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Original Article

HOW TO AVOID HAND STIFFNESS IN METACARPAL FRACTURES?

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Abstract

***Objective**: The purpose of this study was to evaluate the incidence of hand stiffness and range of motion in patients with metacarpal fractures treated with internal fixation by low profile osteo-synthesis (Mini-plates).**Materials and methods**: A prospective study including thirty-six patients with metacarpal fracture was carried out in the period between June 2018 and June 2019 at Sohag University Hospital. All these 36 patients underwent internal fixation of metacarpal fracture by mini-plates. Evaluation of pain measured on a visual analog scale (VAS), active range of motion (ROM); and grip strength and postoperative follow up is up to one year. **Results**: Group of patients including thirty-six patients with metacarpal bone fractures underwent internal fixation by mini plate, the mode of trauma was Motor car accident in 26 cases (72.2%) and Assault in six cases (16.7%) hitting hard objects was in 4 cases (11.1%). No complications were reported in our cases except one case (2.8%) with wound dehiscence which improved with daily dressing and good antibiotics. **Conclusion**: Mini-plate and screws fixation of metacarpal fractures produces anatomical reduction of fractures with stabilization that is rigid enough to allow early mobilization, thereby preventing stiffness and hence good functional results.*

Keywords: *Metacarpal, Mini plate, Motor car accident, Hand, fracture.*

1. Introduction

Traumatic injuries to the hand represent a large proportion of work presenting to emergency departments and hand surgery units [1]. Metacarpal fractures are second most common fractures in the hand. The incidence of metacarpal fractures is 8.4 per 10,000 person-year [2]. These may present as isolated fracture, multiple metacarpal fractures or in combination with bony injuries to other extremity. The metacarpal fractures constitute 18-44% of hand fractures [3,4]. Metacarpal fractures are a common presenting problem to the hand surgeon. During surgical treatment, anatomic reduction is very important [5,6]. A biomechanical cadaveric study shows that as much as 8% loss of grip power may result from every 2 mm of metacarpal shortening. A few degrees of mal-rotation may lead to digital overlap when a fist is made [7,8]. The superficial presence of the bone and the use of hand for evasive action to trauma make the metacarpals as commonly fractured bones. The metacarpal fractures occur more common in men who constitute up to 85% of the patients [3,9]. The fifth metacarpal is the most common metacarpal to get fractured [10]. The metacarpal fracture can be classified depending upon the site as fracture of head, neck, shaft or base of the metacarpal. The fracture pattern may be classified as transverse, short oblique, long oblique or comminuted one [11,12]. Usually these fractures are

managed either conservatively or by Kirschner (K) wire fixation. K-wire fixation may be complicated by pin site infection, protruding or prominent wires and require prolong immobilization [13]. The nonunion, mal-union and joint stiffness, which may result from external immobilization or percutaneous K-wire fixation, is avoided by the rigid internal fixation with mini-plate and screws in metacarpal fracture. [13,14]. The use of plate for fixation of metacarpal fractures was first documented in 1958 [15]. Rotational alignment, correction of dorsal angulation and shortening, stable rigid fixation and early mobilization are most important goals in management of metacarpal fractures [16,17]. The aim of this study was to evaluate the usefulness of open reduction and internal fixation with mini-plate and screws to evaluate the symptomatic improvement and early recovery of functions.

2. Materials and methods

This prospective study was concluded on 36 cases of variable ages and sex (30 males and 6 females) which were presented to orthopaedic & traumatology department at Sohag university hospital in the period from June 2018 till June 2019., the study was done on patients suffering from metacarpal fracture with ages between 18 to 60 years the mean age was 32.3 years. The causes of metacarpal fractures are different and variable mostly, motor car accidents. Motor car accident was the cause in 26 patients (72.2%), six patients (16.7%) Assault injury and in four patients (11.1%) the cause was hitting hard object. Inclusion criteria were: **(1)** fracture of the neck or shaft of the metacarpal with unaccepted angulation and/or any rotational deformity were the indications for surgical intervention **(2)** irreducible or unstable fracture patterns. We excluded patients with complex injury, severely comminuted fracture and bony defects. Metacarpal fractures were in the dominant hand in 24 patients and 12 patients in the non-dominant hand. Right hand was affected in 22 patients and the left hand was affected in 14 patients. There were 18 patients with neck fracture (seven were transverse, five with minimal comminution and six with oblique fracture) and 28 shaft fracture (fourteen were transverse, ten oblique and four with wedge fracture). As regard the affected metacarpal, the 5^{th} metacarpal was the most affected one 22 patients five of them were related to other metacarpal bone fracture. The next common was the 4^{th} metacarpal in 12 patients six of them associated with other metacarpal fracture, the 2^{nd} metacarpal in 8 patients and the 3^{rd} metacarpal was isolated fracture in 2 patients and involved in 3 patients. The general condition of patients with acute major injuries were assessed concerning hypovolemia, associated orthopaedic or other systemic injuries on admission and resuscitative measures were taken accordingly. All patients received analgesics in the form of I.M injections and antibiotics intravenously. Full clinical assessment was performed including detailed history relating to age, sex, handedness, occupation, mode of injury, past and associated medical illness. Examination of the affected hand for degree of angulation, rotation and shortening was done. The hand was immobilized in extended below elbow slab. Routine investigation including blood picture, prothrombin time and concentration, random blood sugar and serum creatinine were done for all patients. All patients were evaluated clinically and radiographically to assess the extent of injury. X-ray was taken in two views (antero-posterior & oblique). The subjective evaluation included the assessment of range of motion (ROM), extension lag, radiographic union. Patients were also asked about the duration of disability and rehabilitation, functional restriction at work or sport and symptoms of pain. Postoperative follow up was to average 9 months (6 to 12 months).

2.1. *Surgical technique*

All the procedures were performed with the patients positioned in supine position on the operating table with the injured hand on side radiolucent table perpendicular with the patient body. The procedure was performed under brachial plexus block anesthesia (regional anesthesia). After the landmarks have been identified and marked on the skin, the limb was exsanguinated, and the tourniquet was inflated to 250 mmHg. A direct longitudinal incision over the fractured metacarpal on the dorsal aspect of the hand a little bit lateral in case of 2nd MCP fracture, a little medial in case of 5th MCP fracture and in between 3rd & 4th MCP bones in case of 3rd or 4th MCP fracture. In cases of multiple metacarpal fracture one incision between every two adjacent metacarpals this is done to avoid incision marks over the plate. After dissection of the subcutaneous tissue the extensor tendon was retracted away then a longitudinal incision of the intrinsic fascia was done to expose the fractured metacarpal, after debridement of the fracture site and reduction a low profile mini plate was applied on the dorsal aspect of the metacarpal. Use of the proper contour according to the location of the fracture allowed each fragment to be fixed. Smooth gliding of the flexor tendon was checked against the protruding screw tip at the volar surface of the bone during the passive range of motion (ROM) of the finger. Adequate soft tissue coverage was ensured over the plate by closure of all fascia of the intrinsic muscle over the plate, the subcutaneous tissue was sutured and closure of the skin by simple interrupted sutures. After surgery the hand was immobilized in below elbow slab for two weeks in functional position. I.V antibiotics were prescribed for one week followed by one week on oral antibiotics with oral analgesics. The patients were discharged in the same day of surgery unless other injuries require hospital stay. After 2 weeks the stitches and the slab were removed. Light work was allowed for 6 weeks and full work was allowed at 8 weeks after surgery. The patients were followed up clinically and radiologically at 6 and 8 weeks of operation initially and then monthly for 1 year to assess the union at the fracture site, range of motion of the involved finger, ability to touch the distal palmer crease with the involved finger, ability to write or work without pain, presence or absence of any deformity and radiological evidence of union at the fracture site. Normal range of movement was taken as MCP of 0–90 degree. Cases were classified according to the range of motion of MCPH joint movement into excellent (ROM more than 80 degree), good (ROM 60-80 degree), poor (ROM 40-60 degree), bad (ROM less than 40 degree).

2.2. *Statistical analysis*

The collected data was revised, coded, tabulated and introduced to a PC using Statistical package for Social Science (SPSS 25). Data was presented and suitable analysis was done according to the type of data obtained for each parameter.

3. Results

The present study included 36 patients with metacarpal fracture, 30 were male and 6 were female. The average age of the patients was 32.3 years (18-60 years). Road traffic accident was the cause of the fracture in 26 patients (72.2%), Assault in six patients (16.7%) and in four patients (11.1%) the cause was hard trauma. the patients were followed up for at least 6 months. Four cases were lost for follow up and the remaining 32 cases were evaluated as in tab. (1).

Table (1) Patients data

No	Sex	Age	Handedness	MCB	Type	Site	pattern	Follow up	ROM	Complication
1	M	24	Dominant	5th	Simple	Neck	Transverse	6 m	Excellent	No
2	M	36	Dominant	2nd	Simple	Shaft	Transverse	7 m	Excellent	No
3	M	18	Non-dominant	5th	Simple	Neck	Oblique	6 m	Excellent	No
4	F	60	Non-dominant	5th	Simple	Neck	Oblique	7 m	Excellent	No
5	M	25	Dominant	3rd & 4th	Simple	Shaft	Oblique	9 m	Good	No
6	M	39	Dominant	4th & 5th	Simple	Neck	Transverse	9 m	Excellent	No
7	F	36	Non-dominant	4th	Simple	Shaft	Transverse	7 m	Excellent	No
8	F	22	Dominant	5th	Simple	Shaft	Wedge	10 m	Excellent	No
9	M	56	Non-dominant	2nd	Compound	Neck	Minimal comminution	12 m	Fair	2mm shortening
10	M	19	Dominant	2nd & 3rd	Simple	Shaft	Transverse	6 m	Excellent	No
11	M	28	Dominant	4th	Simple	Shaft	Oblique	9 m	Excellent	No
12	M	24	Dominant	5th	Simple	Neck	Minimal comminution	10 m	Excellent	No
13	M	48	Dominant	3rd, 4th & 5th	Simple	Neck	Oblique	10 m	Excellent	No
14	M	45	Non-dominant	4th	Simple	Shaft	Oblique	6 m	Excellent	No
15	M	30	Dominant	2nd	Simple	Shaft	Oblique	8 m	Excellent	No
16	F	21	Dominant	3rd	Simple	Shaft	Transverse	6 m	Excellent	No
23	M	34	Non-dominant	2nd, 3rd, 4th & 5th	Simple	Shaft	Transverse	12 m	Good	Sensory disturbance
24	M	48	Dominant	5th	Simple	Neck	Transverse	6 m	Excellent	No
25	M	52	Dominant	5th	Simple	Neck	Minimal comminution	11 m	Good	No
26	M	37	Non-dominant	4th	Simple	Shaft	Transverse	9 m	Excellent	No
27	M	18	Non-dominant	2nd	Simple	Shaft	wedge	7 m	Excellent	No
28	F	20	Dominant	5th	Simple	Neck	Transverse	11m	Excellent	No
29	M	29	Dominant	5th	Simple	Shaft	Oblique	6 m	Excellent	No
30	M	41	Dominant	4th & 5th	Compound	Neck	Oblique	12 m	Fair	No
31	M	19	Dominant	2nd	Simple	Shaft	Transverse	6 m	Excellent	No
32	M	33	Non-dominant	4th	Simple	Shaft	Wedge	9 m	Excellent	No

Results were evaluated every two weeks after discharge. All patients applied a below elbow slab for 2 weeks and Light work was allowed for 6 weeks and full work was allowed at 8 weeks after surgery. No complications of displacement in the fracture line implant failure, distal loss of sense due to nerve damage, malunion and rupture of the extensor tendon, osteonecrosis and sudeck atrophies were observed in the postoperative follow-up of the patients. Dehiscence in the wound dressing was observed in only one patient but there was no active drainage, this disappeared with daily dressing and good antibiotics. Bone union was observed radiologically in all patients with closed fracture in a mean of 6 weeks (range 5-7 weeks). Clinical and radiological results were excellent in 28 cases with closed fracture (as regard pain and function) there was no limitation of motion of the metacarpophalangeal joint. The mean range of motion of MCPH joint was 89 degrees (80-90 degree) with no angular or rotational deformity were observed in any patient. In addition, all four compound cases achieved bony union at an average period of 8 weeks. Two of them had excellent results with full range of motion at metacarpophalangeal joint with no angular or rotational deformity. The other two cases were associated with other injuries but achieved good results at the end of follow up. Four cases had good range of motion at the metacarpophalangeal joint (60-80 degrees) and two cases had fair range of motion at metacarpophalangeal joint (40-60 degree) which improved by physiotherapy for one to two months. At the final follow up all patients regained full flexion at metacarpophalangeal joint and interphalangeal joint with no extension lag. One case had 2mm shortening. One case had sensory disturbance at the dorsum of the hand. No cases had infection at operation wounds or mechanical irritation of the skin or extensor tendons.

3.1. *Examples cases*

Case (1)

34 years old male patient came to our ER with simple transverse fracture 2nd, 3rd, 4th & 5th MCB of left hand due to assault trauma. After full clinical examination X-ray antero-posterior and oblique views were done, fig. (1-a). Extended below elbow slab and full laboratory investigation were done. Dorsal platting was done through 2 separate incisions one between 2nd & 3rd and the other between 4th & 5th, fig. (1-b). We put the hand in extended below elbow slab for 2 weeks after 2 weeks we removed the slab and the stitches. Radiological union achieved after 1.5 months', fig. (1-c). The patient suffered from sensory disturbance at the dorsum of the hand improved spontaneously. The patient's follow up after one year was excellent with full range of motion, fig. (1-d).

Figure (1) **a.** X-ray preoperative, **b.** X-ray postoperative, **c.** ROM after 1 year, **d.** X-ray after 1 year.

Case (2)

24 years old male patient came to our outpatient clinic with compound fracture 4th& 5th MCB due to motor car accident. After full clinical examination X-ray antero-posterior and oblique views were done, fig. (2-a). Extended below elbow slab and full laboratory investigation were done. Dorsal platting was done through one incision between 4th & 5th MCB after good wash and debridement. We put the hand in extended below elbow slab for 2 weeks. Wound dehiscence resolved by daily dressing and antibiotics. Radiological union achieved after 1.5 months', fig. (1-b). The patient's follow up after 8 months was excellent with full range of motion, figs. (1-c & d).

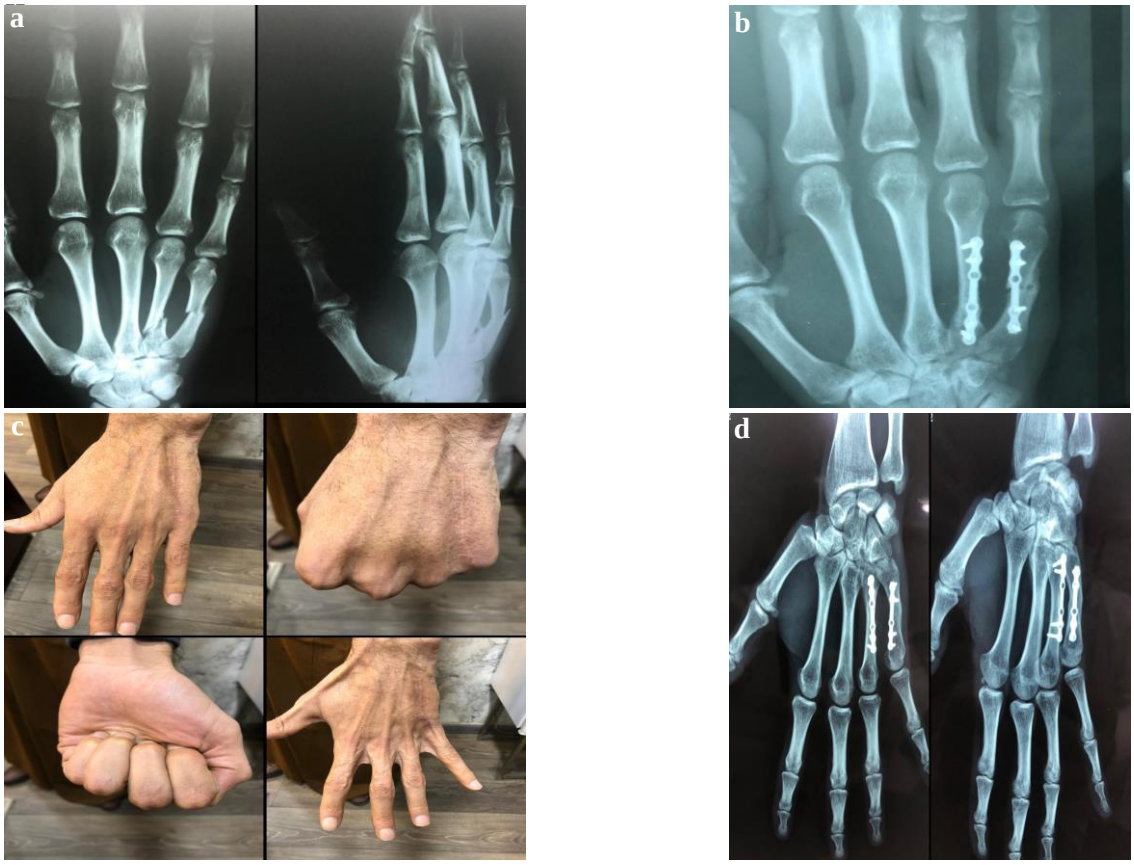

Figure (2) X-ray preoperative, **b.** X-ray postoperative, **c.** ROM after 1 year, **d.** X-ray after 1 year.

4. Discussion

The aim of this study was to evaluate the results of open reduction and internal fixation with mini-plate and screws for the management of metacarpal fractures. These fractures are generally managed conservatively. Some orthopedic surgeons, prefer fixation with K-wire. However, rigid fixation cannot be achieved by K-wire. Further, pin infection, deformity, non-union and joint stiffness are common when managed with K-wire [18,19]. Internal fixation with Kirschner wire, tension band technique and isolated screws produces weaker fixation than mini-plate and screws. Mini-plate and screws fixation of unstable metacarpal fractures produces anatomical reduction of fractures with stabilization that is rigid enough to allow early mobilization, thereby preventing stiffness [20,21]. Plate fixation in closed multiple metacarpal fractures is necessary for several reasons. Firstly, metacarpal length is very likely to be reduced in multiple metacarpal fractures. This is more evident when a border metacarpal is involved, as it cannot rely on the adjoining metacarpals to hold it out to length. Definite guidelines for acceptable metacarpal shortening are lacking [22]. However, it is recognized that shortening as well as loss of the transverse arch, which result from multiple displaced metacarpal fractures. Plate fixation and anatomical reduction are very important in metacarpal rotation as one degree of metacarpal fracture rotation has been shown to produce 5° of fingertip rotation [11,23]. These factors that can compromise normal hand function by altering interosseous muscle anatomy and flexion and extension force ratios, both of which can lead to an asynchronous, non-integrated grasp resulting in reduced grip strength [22]. Plate fixation for metacarpal shaft fractures was found to be statistically advantageous in several parameters as compared to other varieties of treatment. These included grip

strength, digital range of motion, residual rotation, and DASH scores. Radiographic fracture reduction was achieved equally in all groups. Operative time was significantly longer for surgical plate implantation as compared with other methods of treatment [16,24]. Several authors have noted a large number of satisfactory outcomes after plate fixation of metacarpal fractures (Dabezies and Schutte, 1986; Ford et al., 1987; Hastings, 1987). Other authors have noted complication rates of up to 35% with plate fixation (Fusetti et al., 2002; Page and Stern, 1998; Stern et al., 1987). These studies must be interpreted cautiously as they include open and closed fractures, single and multiple fractures, combinations of metacarpal and phalangeal fractures and the use of implants not designed specifically for use in the hand [25,26]. Fusetti et al. (2002) are the only authors to report a series of multiple metacarpal fractures (19 patients) they speculated that the higher incidence of complications in their series of patients with multiple metacarpal fractures was related to the higher-energy trauma sustained by these patients [27]. Our data show that good outcome can be expected after plate fixation in closed multiple metacarpal fractures utilizing hardware specifically designed for use in the hand, provided the principles of internal fixation in the hand are followed at the final follow up all patients regained full flexion at metacarpophalangeal joint and interphalangeal joint with no extension lag. We agree with Hastings (1987) and Stern (2000) in that we think that the poor results published on plate fixation are not related to the plates, but stem from inappropriate patient selection, failure to apply biomechanical principles, faulty technique, poor soft tissue handling and inadequate functional aftercare [22,28]. The stable fixation with mini-plate and screws provides good functional results. Active mobilization can be started immediately after surgery; edema, fibrosis and scar formation can be reduced; and tendon gliding can be preserved [21].

5. Conclusion

Mini-plate and screws fixation of unstable metacarpal fractures produces anatomical reduction of fractures with stabilization that is rigid enough to allow early mobilization, thereby preventing stiffness and hence good functional results.

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