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A prospective study to analyse various methods of surgical fixation of metacarpal & phalangeal fractures

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Abstract
Introduction: Fractures of metacarpals and phalanges are among the most common injuries seen in emergency departments, constituting between 14% to 28% of all visits. Though large number of hand fractures can be treated conservatively, but in some fractures like unstable, intraarticular and malrotated fractures, operative treatment is indicated. The present study was undertaken to evaluate the results of surgical stabilisation of metacarpal and phalange fractures of the hand.
Method: A total of 25 patients of metacarpals and phalanges fractures of hand were included in this prospective study during the period April 2010-July 2013. Fractures were fixed with various fixation method as indicated. I.e. ORIF with Plate, ORIF with Screws, CRIF with Kirschner wires or External Fixator. Final evaluation of patients was done at the end of six months, based on criteria for American society for Surgery of Hand.
Results: A total of 34 digits were involved in 25 patients. 32.35% of the fractures were spiral/ long oblique followed by 29.41% short oblique followed by comminuted and transverse fractures. Most of the patients were treated by Open reduction and internal fixation with plates and screws (47%) followed by fixation with screws and kirschner wire. A total of 12 minor complications were observed in 10 patients out of a total of 25. Finger stiffness was the most commonly observed complication. Overall end result was graded as acceptable in 97.03% (excellent to good) and non-acceptable in 02.94% (fair) cases.
Conclusion: In conclusion, our series suggests that in low-severity fractures treated with miniature plates and screws, very favourable outcomes should be expected. Screw fixation was observed to give excellent results in spiral fractures of metacarpals and phalanges, while fixing fractures with kirschner wires trans fixation of joints should be avoided to get optimum results. Early mobilization is the key to get excellent functional results in all hand fractures.

Keywords: Hand fractures, metacarpal fracture, phalanx fracture, mini plate, condylar plate

1. Introduction
Fractures of metacarpals and phalanges are among the most common injuries seen in emergency departments, constituting between 14% to 28% of all visits [1, 2]. With rapid industrialisation and advances in agricultural machinery, the incidence of hand fractures has increased tremendously. Though large number of hand fractures can be treated conservatively, but in some fractures like unstable, intraarticular and malrotated fractures, operative treatment is indicated [3]. The goal of management of metacarpal and phalangeal fractures is to achieve bone healing and recovery of motion simultaneously, not consecutively. Many factors other than accurate reduction and fixation affect the recovery of good mobility. These include delicate handling of tissues, preservation of gliding planes for tendons, prevention of infection and early and appropriate physiotherapy [4]. There are various surgical options to achieve these goals ie. Both internal and external fixation. Screws are indicated for unstable, long oblique or spiral fractures of the metacarpals and phalanges. Plates at the metacarpal level are indicated for segmental defects with substance loss and oblique or transverse diaphyseal fractures [5]. Extremely communited fractures can be managed with External Fixator.
Keeping in view the advantages of early operative stabilization, the present study was undertaken to evaluate the results of surgical stabilization of metacarpal and phalange fractures of the hand.

2. Materials and Methods

A total of 25 patients of metacarpals and phalanges fractures of hand were included in this prospective study during the period April 2009-January 2012. All unstable metacarpal and phalange fractures, multiple fractures, intra articular fractures, avulsion fractures were included in this study. Patients below the age of 14 years, open fractures, fractures associated tendon injuries were excluded from the study.

A detailed history of the patient with special reference to the mode of injury, duration of injury, previous management and occupation of the patient was noted. Hand dominance was also noted. A detailed clinical examination was carried out. The operative procedure was explained to the patient and informed written consent taken. All patients were operated under suitable regional anaesthesia.

2.1 Fixation Techniques

2.1.1 Open Reduction with Plate Fixation

Plate fixation was used for transverse, comminuted and short oblique fractures of metacarpals. Fracture was exposed and reduced and fixed with a straight, condylar or 'L' mini plate after proper contouring. The plate was applied on dorsal surface of the metacarpal.

2.1.2 Open Reduction with Screw Fixation

Long oblique or spiral fractures of both metacarpal and phalanges were fixed by screws alone. The fracture was exposed, reduced and held by a towel clip. A hole was made at right angle to the fracture surface. The proximal cortex was over drilled to produce 'lag' effect. The distal cortex was tapped and a corresponding screw was tightened to produce compression at the fracture site.

2.2 Closed Reduction and Kirschner Wire Fixation

Percutaneous Kirschner wire fixation was done for fractures of proximal phalanx and metacarpal when closed reduction was possible. The fractures were reduced by traction and manipulation. These were then fixed with Kirschner wires percutaneously. The wires were bent and cut just outside the skin. A povidine iodine gauze was applied and a gentle compression bandage was applied. A plaster of Paris splint was applied.

2.3 Closed Reduction and External Fixation

External fixator was used for comminuted intra articular metacarpal fracture. Assembly of the frame was made in such a way, so as to provide adequate stabilization of fracture, while allowing mobility at the maximum number of joints. Whenever joints had to be immobilized, they were immobilized in functional position. In case of metacarpal fractures, a total of 4 schanz pins were used, 2 on each side of fracture, so as to engage 4 cortices on each side. The fracture was reduced and frame assembled over the pins.

All the patients were followed up clinically and radiologically, at regular intervals, to observe progress of healing, complications, if any, like infection, proximal migration of Kirschner wires, pin loosening, screw or plate prominence, stiffness and loss of reduction were noted. The Kirschner wires and External fixation devices were removed between 3 to 6 weeks. Plates and Screws were removed only if they caused problems like tendon adhesions or prominence.

Final evaluation of patients was done at the end of six months. It was based on criteria for American society for Surgery of Hand, which uses Total Active Range of Motion for digital functional assessment [6].

3. Results

All the affected patients were in the productive age group of 18-50 years. There was a marked male preponderance with males accounting for 96% of patients. Factory labourers were observed to be the most affected group (72%) in our study because maximum patient attending our institute are industrial worker. Most of the fractures were in the right hand accounting for 64% of the total injuries. Most of the patients in our study were observed to be right handed (96%). Majority of the patients in the present study had only a single digit involvement (55.88%). A total of 34 digits were involved in 25 patients. In our experience 32.35% of the fractures were spiral/ long oblique followed by 29.41% short oblique followed by comminuted and transverse fractures. (Chart 1) Most fractures in the present series were extra articular (97%). Extra articular fractures of metacarpals (96%) were observed to be as common as compared to phalangeal fractures (100%).

Four different techniques of fracture fixation were used, depending upon the fracture type, site and configuration. Most of the patients were treated by Open reduction and internal fixation with plates and screws (47%) followed by fixation with screws and kirschner wire. (Chart 2)

A total of 12 minor complications were observed in 10 patients out of a total of 25. No major complication was noticed. Finger stiffness was the most commonly observed complication, accounting for 3 fractures (8.82%), Deformity was observed in 6% of all fractures, while soft tissue infection, pain on passive movements of joints, aseptic loosening of k wires, and pin tract infection in 2.94% each. (Table 1)

A higher total active range of motion was observed with single digit involvement (73.68%) as compared to when the fractures involved more than one digit (40%). An oblique /spiral fracture has greater total active range of motion followed by transverse fractures. Comminuted fractures had least total active range of motion. Excellent total active range of motion was observed in fractures that were treated by open reduction and internal fixation with plate and screw (68%) or screw fixation (77.78%) and by closed reduction and percutaneous Kirschner wire fixation (25%) fractures). (Table 2)

The final grading of patients was based on the criteria used by American Society for Surgery of Hand which uses Total Active Range of Motion for final functional assessment [6]. The end result in the present series was graded as excellent good in 96% of patients. (Table 3)

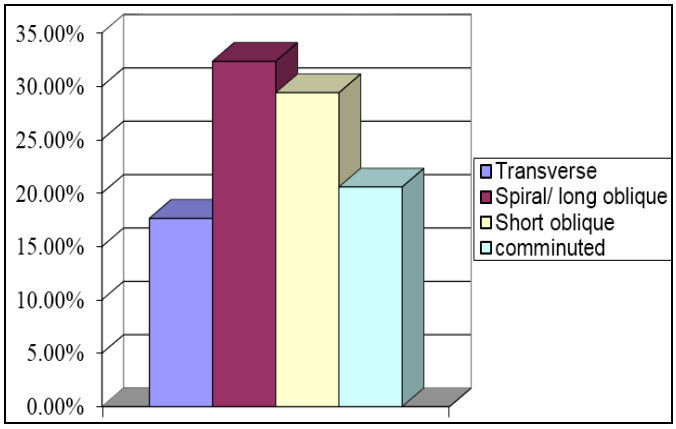

Chart 1: Fracture Patterns

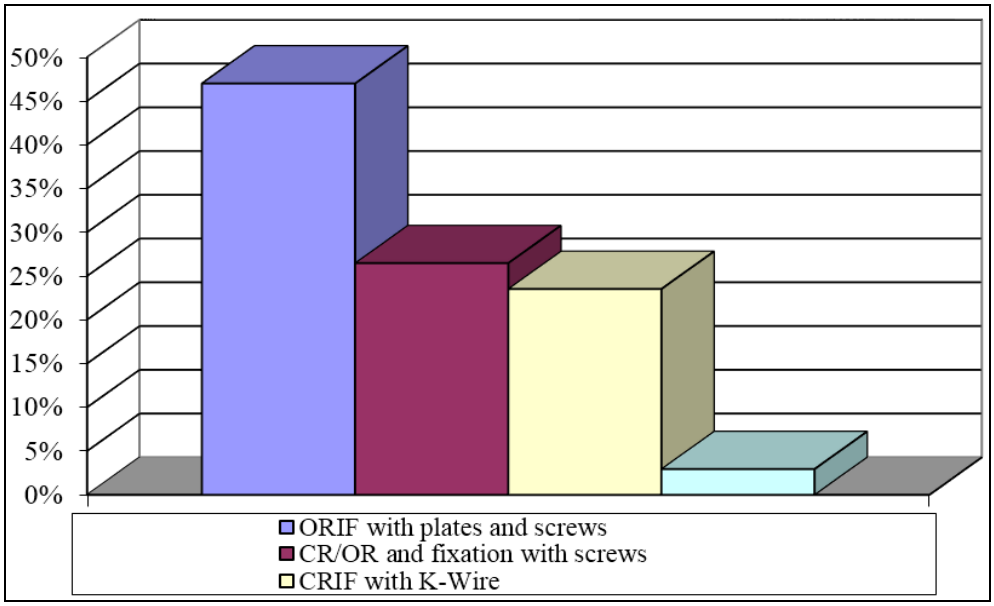

Chart 2: Methods of Fracture Fixation

Table 1: Postoperative Complications

Complications	Metacarpal fracture	Phalangeal fracture	total	Percentage (total 34 fractures)
Pain on passive movements of joints	1	0	1	2.94
Extension lag	0	0	0	0
Skin necrosis	0	0	0	0
Soft tissue infection	1	0	1	2.94
Vessel injury	0	0	0	0
Nerve injury	0	0	0	0
Aseptic loosening of k-wires/schantz screws	1	0	1	2.94
Pin tract infection	1	0	1	2.94
Tendon rupture	0	0	0	0
Finger stiffness	3	0	3	8.82
Finger clawing	0	0	0	0
Mal union	1	1	2	5.88
Non union	0	0	0	0
Deformity	1	1	2	5.88
Osteomyelitis	0	0	0	0
Articular incongruity	1	0	1	2.94

Table 2: Total active range of motion and technique of fixation

Group	Technique of fixation	Fingers (220^0-260^0) Thumb (119^0-140^0) No. (%)	Fingers (180^0-219^0) Thumb (98^0-118^0) No. (%)	Fingers (130^0-179^0) Thumb (70^0-97^0) No. (%)	Fingers (<130^0-179^0) Thumb (<70^0) No. (%)	Total
I	Open Reduction with plate and screw or screw fixation	11 (68.75%)	5 (31.25%)	0 (00.00%)	0 (00.00%)	16
II	Closed reduction and percutaneous Kirschner wire fixation	2 (25.00%)	5 (62.50%)	1 (12.50%)	0 (00.00%)	8
III	CR/OR and fixation with screws	7 (77.78%)	2 (22.22%)	0 (00.00%)	0 (00.00%)	9
IV	External Fixation	0 (00.00%)	1 (100.00%)	0 (00.00%)	0 (00.00%)	1

Table 3: Final Outcome

Result	Number of patients	Percentage
Excellent	17	68
Good	7	28
Fair	1	4
Poor	0	0
Total	25	100

Fig 1: Incision for Metacarpal Fracture Fixation

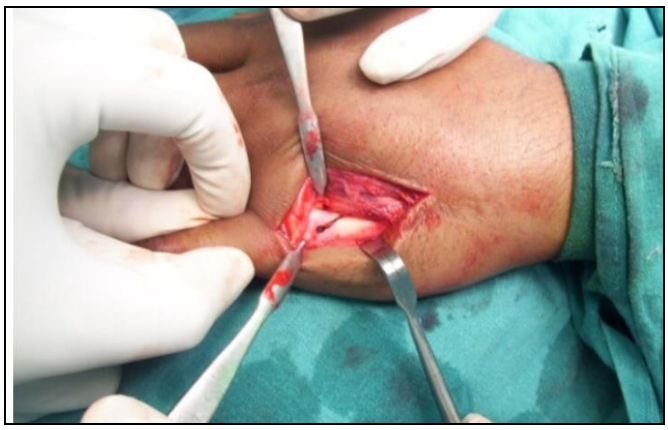

Fig 2: Exposure of Fracture for Plate Fixation

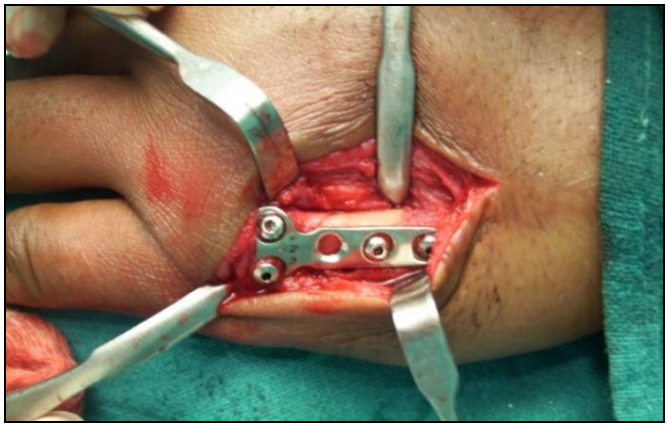

Fig 3: Mini Condylar Plate application

4. Discussion

The functional outcome of metacarpal and phalangeal injuries is important on account of the fact that not only hand is an important sensory organ but it is also an essential means of livelihood for most of the people. The conventional method of closed reduction and plaster of Paris cast immobilization is not very effective in maintenance of reduction and requires prolonged immobilization. On the other hand surgical stabilization of these fractures is expected to restore congruent reduction of fracture and its maintenance with the added advantage of early mobilization [7]. There has been much progress in developing versatile techniques for fixation of fractures in hand [8]. In literature, there is no consensus of opinion about the best technique of fixation for fractures of metacarpals and phalanges. This was the basis for using a variety of techniques of fixation in this series. We used screws alone or plates and screws, percutaneous Kirschner wires, external fixator, depending upon fracture type, site and configuration.

There were a total of 34 fractures in 25 patients. Metacarpal (27) fractures were more commonly observed than phalangeal (7) fractures. There were 17.64% transverse fractures, 32.35% spiral/ long oblique fractures, 29.41% short oblique fractures and 20.58% comminuted fractures. Shehadi also reported higher incidence of metacarpal (19) fractures than phalange (11) fractures in 30 cases of closed hand injuries. [9] Most of the fractures observed in the present series were extra reticular fractures (97.05%). Pun *et al*. and Chow *et al*. have also reported higher incidence of extra articular fractures in their study [10, 11].

Fractures were stabilized by plate and screws, screws alone, Kirschner wire and external fixator depending upon type of fracture, fracture site and configuration. Open Reduction and Plate Fixation was done in 16 (47%) fractures. Early movements were started in all the cases. 68.75% excellent and 31.25% good totals active of range of motion obtained in the fractures treated by this technique. Page and stern have reported high incidence of/complications with plate fixation especially in Phalangeal fractures [12]. The results are comparable to those obtained by Bosscha and Snellen (92%) excellent, total active range of motion) [13]. We observed minor complication like superficial infection 1 (06.25%), finger stiffness 3 (18.75%) which responded to early physiotherapy and malunion in 1 (06.25%) metacarpal fracture.

Open reduction with screw fixation was done for stabilization of 5 metacarpals and 4 phalanx fractures. All these fractures were long oblique or spiral configuration. All the fractures united well in time. 77.78% of the cases achieved excellent and rest of the 22.22% achieved good total active range of motion. Multiple fractures had lesser range of movements as compares to single fracture. Crawford observed that although screw fixation was excellent for proximal phalangeal fractures, it did not offer much advantage over conservative means for similar metacarpal fractures [14]. This is disputed by Dabezies and Schutte who advocated screw fixation for spiral fractures of metacarpals as these are prone to rotational deformities [15]. Shewring and Thomas have also recommended surgical stabilization of avulsion fractures with a screw as the fractures, which were not stabilization, went into non-union [16].

In 8 fractures closed reduction and percutaneous Kirschner wire fixation was done. This included three phalangeal fractures and five metacarpal fractures. Of the 8 fractures treated, 25% achieved excellent and 62.50% achieved good total active range of motion which is inferior to results observed by Belskey *et al*. and Green and Anderson. Belskey *et al*. in their series of 100 cases of phalangeal fractures, treated by closed reduction and percutaneous Kirschner wire fixation, have reported 60% excellent results [17]. Similarly Green and Anderson treated 26 fractures and reported excellent total active range of motion in 18 of them (68%) [18]. We treated only one metacarpal fracture by external fixation. It was a closed comminuted intra articular fracture of base of 5th metacarpal. We achieved good total active range of motion in this case. The number of cases treated with this technique are too less to compare the results with other studies.

A total of 12 minor complications were observed in 10 patients out of a total of 25. Finger stiffness (8.82%) was the most commonly observed complication in the present series probably on account of formation of adhesions of extensor

tendons and contracture ligaments. One patient had superficial soft tissue infection which responded to regular aseptic dressings. One patients with fracture of proximal phalanx developed angulation at fracture site after kirschner wire was removed three weeks postoperatively before any radiological union. One patient developed articular incongruity of comminuted intra articular fracture fixed by spanning external fixator. Overall incidence of complications in the present study was observed to be higher in metacarpal fracture (83.33%) as compared to phalangeal fractures (16.67%), because there were more metacarpal (27) fractures than phalangeal (7) fractures. Swanson *et al*. have reported a higher incidence of finger stiffness in phalangeal fractures as compared to metacarpal fractures [19]. Similarly page and stern have also reported higher incidence of complications in phalangeal fractures (92%) treated with plate fixation [12]. In contrast the incidence of complications observed by them in metacarpal fractures was only 36%. Ouellette and Freeland reported 67 complications in 40 fractures treated by mini condylar plates. Most of their reported complications involved phalangeal fractures [20]. Stern *et al*. reported complications in 16 patients out of 38 treated by plate fixation (42%). They also observed that the complications occurred more frequently in phalangeal fractures (67%) than metacarpal fractures (34%) [21]. Fusetti *et al*. in their series of hand fractures reported complications in 35% of their patients [22].

Final total active range of motion was observed to be much better in metacarpal fractures (100% excellent to good grading) as compared to phalangeal fractures (85.70% excellent to good grading). The results of present study following surgical stabilization of fractures of metacarpals and phalangeal were observed to be superior to those reported by Duncan *et al*. (63% excellent and good for metacarpal fractures) and (32% excellent and good for phalangeal fractures) and pun *et al*. 47(31% good results of operative fixation) [23, 10]. Final total active of motion was observed to be fair in 14.28% of phalangeal fractures with no poor results. Drenth and kiasen have reported 16.7% of poor grading in metacarpal fractures and 28.6% poor grading for phalangeal fractures (19%) [3]. Page and Stern have also reported 76% excellent or good grading of total active of motion in metacarpal fractures and 11% excellent or good grading in phalangeal fractures [12]. Similarly Quellette and Freeland in their series reported high percentage of excellent total active range of motion scores for metacarpal (54%) than for phalangeal fractures [20].

In the present study overall end results of hand fractures managed by surgical stabilization were graded as acceptable in 97.03% (excellent to good) and non-acceptable 02.94% (fair). The overall end results in the present study are comparable to those reported by Freeland (80% excellent to good), Tan *et al*. (79% excellent to good) and Schuind *et al*. (96% excellent to good) [24-26]. The end results in the present study are better than those reported by Drenth and Klasen (55% excellent to good), And Ouellette and Freeland (38% of excellent and good results) [3, 20]. This is probably on account of the fact that their study involved only open fractures. The present study, therefore, reaffirms the findings of tan *et al*. and Bosscha and Snellen that surgical stabilization of hand injuries is quite useful in improving the final outcome [25, 13]. This Study corroborates the findings of Page and Stern, Schuined *et al*. and Duncan *et al*. that the outcome is much better in metacarpal fractures as compared to phalange fractures [12, 26, 23]. Further, it is advisable to avoid Trans fixation of joints wherever possible so as to decrease the chances of joint stiffness to minimum.

5. Conclusion

In conclusion, our series of metacarpal and phalangeal fractures suggests that in low-severity fractures treated with miniature plates and screws, very favorable outcomes should be expected, and that this subgroup of fractures could be a good indication for this type of fixation. Screw fixation was observed to give excellent results in spiral fractures of metacarpals and phalanges, while fixing fractures with kirschner wires trans fixation of joints should be avoided to get optimum results. Final total active range of motion achieved in patients of hand fractures was observed to be better in metacarpal fractures than the phalangeal fractures. Fractures with single digit involvement were observed to be other important determinant in achieving a better grade of total active range of motion. The functional results do not always correspond to excellence of fixation as seen radiologically. Early mobilization is the key to get excellent functional results in all hand fractures.

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