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Outcomes of Interfragmentary Mini Screws for Fixation of Metacarpals and Phalanges Fractures

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ABSTRACT

Background: Hand fractures represent a considerable burden upon society in terms of medical costs and reduced workplace productivity. Fractures of the metacarpals and phalanges are the most common fractures of the upper extremity. Outcome of conservative treatment in displaced, irreducible, unstable and rotational fractures is poor.
Objective: To assess the outcome of fixation of oblique and spiral fractures of phalanges and metacarpals of the hand by interfragmentary mini screws and to evaluate the rate of complications. **Patients and methods:** A study included 18 patients with oblique and spiral fractures, 6 metacarpals and 12 phalangeal fractures. Patients were managed by open reduction and internal fixation using mini Interfragmentary screws with lag technique at Zagazig University Hospital and Zagazig General Hospital. **Results:** Four weeks postoperative, the mean total active motion (TAM) score was 83.22 ± 13.26. Early range of motion assessment revealed one (5.6%) poor, two (11.1%) fair, five (27.8%) good and ten (55.6%) excellent results. The end results by measuring grip strength of affected hand for metacarpals was excellent in two patients (40%), good in two patients (40%) and fair in one patients (20%). The mean grip strength for metacarpals was 85.8 ± 7.5**.** While the grip strength of affected hand for phalanges was excellent in eight patients (61.5%), good in four patients (30.7%) and fair in one patients (7.7%). The mean grip strength for phalanges was 90.07 ± 7.3.
Conclusion: Inter-fragmentary mini lag screws fixation represents an effective method for managing such rotationally unstable fractures as oblique and spiral hand fractures. Younger patients with hand fractures revealed better results of range of motion and hand function.
Keywords: Mini screws, Spiral hand fractures, TAM score, Metacarpal fractures.

INTRODUCTION

Hand fractures represent a major burden to society in terms of medical costs and low productivity of the workplace [(1)]. Approximately, 70% of all metacarpal and phalangeal fractures occur between the age of eleven and 45 years [(2)]. Additionally, when the hand has multiple fractures that each might be stable in isolation, the collective may necessitate operative fixation, as is sometimes the case for metacarpal shaft fractures [(3)]. Many hand fractures that require surgical treatment are amenable to minimally invasive techniques for several reasons. First, the subcutaneous location of bones lends them to the placement of percutaneous fixation. Second, the deforming forces exerted by the forearm and hand musculature are relatively modest, so rigid fixation with plates and screws is less necessary than in other parts of the body where forces are greater [(4)]. Open reduction and internal fixation with lag screws are technically demanding but provides inter-fragmentary compression. It avoids the risk of soft tissue dissection [(5)]. The main advantages of these implants are the added stability provided by fracture compression and the resultant or independent neutralization of bending, rotational and shear forces acting upon the fracture site. These features help to ensure timely fracture healing and to allow earlier and more intensive digital rehabilitation [(6)].

Optimal treatment for metacarpal and phalangeal fractures remains to be debated. Closed reduction and immobilization or functional bracing is reported, but requires careful selection of patients with fracture patterns amenable to non-operative treatment. While, in those patients who are requiring surgical fixation, treatment options are variable and include: closed or open reduction and fixation with percutaneous pinning, extra- or intra-osseous wiring, lag screws, intramedullary devices, plates or external fixation [(7, 8)].

The current study aimed to evaluate the outcome of fixation of oblique and spiral fractures of metacarpals and phalanges of the hand by Inter-fragmentary mini screws and to assess the rate of complications, in particular related to joints stiffness and bone healing.

PATIENTS AND METHODS

This study included 18 patients with oblique and spiral fractures, 6 metacarpals and 12 phalangeal fractures. Patients were managed by open reduction and internal fixation using mini interfragmentary screws with lag technique at Zagazig University Hospital and Zagazig General Hospital.
Inclusion criteria: Skeletally mature patients with spiral displaced metacarpals or phalanges (8 patients), oblique displaced metacarpals or phalanges (10 patients), closed fractures (17 patients), open fractures with minimal tissue laceration (one patient). All patients had recent fracture within 2 weeks of trauma.
Exclusion criteria: Patients with a non-displaced fractures, comminuted fractures, fractures associated with tendon injuries and significant neurovascular injuries, high grade open fractures and fire arm injuries.

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All patients were subjected to personal history and local examination of the affected. Routine plain radiographic images were obtained for all patients including antero-posterior 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.

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 the operation. 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.

Operative management:

All patients were operated in supine position with the involved hand on a side table. Intraoperative fluoroscopy was used in all surgical operations in this study. Implant was done using 2 mm mini screws to fix 18 oblique and spiral metacarpal and phalangeal fractures using lag technique. Internal fixation of the fracture was done according to AO rules. A minimal distance between the apex of the fracture and the screw head was determined to be at least equal to the screw head diameter. The screw direction aimed to be perpendicular to fracture plane to avoid any displacement when the screw was tightened. About 1.5 mm drill bit was used to drill both cortices then the 2 mm drill bit was used to drill the near cortex only forming a gliding hole that apply fracture compression as the screw was tightened. The average number of screws used for fixation for each fracture was 1.8 (range 1-3) screws. Absorbable vicryl sutures 2/0 were used to repair intertendinous connection. Mean operative time for open reduction and internal fixation by mini screws was 90 (range 60-120) minutes.

Postoperative Follow up:

Following the operation, patients were prohibited from returning to work using the involved hand and wrist for one week. Postoperative splint in function position was applied for a week. In the second week, the patients were allowed to start movement with a protective orthotic and buddy taping to the adjacent finger however some patients were delayed due missed follow up visits. In the third week, the patients continued active movement without buddy taping. The patients were examined for local pain and swelling of the injured hand every week. Resolution of local tenderness, pain and local signs of injury were checked carefully for at least four weeks.

Assessment:

Functional results were evaluated through range of motion of the affected finger and the ability of the patient to use the affected hand in normal daily activity and grip strength measuring.

Statistical analysis

Data were then imported into (SPSS version 20.0). Qualitative data were represented as number and percentage. Quantitative continues group was represented by mean ± SD. The following tests were used to test differences for significance; difference and association of qualitative variable by Chi square test (X^2) and repeated measures by chi square or sign test. Differences between quantitative independent groups by t test and paired groups by paired t test. P value was set at ≤ 0.05 for significant results & < 0.001 for high significant result.

RESULTS

The present study included 18 patients with fractures, TAM score was measured for thirteen phalangeal fractures and five metacarpal fractures in two periods. The first one was four weeks postoperative for assessment of early return of range of motion, while the second was at the final follow up (mean 23.1 weeks) visit for assessment of final result. Four weeks postoperative, the TAM score mean was 83.22 ± 13.26. Early range of motion assessment revealed one (5.6%) poor, two (11.1%) fair, five (27.8%) good and ten (55.6%) excellent (Table 1). For five cases of metacarpals only, the mean value of TAM score at four weeks postoperative follow up was 83.4% ± 13.4%. Early range of motion assessment revealed one (20%) fair, one (20%) good and three (60%) excellent. The mean TAM score for metacarpals at end of follow up was 86.4% ± 12.033 and final range of motion assessment revealed one (20%) fair, one (20%) good and three (60%) excellent (Table 2). For thirteen cases of phalanges only, the mean value of TAM score at four weeks postoperative follow up was 83.1% ± 13.8. Early range of motion assessment revealed one (7.7%) poor, one (7.7%) fair, four (30.8%) good and seven (53.8%) excellent. The mean TAM score for phalanges at end of follow up was 87.2% ± 12.008 and final range of motion assessment revealed two (15.4%) fair, one (7.7%) good and ten (76.9%) excellent **(Table 3)**.

Table (4) showed that the end results by measuring grip strength of affected hand for metacarpals was excellent in two patients (40%), good in two patients (40%) and fair in one patients (20%). The mean grip strength for metacarpals was 85.8% ± 7.5 (range from 75% to 94%)**.**

While the grip strength of affected hand for phalanges was excellent in eight patients (61.5%), good in four patients (30.7%) and fair in one patients (7.7%). The mean grip strength for phalanges was 90.07% ± 7.3 (ranged from 71% to 97%) (Table 5).

The mean age of patients with excellent and good results (favorable cases) was 32.6 years, while the mean age in patients with fair and poor results (unfavorable cases) was 47 years. Studying the relation between different age groups and the result was statistically significant ($p = 0.04$) (Table 6).

Table (1): TAM score results

Result		4 weeks follow up		Final Follow up	
		No.	%	No.	%
Poor		1	5.6%	0	0.0%
Fair		2	11.1%	3	16.7%
Unsatisfactory		3	16.7%	3	16.7%
Good		5	27.7%	2	11.1%
Excellent		10	55.6%	13	72.2%
Satisfactory		15	83.3%	15	83.3%
Total		18	100%	18	100%
TAM %	Min - Max	49% - 96%		58% - 98%	
	Mean ± SD	83.22 ± 13.26		87 ± 11.66	

Table (2): TAM score results for metacarpals

Result		4 weeks follow up			Final Follow up		
		No.	% of MC	% of All Cases	No.	% of MC	% of All Cases
Poor		0	0.0%	0.0%	0	0.0%	0.0%
Fair		1	20%	5.5%	1	20%	5.5%
Unsatisfactory		1	20%	5.5%	1	20%	5.5%
Good		1	20%	5.5%	1	20%	5.5%
Excellent		3	60%	16.7%	3	60%	16.7%
Satisfactory		4	80%	22.2%	4	80%	22.2%
Total		5	100%	27.8%	5	100%	27.8%
TAM %	Min-Max	63%- 96%			69%-98%		
	Mean ± SD	83.4% ± 13.4			86.4% ± 12.033		

Table (3): TAM score results for phalanges

Result		4 weeks follow up			Final Follow up		
		No.	% of phalanges	% of All Cases	No.	% of phalanges	% of All Cases
Poor		1	7.7%	5.5%	0	0.0%	0.0%
Fair		1	7.7%	5.5%	2	15.4%	11.1%
Unsatisfactory		2	15.4%	11.1%	2	15.4%	11.1%
Good		4	30.8%	5.5%	1	7.7%	5.5%
Excellent		7	53.8%	16.7%	10	76.9%	55.5%
Satisfactory		11	84.6%	61.1%	11	84.6%	61.1%
Total		13	100%	72.2%	13	100%	72.2%
TAM %	Min Max	49% 96%			58% 98%		
	Mean ± SD	83.1% ± 13.8			87.2% ± 12.008		

Table (4): Grip strength results for metacarpals

	% of opposite side	No.	% of all metacarpals	% of all cases
Satisfactory	Excellent (90% - 100%)	2	40%	11.1%
	Good (80% - < 90%)	2	40%	11.1%
Unsatisfactory	Fair (70% - < 80%)	1	20%	5.5%
	Poor (< 70%)	0	0%	0.0%
Mean	Min.	Max.		SD
85.8%	75%	94%		7.5

Table (5): Grip strength results for phalanges

	% of opposite side	No.	% of all phalanges	% of all cases
Satisfactory	**Excellent (90% - 100%)**	**8**	**61.5%**	**44.4%**
	Good (80% - < 90%)	**4**	**30.7%**	**22.2%**
Unsatisfactory	**Fair (70% - < 80%)**	**1**	**7.7%**	**5.5%**
	Poor (< 70%)	**0**	**0%**	**0.0%**

Mean	Min.	Max.	SD
90.07%	71%	97%	7.3

Table (6): Correlation between age and results

	Excellent	Good	Fair	Poor	P
<40	**11**	**2**	**0**	**0**	**0.04***
≥ 40	**2**	**0**	**3**	**0**	
	Favorable	**Unfavorable**		**X^2**	**P**
Mean Age ± SD	**32.6±6.63**	**47.0±5.29**		**3.514**	**0.003***

DISCUSSION

The hand serves as a very important sensory organ for the perception of one's surroundings. The hand is also a primary effector organ for our most complex motor behaviors, and the hand helps to express emotions [7]. The close relationship between different soft tissue structures contributes to the complex kinesiology of the hand. Injury to any of these even very small structures can alter the overall function of the hand and thereby complicate the therapeutic management. Therefore, after trauma or surgery, the tissues that need to glide and stretch should be moved as soon as possible to prevent adhesions, shortening, and/or stiffness [8].

In this study, range of motion, functional and radiological results of treatment of oblique and spiral metacarpal and phalangeal fractures by open reduction and internal fixation using inter-fragmentary mini screws were evaluated on eighteen fractures in eighteen hands.

In our study, TAM score was calculated in two different periods of follow-up (at four weeks and final follow-up of 15 to 31 weeks) with measuring grip strength of all cases at final follow-up along with the tip to palm distance, time to return to work, and radiological union time. Also, the TAM score in our study was mentioned by a percentage value from the expected total which ends with 100%. At final follow up, the TAM score percentage was 87 ± 11.6% (range 58% - 98%). The final range of motion assessment revealed three patients (16.7%) fair, two patients (11.1%) good and thirteen patients (72.2%) excellent results. This is in agreement with **Rashed *et al.*** [1] reported the mean TAM value percentage was 90.3 ± 9.8%. While, the mean grip strength grade was 93.04 ± 11.51% ranged from (64.5% to 100%) and the functional end results according to both TAM score percentage and grip strength measurement showed that fourteen patients (70%) had excellent results at the final follow up, two patients (10%) with good results, and four patients (20%) with unsatisfactory results.

According to **Başar *et al.*** [9] study, patients with phalangeal fractures treated by screws only showed a mean TAM score of 235 ± 25.6% (90.3% ± 9.8%) while patients with metacarpal fractures treated by the same manner had a mean score of 240 ± 23.9 (92.3 ± 9.1%). In the assessment of TAM values of patients at the last control examination, no significant difference was detected between patients with metacarpal fractures treated with mini-plate plus screw and those treated with screw only. The values of patients with phalangeal fractures treated with screws only were significantly better. A prospective study by **Gupta *et al.*** [10] on 45 phalangeal fractures used various techniques including conservative, K-wires, and mini screws. The functional outcome after fracture treatment was assessed by calculating TAM score. The end results noted that 92% were excellent in the group treated with mini screws, 60% excellent in the group treated with k-wires and 55% excellent in the group treated conservatively with multiple configurations of fractures in hand with varied treatment including metacarpal and phalanges. This opposite for **Rashed *et al.*** [1] study and our study as the use of mini inter-fragmentary screws in their indication of oblique and spiral fractures of the hand gave us a satisfactory results.

In the study of **Nalbantoglu *et al.*** [11], they treated phalangeal fractures only by inter-fragmentary mini screws and low profile mini-plates. Their mean TAM value of all patients was 200 ± 39.5 (76.9% ± 15.19%). End results of hand function were graduated as excellent in 6 fingers (33.3%), good in 5 (27. 7%) and fair in 7 (38. 8%) of all study cases. Excellent and good TAM values were achieved in 8 of the 11 fractures (72.7%) where fixation was performed with mini screws between fragments while the favorable results

(excellent and good results) achieved in 3 of the 7 fractures (42.8%) where they were fixed by low profile plates and screws.

In our study, the mean value of grip strength percentage of opposite normal hand at the final visit revealed 88.9% ± 7.4% ranged (from 71% to 97%) with excellent result in 10 patients (55.6%), good in 6 patients (33.33%) and fair in two patients (11.11%). The satisfactory results in our study represented 88.9% and only 11.11% for unsatisfactory results. The mean value in phalanges only was 90.07 ± 7.3%, while in metacarpals was 85.8 ± 7.5%. This is comparable with **Rashed *et al.* (1)** and **Başar *et al.* (9)** results and these better results may be due to using different scales for achieving the values of their study.

Finally, like most study, unfavorable cases were significantly associated with higher age, also significantly associated with the presence of comorbidities and associated complications.

CONCLUSION

Inter-fragmentary mini lag screws fixation represents an effective method for managing such rotationally unstable fractures as oblique and spiral hand fractures. Younger patients with hand fractures revealed better results of range of motion and hand function.

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