removal. Conclusions: The functional and radiological outcomes of intramedullary nailing of metacarpal fractures among adults in Erbil city are acceptable.

Keywords: *Metacarpal fractures, Intramedullary nailing, Outcomes*

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1. INTRODUCTION

Metacarpal fractures are common fractures that represented about 36% of hand fractures (1) with incidence of 12.5 cases per 10,000 population and predominance in male gender adults (2). The metacarpal fractures are commonly caused by direct trauma (3). The fractures of metacarpal shafts are resulted from direct blow to dorsal part of hand causing transverse fracture and sometimes comminuted fracture in regard to injury velocity (4). Rotational and axial force are causing oblique metacarpal fracture, while bending with axial force lead to butterfly fractures accompanied sometimes by comminuted fracture according to force of injury (5). Fracture of neck of fifth metacarpal with displacement of volar cortex or boxer's fracture occurs in about one- fifth of patients with hand fractures and caused by combining axial force with slight flexion position leading to metacarpal neck fracture and volar cortical displacement. In the same way, the intraarticular fractures of metacarpal bone base are caused by axial force leading to carpometacarpal joint arthritis (6).

Diagnosis of metacarpal bone fractures are dependable on history, physical examination and x-ray (anterioposterior, oblique and lateral) and in some cases with fractures of metacarpal bone base fractures, the computerized tomography scanning is required (7). Metacarpal fractures could be treated mostly with non-surgical measures, however, the treatment of metacarpal fractures required surgical intervention especially for fractures that are difficult to be reduced or stabilized in suitable anatomical positioning (8) in addition to fractures of multiple metacarpals which lack the efficient stabilizing forces. Instability of metacarpal fractures might be attributed to imbalanced anatomical stability, distorted muscular power and comminuted volar cortical fracture (9,10). The surgical measures in managing metacarpal fractures involves different plate and screw constructing, screws , percutaneous intermetacarpal wires, crossed K-wires, intramedullary-K-wires, Bouquet technique (11-17) and proximally-locked intramedullary metacarpal nailing (18,19). First attempts in stabilizing metacarpal fractures by intramedullary fixation had begun at mid of previous century by two surgeons in order to prevent stiffness and earlier re-functioning. They reported better union and low infection rate following fixation (20,21). At beginning of intramedullary fixation, there was no locking for nails, but after that, many wiring techniques were used such as crossed K wires, cerclage wires and wire loops. Nowadays, various small plates were applied in nailing which resulted in better stabilization than other

measures (15,22), but they are accompanied with different complications like stiffness, non-union, infection, rupture of tendons and plate prominence (23). The complications of managing metacarpal fractures are mainly nonunion, malunion, infection, hand stiffness and skin irritation. The metacarpal nonunion is rare occurs in 0.2-0.7% of cases. The delayed or non- union after metacarpal fractures fixation are reported commonly following fixation with K-wires (24). The Bouquet technique is associated by reduced rotational stabilization, high cost and need for secondary surgical intervention for wires removal (25). Many developments and advances in Bouquet technique were implemented to produce a flexible locked or unlocked intramedullary nailing in treating metacarpal fractures (17,18). The plates and screws measures resulted in rigid fixation and anatomical reconstruction of the fractures, but unfortunately resulted in scarring and adhesions of extensor tendons (26,27). Although these complications, the intramedullary nailing of metacarpal fractures is minimally invasive, reduces soft tissue exposure and resulted stable fixation (18). In Erbil city, the emergency hospitals received tens of injured cases especially from road traffic accidents that are sometimes associated with metacarpal bone fractures which represented a burden on national health institutes if not well treated (28) in addition to scarcity of national literatures discussing management of metacarpal bone fractures. All of these reasons urged us to conduct this study which aimed to evaluate the functional and radiological outcomes of intramedullary nailing in metacarpal fractures in adults.

2. PATIENTS and METHODS

The current study was a clinical prospective follow up study implemented in public and private hospitals in Erbil city-Kurdistan region/Iraq during the period of two years from 1st of November 2019, to 31st of October 2021. The studied population was all patients with metacarpal bone fractures presented to hospitals. Inclusion criteria were adult (age≥18 years) patients with close, simple pattern metacarpal bone fractures. Exclusion criteria were pediatric patients, metacarpal fractures with intra-articular extension, pathological metacarpal fractures, metacarpal fractures associated with tendon injuries, metacarpal comminuted fractures, open metacarpal fractures, incomplete or missing data and lost to follow up. The study ethics were implemented in regard to Helsinki Declaration by documented approval of health authorities and confidentiality of data in addition to completing management of fractures patients. A convenient sample of twenty two adult

patients with metacarpal fractures was enrolled in current study after eligibility to inclusion and exclusion criteria.

Information of patients with metacarpal fractures was collected directly by researcher through a prepared questionnaire designed by the researcher himself according to previous literatures (1,14). The questionnaire included general characteristics of patients with metacarpal fractures (age, gender, duration between injury and surgical operation, causes of fractures and side of fractures), characteristics of metacarpal fractures (involved metacarpal bone, steroids therapy, location of fracture and fracture pattern) and intermedullary nailing outcome of patients with metacarpal fractures (nail removal duration, DASH score, ROM score, union duration and postoperative complications). The metacarpal fracture cases were diagnosed by the orthopedic surgeon through examination and plain radiographs. The Dash questioner was translated to Kurdish and filled by patient either directly or through phone call, the ROM was measured by examining the patients using a goniometer. Patients were followed up at 2 weeks, 4 weeks, 12 weeks and 24 weeks both clinically and radiologically (some patients are taken before 2 months so they could not be followed up for 24 weeks, we can change their operation time if it will make a problem). Functional Outcome was assessed using Dash Score and ROM , and notes were taken from surgeon for intra operative complications and history was taken, examination done and radiographs taken during follow up to detect complications. The patients' information were entered and interpreted statistically by SPSS program-26. Suitable statistical tests (Fishers exact test) for data were implemented accordingly and p value of ≤ 0.05 was significant.

3. RESULTS

This study included twenty two adults patients with metacarpal fractures presented with mean age of (27.6 years) ranged between 18-39 years; 9.1% of patients were in age group <20 years, 59.1% of them were in age group 20-29 years and 31.8% of them were in age group 30-39 years. Male patients with metacarpal fractures were more than female with male to female ratio as 2.6:1. Mean duration between injury and surgical operation was (2.9 days); half of them had surgical operation after one day. The common cause of fracture was direct blow (77.3%) and the common fracture side was the right (68.2%), (Table 1).

The main involved metacarpal bone was the 5th metacarpal bone (50%), followed by; 4th metacarpal bone (22.7%), 4th and 5th metacarpal bones (13.6%), 2nd metacarpal bone

(9.1%) and 2nd and 3rd metacarpal bones (4.5%). The shaft fracture was the common location of metacarpal bone (68.2%), while neck fracture was represented in 31.8% of metacarpal bone fractures. The fracture patterns of studied metacarpal bone fractures were distributed as followings; transverse fractures (50%), oblique fractures (31.8%) and spiral fractures (18.2%), (Table 2).

The mean nail removal duration of metacarpal bone fractures after intramedullary nailing was (3.7 months); 31.8% of patients had removed nails after three months. Mean DASH score of metacarpal bone fractures after intramedullary nailing was (1.8); 40.9% of patients had DASH score more than two. Mean ROM score at 6th week of metacarpal bone fractures after intramedullary nailing was (88.9); half of patients had ROM score of 90 and more. Mean union duration of metacarpal bone fractures after intramedullary nailing was (5.6 weeks); 63.6% of patients had union duration of 6 weeks and more. The postoperative complications of metacarpal bone fractures after intramedullary nailing was present in 7 (31.8%) patients; commonly skin irritation at entry site (57.1%), followed by; infection (14.3%), partial tendon injury (14.3%) and delayed union (14.3%), (Table 3).

No significant differences were observed between patients with shaft metacarpal bone fractures and patients with neck metacarpal bone fractures regarding age ($p=0.54$), gender ($p=0.92$), cause of fracture ($p=0.51$) and side of fracture ($p=0.82$). There was a significant association between shorter duration between injury and surgical operation and neck metacarpal bone fracture ($p=0.02$), (Table 4).

A significant association was observed between 5th metacarpal bone and neck fracture ($p=0.03$). There was a significant association between transverse fracture pattern and neck metacarpal bone fracture ($p=0.006$), (Table 5).

There was a significant association between longer duration of nail removal and neck metacarpal bone fracture ($p=0.02$). No significant differences were observed between patients with shaft metacarpal bone fractures and patients with neck metacarpal bone fractures regarding DASH score ($p=0.4$), ROM score at 6th week ($p=0.17$), union duration ($p=0.6$) and postoperative complications ($p=0.4$), however, the only one case with delayed union was neck metacarpal bone fracture.(Table 6).

Table 1. General characteristics of patients with metacarpal fractures.

Variable		No.	%
Age (year)	<20	2	9.1
	20-29	13	59.1
	30-39	7	31.8
Mean age ±SD*	27.6 ± 6.2	-	-
Gender	Male	16	72.7
	Female	6	27.3
Duration between injury and surgical operation	≤1 day	11	50.0
	>1 day	11	50.0
Mean ±SD	2.9 ± 3.5 days	-	-
Cause of fracture	Direct blow	17	77.3
	Fall on hand	5	22.7
Side of fracture	Right	15	68.2
	Left	7	31.8

Table 2. Characteristics of metacarpal fractures.

Variable		No.	%
Involved Metacarpal bone	2nd metacarpal	2	9.1
	4th metacarpal	5	22.7
	5th metacarpal	11	50.0
	2nd and 3rd metacarpal	1	4.5
	4th and 5th metacarpal	3	13.6
Location of fracture	Shaft	15	68.2
	Neck	7	31.8
Fracture Pattern	Oblique	7	31.8
	Transverse	11	50.0
	Spiral	4	18.2

Table 3. Intramedullary nailing outcome of patients with metacarpal fractures.

Variable		No.	%
Time of Nail Removal	≤3 months	15	68.2
	>3 months	7	31.8
Mean ± SD	3.7±2.5 months		
DASH score	≤2	13	59.1
	>2	9	40.9
Mean ± SD	1.8 ± 1.2		
ROM score at 6th week	<90	11	50.0
	≥90	11	50.0
Mean ± SD	88.9±1.9		
Union duration	<6 weeks	8	36.4
	≥6 weeks	14	63.6
Mean ± SD	5.6±1.1 weeks		
Postoperative complications	Yes	7	31.8
	No	15	68.2
Types of complications	Skin irritation at entry site	4	57.1
	Infection	1	14.3
	Partial Tendon Injury	1	14.3
	Delayed Union	1	14.3

Table 4. Distribution of patients' general characteristics according to location of fractures

Variable	Location of fracture				P
	Shaft		Neck		
Age (year)	No.	%	No.	%	
<20	2	13.3	0	-	0.54 NS
20-29	8	53.3	5	71.4	
30-39	5	33.3	2	28.6	
Gender					
Male	11	73.3	5	71.4	0.92 NS
Female	4	26.7	2	28.6	
Duration between injury and surgical operation					
≤1 day	5	33.3	6	85.7	0.02 S
>1 day	10	66.7	1	14.3	0.51 NS
Cause of fracture					
Direct blow	11	73.3	6	85.7	
Fall on hand	4	26.7	1	14.3	
Side of fracture					
Right	10	66.7	5	71.4	0.82 NS
Left	5	33.3	2	28.6	

S:Significant, NS: Not significant.

Table 5. Distribution of metacarpal bone fractures characteristics according to location of fractures

Variable	Location of fracture				P
	Shaft		Neck		
	No.	%	No.	%	
Involved Metacarpal bone					**0.03** S
2nd metacarpal	2	13.3	0	-	
4th metacarpal	5	33.3	0	-	
5th metacarpal	4	26.7	7	100	
2nd and 3rd metacarpal	1	6.7	0	-	
4th and 5th metacarpal	3	20	0	-	
Fracture Pattern					**0.006** S
Oblique	7	46.7	0	-	
Transverse	4	26.7	7	100	
Spiral	4	26.7	0	-	

S:Significant

Table 6. Distribution of intramedullary nailing outcomes according to location of fractures

Variable	Location of fracture				P
	Shaft		Neck		
	No.	%	No.	%	
Nail Removal					**0.02** S
≤3 months	13	86.7	2	28.6	
>3 months	2	13.3	5	71.4	
DASH score					0.4 NS
≤2	8	53.3	5	71.4	
>2	7	46.7	2	28.6	
ROM score at 6th week					0.17 NS
<90	9	60	2	28.6	
≥90	6	40	5	71.4	
Union duration					0.6 NS
<6 weeks	6	40	2	28.6	
≥6 weeks	9	60	5	71.4	
Postoperative complications					0.44 NS
Yes	4	26.7	3	42.9	
No	11	73.3	4	57.1	
Types of complications					0.4 NS
Skin irritation at entry site	2	50	2	66.7	
Infection	1	25	0	-	
Partial Tendon Injury	1	25	0	-	
Delayed Union	0	-	1	33.3	

S:Significant, NS: Not significant.

4. DISCUSSION

The metacarpal bone fractures are the second common fractures of the hand. The management of these fractures is important in acquiring the stabilization of bones and maintaining normal hand activities (29).

The present study showed that more than half of patients with metacarpal bone fracture were at age group of 20-29 years with predominance of male gender (72.7%). These findings are consistent with results of Nakashian et al. (30) study in USA which stated that metacarpal bone fractures represented the active lifestyle of population with higher incidence in younger male adults. Our study revealed that mean duration between injury and surgical operation for patients with metacarpal fractures was (2.9 days). This duration is lower than mean duration between injury and surgical operation for patients with metacarpal fractures of (8.48 days) reported by Aykut et al. (31) retrospective review study in Turkey. This lower duration is indicative for earlier surgical intervention implemented by surgeons in Erbil centers for metacarpal fractures to avoid complications. In our study, the direct blow was the commonest cause of metacarpal bone fractures. This finding is similar to results of McNemar et al. (32) study in USA which reported that direct blow is the commonest cause of metacarpal fracture. Our also found that right sided fracture is prevalent in metacarpal fractures. This finding coincides with results of Kocaoğlu et al. (33) study in Turkey.

In current study, the 5th metacarpal bone fracture represented half of studied metacarpal bone fractures. This finding is close to results of de Jonge et al. (34) study in Netherlands which documented that5th metacarpal bone fracture represented 40% of studied metacarpal bone fractures. Our study found that shaft fracture was the common location of metacarpal bone fracture (68.2%). Similarly, Kollitz et al 24 review study in USA stated that shaft fractures are the commonest location of metacarpal bone fractures. Our study also found that half of metacarpal bone fractures were transverse fractures (50%). This finding is consistent with reports of Hussain et al. (35) study in Pakistan which revealed that transverse fracture the commonest fracture type for metacarpal fractures especially boxers fractures.

The present study found that mean nail removal duration of metacarpal bone fractures after intramedullary nailing was (3.7 months); 31.8% of patients had removed nails after three months. These findings are inconsistent with results of Mirza et al. (36) study in USA which reported mean duration of about two months for nails removal after intramedullary nailing of

metacarpal fractures. This inconsistency might be due to differences in severity and instability of metacarpal bones between two studies. Our study showed that mean DASH score of metacarpal bone fractures after intramedullary nailing was (1.8); 40.9% of patients had DASH score more than two. These findings are close to results of Abulsoud et al. (37) prospective case series study in Egypt which reported that mean DASH score after intramedullary nailing of metacarpal fractures was (2.6) after 12 months. In current study, mean ROM score at 6th week of metacarpal bone fractures after intramedullary nailing was (88.9); half of patients had ROM score of 90 and more. These findings are close to results of Jun et al. (38)study in South Korea which reported that mean ROM score after intrarmedullary nailing of metacarpal fractures was (87) after 6 months. Our study showed that mean union duration of metacarpal bone fractures after intramedullary nailing was (5.6 weeks); 63.6% of patients had union duration of 6 weeks and more. These findings are better than results of Ghazala et al. (39) retrospective case series study in UK which reported mean union duration of (7 weeks) after intramedullary nailing of metacarpal fractures. The union duration of metacarpal bone fractures are affected by fracture location and number of K-wires used.d7 Present study found that postoperative complications of metacarpal bone fractures after intrarmedullary nailing was present in 7 (31.8%) patients. This finding is higher than results of Siddiqui et al. (40) study in Pakistan which reported that only 3 (9.6%) patients with metacarpal fractures developed postoperative complications after intramedullary nailing. This difference might be due to discrepancy in follow up duration and severity of metacarpal fractures between different studies. Our study showed that skin irritation at entry site was the common complication (57.1%), followed by; infection (14.3%), partial tendon injury (14.3%) and delayed union (14.3%). These findings are close to results of Mirza et al. (1) study in UK and Orbay study (41) in USA which reported minimal postoperative complications of intramedullary nailing of metacarpal fractures such as stiffness, infection and in less prevalence delayed union.

In present study, there was a significant association between shorter duration between injury and surgical operation and neck metacarpal bone fracture (p=0.02). This finding is similar to results of Padegimas et al. (42) study in USA which reported that neck metacarpal bone fracture required earlier surgical intervention. Our study found a significant association between 5th metacarpal bone and neck fracture (p=0.03). This finding coincides with results

of Hussain et al. (35) review study in USA. Our study also showed a significant association between transverse fracture pattern and neck metacarpal bone fracture (p=0.006). This finding is parallel to results of Chiu et al. (43) study in Taiwan which documented that transverse fractures are predominant in metacarpal neck fractures. The current study found a significant association between longer duration of nail removal and neck metacarpal bone fracture (p=0.02). This finding is similar to results of She et al. (44) study in China which found that neck metacarpal fractures required long duration in nail removal.

5. CONCLUSIONS

The functional and radiological outcomes of intramedullary nailing of metacarpal fractures among adults in Erbil city are acceptable. The postoperative complications of intramedullary nailing for metacarpal fractures are minimal and skin irritation is the common complication. The metacarpal neck fractures are related commonly with shorter duration between injury and surgical operation, 5th metacarpal bone, transverse pattern and longer duration of nail removal. This study recommended supporting further national researches evaluation outcomes intramedullary nailing for metacarpal fractures.

Ethical Clearance : Ethical clearance and approval of the study are ascertained by the authors. All ethical issues and data collection were in accordance with the World Medical Association Declaration of Helsinki 2013 of ethical principles for medical research involving human subjects. Data and privacy of patients were kept confidentially.

Conflict of interest: Authors declared none

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