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A prospective study of functional outcome between Mini-plates and percutaneous K-wire fixation following metacarpal shaft fractures

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Abstract
Background: Metacarpal fractures comprise between 18–44 % of all hand fractures. Too often these metacarpal fractures are neglected or treated as minor injuries and results in major disability and deformity with permanent crippling of fine movements. A stable fracture fixation helps in restoring early mobilization. Early mobilization can prevent adhesions and is the key to good clinical outcome.
Methods: Thirty six patients with metacarpal fractures were surgically fixed with k-wire or plate and screw in our trauma centre. 27 males and 9 females patients were part of the study. Radiographs of affected hand, both AP & Lateral views were obtained before surgery, post- surgery, and at follow-ups.
Results: In this study, after 6 weeks of follow up it was found that metacarpal shaft fractures fixed with ORIF with mini plates show better functional outcome compared to CRIF with percutaneous K-wires. Finger stiffness being the commonly encountered complication.
Conclusions: Mini-plates fixation in oblique and spiral fractures provide stable and rigid internal fixation that allows early active range of motion and early excellent results. Percutaneous K-wire fixation has the advantages of preserving the soft tissue.

Keywords: Metacarpal shaft fracture, finger stiffness, k-wire, plates and screws

Introduction
Metacarpal fractures account for 18–44 % of all hand fractures [1-3]. Most metacarpal fractures occur in the active and working population, particularly adolescents and young adults. Incidence of trauma to the hand has increased for the years, frequently resulting in metacarpal, fractures and dislocations [3-4].
Fractures of the metacarpal bones of the hand are one of the most frequently encountered orthopaedic injuries constituting between 14-28% of all visits to the hospital following trauma by various means like self-fall, assault, road traffic accidents, industrial accidents, agricultural accidents [5].
Metacarpal fractures are often neglected or treated as minor injuries, resulting in major disability and deformity with permanent crippling of fine movements of the hand. Metacarpal fractures can be complicated by deformity from no treatment, stiffness from over treatment and both deformity and stiffness from poor treatment [6].
Many factors, such as delicate handling of tissues, preservation of gliding planes for tendons, prevention of infection and early and appropriate physiotherapy other than accurate reduction and fixation affect recovery of good mobility.
In this prospective clinical study we have tried to analyse various mechanism and patterns of metacarpal fractures and their surgical management, functional outcomes, and complications following surgical treatment.

Methods
Patients admitted to SSMC, Tumkur form June 2017 to December 2018 diagnosed with displaced metacarpal shaft fractures were prospectively observed and included in the study group.
Thorough clinical history was taken from the patient and/or attendants to know the mechanism of the injury and the severity of the trauma, site of the incident,

circumstances about which the injury occurred. Radiographic evaluation including antero posterior and oblique radiographs of affected hand were obtained.

Out of total 36 cases, 18 cases of Metacarpal fractures were treated with CRIF with K-wire (Group A) and 18 cases were treated by ORIF with plate and screws (Group B).

Medically fit patient were then taken up for surgery after written valid consent.

Hand and distal half of forearm was scrubbed with betadine scrub and savlon solution. Pneumatic tourniquet was used in all patients after exsanguination of blood. Operative site painted with betadine solution.

Internal fixation with plates and screws

A linear incision measuring about 3-4 cm was made centring over the fracture site dorsally. Superficial fascia and extensor tendon were retracted, dorsal interosseous muscle were retracted after incising the periosteum, and fracture site was identified.

The fracture was reduced with reduction forceps. The chosen plate was contoured to the dorsal surface of the metacarpal when necessary. The reduction was maintained over which plate was fixed through screw hole adjacent to the fracture site. The drill bit 2.0mm in size and the screws of 2.7 mm in size were used.

Anatomical reduction was achieved and maintained by an assistant while the first drill hole on the other side of the fracture was drilled away from fracture. After measuring the depth and tapping the hole, second screw was inserted. Both the screws were terminally tightened, then remaining screws were placed.

The wound is closed in layers and sterile compression bandage applied (Figure 1).

Fig 1: 3rd and 4th metacarpal fracture managed by mini-plate

Internal fixation with Kirschner wires

Surgery was performed under fluoroscopic guidance. The fracture was reduced using the closed method, in which the metacarpophalangeal and proximal interphalangeal joints are flexed to an angle of 90 degrees, and upward pressure with traction was applied on the flexed finger to correct dorsal angulation and rotational deformity. Once the fracture was reduced, a K-wire was inserted through the metacarpal head in the retrograde direction, while reduction is maintained. After insertion of the first K-wire, another K-wire was inserted in the same manner for angular and rotational fracture stability. Then, the wrist was maintained into a fully flexed position, and the wires were sequentially advanced farther through the dorsal subchondral bone of the metacarpal bone, soft tissue overlying the carpal bone, and dorsal skin. The distal end of the wires was just within the subchondral bone of the metacarpal head, clear of the articular surface. The wires were bent back distally the point of bending being where the wires emerged from the metacarpal. This bend takes the wires clear of the wrist joint (Figure 2).

Fig 2: 4th and 5th metacarpal fractures managed by k wire fixation

Post-operative period

Active movements of fingers were advised as early as possible and aggressive hand physiotherapy within patient's pain limit is instituted.

The wound inspected on 2nd post-operative day. Sutures were removed on 12th or 14th day depending on the condition of the wound.

Follow up

At 4 weeks, clinical examination was done regarding tenderness at fracture site and movements of the affected metacarpo phalangeal joints and inter phalangeal joints was assessed. X-rays were analysed for any signs of callus formation, and assess the implants position.

In Patients treated with k-wire, at the end of 6 weeks k-wire was removed under local anaesthesia in outpatient department.

Regular clinical and radiological follow up was done at an interval 8 weeks and 12 weeks. At the follow up, attention was paid to complications like, stiffness, malunion, nonunion.

By 24 weeks, complete consolidation of fracture site was seen radiologically in all cases.

No patient was lost to follow up.

Results

Dash Score

DASH score at final follow up (after 3 months) in group A was excellent in 16 patients (88.8%), good in 1 patients (5.6%) and fair in 1 patient (5.6%), while in group B, results were excellent in 12 patients (66.6%), good in 4 patients (22.2%) and fair in 2 patient (11.2%). (Table 1)

Table 1: Dash Score

DASH Score	Group A (N = 18)		Group B (N = 18)	
	N	%	N	%
Excellent	16	88.8	12	66.6
Good	1	5.6	4	22.2
Fair	1	5.6	2	11.2

Union

In group A, time of union ranged between 4 and 6 weeks. While in group B, time of union ranged between 6 and 7 weeks. Although the mean time of union was better in group A, the results were statistically insignificant (Table 2).

Table 2: Comparison between the two studied groups according to time of union

Time of Union	Group A (N = 18)		Group B (N = 18)	
	N	%	N	%
4 weeks	2	11.1	1	5.6
5 weeks	13	72.2	4	22.2
6 weeks	2	11.1	8	44.4
7 weeks	1	5.6	5	27.8

Hand grip

In group A, 14 patients had strong hand grip (77.8%), 3 patients had average hand grip (16.6%), one patient had weak hand grip (5.6%). While in group B, 13 patients had strong hand grip (72.2%), 3 patients had average hand grip (16.6%), 2 patients had weak hand grip (11.2%). Although the hand grip was better in group A, the results were statistically insignificant (Table 3).

Table 3: Comparison between the two studied groups according to hand grip

Hand Grip	Group A (N = 18)		Group B (N = 18)	
	N	%	N	%
Strong	14	77.8	13	72.2
Average	3	16.6	3	16.6
Weak	1	5.6	2	11.2

Complications

In this study three patients (8%) developed stiffness of the fingers.

There was no cases with nonunion, malunion, skin necrosis, hardware prominence.

Discussion

Hand is a specialized structure interacting with the environment, is especially sensitive to functional impairment. The prime functions of hand are feeling (sensibility) and motion. Hand performs the mechanical functions of hook, as in tilting a book from a shelf**;** grasp, as in picking it up; pinch, as in turning its pages. The loss or diminution of any of these functions is a serious blow.

The incidence of metacarpal fractures is most common in males and peaks between age 10 and 40 years a time when athletic and industrial exposure is the greatest. Fracture healing in the hand is not an isolated goal; rather the functional result is of paramount importance.

In our series majority of the patients were males, 27 patients (75%) as compared to study by fusseti C *et al.* [7] (79%), kelesh G and Ulrich C [8] (92%).

Right handed predominance in 27 cases (75%) compared to the left side is seen in our study which is comparable to study by fusseti C *et al.* (74%).

In our series all metacarpal fractures were closed injury and compound fractures were not included in this study. Transverse fractures were the most commonly observed pattern in this study.

Mode of injury in majority of cases is RTA, 18 cases (50%) followed by self-fall on outstretched hand, 10 cases (27.8%) and assault, 8 cases (22.2%) as compared to study by kelesh G and Ulrich C (45%) fall on outstretched hand was most common mode of injury.

Open reduction and intramedullary k-wire osteosynthesis of metacarpal bones stands out because of the simplicity of the method and the fact it puts least strain on sliding tissue however chances of stiffness of finger and pin tract infection are much higher.

ORIF of metacarpal fractures with plate and screws provide two basic objectives of rigid internal fixation.

a) Maintenance of precise alignment of fracture
b) Facilitation of early active motion thus minimizing stiffness

The technique of plate fixation in the hand is well documented but there are many drawbacks. Stern *et* al [9] stated that main disadvantage of plate was their size and wide exposure necessary for plate fixation and this may involve extensive periosteal stripping. Plate is usually placed under the extensor apparatus and can interfere with tendon gliding.

Closed reduction with subsequent intramedullary k-wire (CRIF) under image intensifier produce good functional result in long term. With low rate of complication CRIF with k-wire under image intensifier can be recommended for stabilization of metacarpal fracture and implant removal at outpatient department is the further advantage.

Despite early active motion, stiffness was most frequent complication.

All-though in this study sample size is small (36 cases), With low rate of complication, CRIF with k-wire under image intensifier can be recommended for stabilization of metacarpal fracture, intraoperative image intensifier radiation is the only drawback and implant removal at outpatient department is the further advantage.

Conclusion

Mini-plates fixation in oblique and spiral fractures provide stable and rigid internal fixation that allows early active range of motion and early excellent results. Percutaneous K-wire fixation has the advantages of preserving the soft tissue. Multiple metacarpal fractures treated surgically gives better results than those treated conservatively.

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