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# A COMPREHENSIVE STUDY OF THE VARIOUS TECHNIQUES FOR MANAGEMENT OF CLOSED METACARPAL FRACTURES

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### Abstract

**Background:** Metacarpal fractures are one of the most common fractures of the upper extremity particularly involving young adults. The ideal treatment option for metacarpal fractures depend on the fracture location, fracture geometry and fracture stability. The objective of the study was to analyze the treatment outcome in closed metacarpal fractures treated by various conservative and operative modalities.

**Materials and Methods:** 73 closed metacarpal fractures in 59 patients treated in a tertiary care medical teaching hospital between September 2015 and March 2019 were enrolled in the study. 7 patients were lost for follow-up leaving 52 patients with 65 metacarpal fractures for the final analysis. Conservative treatment with volar splint or thumb spica was the first line of treatment. Patients with unstable fracture patterns, irreducible deformity and significant shortening were treated by various surgical modalities. Belsky Criteria for assessment of finger injuries with special emphasis on Total Active Movement (TAM) of the involved finger was used to assess the results with clinical and radiological parameters at three months.

**Results:** Conservative treatment with closed reduction and volar splint or thumb spica was used for 39 fractures (60%). Surgical treatment was used in 26 fractures (40%). The results with conservative management were 18 excellent results (46.15%), 17 good results (43.58%) and 4 poor results (10.2%). The results with the various surgical methods were 10 excellent

results (38.46%), 12 good results (46.15%) and 4 poor results (15.38%). Complications in the conservative treatment group were 3 malunions, 2 cases with extensor lag and 4 cases with stiffness of the involved finger. Complications in the operative treatment group were 1 malunion, 3 cases with extensor lag, 2 patients with superficial pin infections and 4 cases with stiffness of the involved finger.

**Conclusion:** Conservative treatment is the gold standard for treatment of metacarpal fractures. Fractures treated by this method are sufficiently stable to allow mobilization by 4 weeks thereby avoiding finger stiffness. In some carefully defined fracture patterns, surgical treatment gives the advantage of stability of fixation to allow early mobilization. The aim of the various surgical treatment methods should be to achieve results comparable to conservative treatment methods and not to replace conservative methods of treatment.

**Keywords:** Metacarpal fracture, K-wire, Belsky Criteria, Total Active Motion (TAM)

## Introduction:

The metacarpals provide a stable platform for the phalanges and palmar neurovascular structures and thus help in efficient functioning of the fingers and the thumb.<sup>1</sup> Fractures of metacarpals and phalanges constitute between 14-28% of all visits to the emergency department.<sup>2</sup> Functional outcome of the fractures of small bones of the hand is partly dependent upon the severity of initial injury and its management.<sup>3</sup> Fracture healing in the hand is not an isolated goal; rather, the functional end result is of paramount importance.<sup>4</sup> Very often these fractures are neglected or treated as minor injuries and results in major disability and deformity with permanent crippling of fine movements. The key in metacarpal fracture is to strike a balance between immobilizing to achieve union and stiffness from over immobilization.<sup>5</sup> The primary goals of treatment are to achieve acceptable alignment, stable reduction, strong bony union, and unrestricted motion. In this study we have tried to evaluate the mechanism of injury, fracture characteristics (types and patterns) and the functional and radiological results of various methods of treatment of closed metacarpal fractures of hand.

## Materials And Methods:

The study is a prospective study of 73 closed metacarpal fractures in 59 patients treated in a tertiary care medical teaching hospital between September 2015 and March 2019. All patients aged more than 16 years with closed metacarpal fractures (single or multiple) managed by conservative or surgical methods were included in this study. Patients with additional fractures in the same hand and ipsilateral extremity were excluded from the study. Patients with open

metacarpal fractures and pathological fractures were also excluded.

On presentation to the hospital, a detailed history was taken and a meticulous examination was done to assess the site of injury, the overlying soft-tissue condition, the deformity and neurological and vascular status of the involved ray. In particular, care was taken to assess the patient for tendon tears which would require supplemental tendon repair. Standard radiographs of the hand were performed which included an antero-posterior and oblique views to confirm the diagnosis and to assess the fracture pattern, location and to look for associated injuries in the same finger or in other fingers.

The accepted criteria for conservative treatment were undisplaced or minimally displaced fractures, apex dorsal angulation of less than 10° in the thumb, index and middle finger, 25° in the ring finger and 45° in the little finger and shortening of the ray of less than 5mm.<sup>6</sup> Inability to correct rotational mal-alignment and any degree of scissoring of the fingers (overlap of fingers) after attempted closed reduction was taken as an indication for surgical management. Inability to maintain reduction resulting in unacceptable angulation as described above, multiple metacarpal fractures and shortening of more than 5mm were other indications for surgical management.

Closed reduction was achieved by gentle longitudinal traction in most cases. In cases with flexion deformity, reduction was achieved by exerting pressure on the metacarpal head from the palmar aspect, either directly, or using the proximal phalanx as a piston. In spiral oblique fractures, shortening of the metacarpal was associated with rotational malalignment

where reduction was achieved by a combination of longitudinal traction on the finger and derotation.<sup>7</sup> The reduction was secured by a volar splint applied with wrist in 30° of extension and the metacarpophalangeal (MCP) joints in 90° of flexion and interphalangeal (IP) joints in extension (Edinburgh position). The main aim of placing the hand in the Edinburgh position is to ensure the MCP joint collateral ligaments are fully stretched in flexion and the IP joint collateral ligaments are maximally stretched in extension, thus preventing contractures and limiting full recovery of movements.<sup>8</sup> Care was taken to mould the splint in the desired position and the splint was secured by elastic bandage. The tips of all the fingers were visualized through the splint to ensure that there was no abnormal shortening or rotation in the fingers. A potential disadvantage of this technique was the complete immobilization of uninjured fingers and joints. There is a described technique of using a forearm splint upto the MCP joint and inserting a pre-bent aluminium splint on the injured finger so as to mobilize the other fingers. The drawback of this method is that this technique has less control over rotation. We have no experience using this method. Fractures of the first metacarpal were immobilized with a well padded thumb spica keeping the thumb in 30° of abduction. Immediately after application of the volar splint or the thumb spica, an X-ray was performed to assess loss of reduction.

All patients who underwent operative intervention were taken up for surgery under general anesthesia or regional anesthesia. The most common fixation method used was closed reduction and percutaneous K-wiring. The K-wires were inserted

retrograde from the metacarpal head either through the medullary canal (single K-wire) to transfix the carpometacarpal joint or in a cross-pinning method (two K-wires) in which the carpometacarpal joint is spared. When cross-pinning was done, the K-wires were inserted from near the origin of the collateral ligaments to avoid injury to the articular surface. The K-wires crossed each other either proximal or distal to the fracture site to achieve maximum stability. The described technique for treating metacarpal neck fractures is with a single or multiple bent K-wire (boquet technique) inserted antegradely from the metacarpal base on the dorsal surface to the metacarpal head. We have no experience with this technique. Occasionally, some patients with irreducible fractures of the metacarpal necks with irreducible angulation needed open reduction and K-wiring. Patients who underwent K-wiring were protected by a splint. Joshi's External Stabilizing System (JESS) fixator<sup>9</sup> was used in few patients with first, second and fifth metacarpal fractures with the advantage of not requiring a splint and early mobilization at the end of one week under the supervision of a therapist. Open reduction and internal fixation with mini-plates and 2mm cortical screws by dorsal approach was used in some young, high-demand patients. These patients were splinted for a week until edema subsided and were then mobilized under the supervision of a therapist. We have no experience with isolated lag-screw fixation.

Follow-up check x-rays in the splint were advised after one week to look for loss of reduction. Immobilization was continued until 4 weeks at which time an x-ray without the splint was taken to confirm healing. In most cases, the

fracture line was still visible. Splinting was discontinued and mobilization was initiated. At 8 weeks patient was reassessed and full manual loading was permitted. A final clinical and radiological evaluation was done at three months for total active motion (TAM) of the finger, pain, deformity and to confirm union. Belsky's criteria<sup>10</sup> was used to assess the result of second to fifth metacarpal fractures. The TAM of these fingers was calculated by adding the active flexion of the MCP,

PIP and DIP joints and subtracting any extensor lag in these joints. The TAM of a normal finger was seen to be 260°. The results were graded as presented in Table 1. Fractures of the first metacarpal were assessed based on the Total Active Flexion (TF) of the thumb and Palmar Abduction (PAB). The normal TF of the thumb is 140° and the normal PAB was 45°. The results of first metacarpal fractures were graded as presented in Table 1.

**Table 1: The Belsky Criteria assessment of finger injuries<sup>10</sup>**

For the second to fifth ray		
Excellent	Good	Poor
Pain-free union No deformity TAM > 215°	Pain-free union Minimal deformity (Deformity detected by the surgeon, not noticed by the patient TAM 180°-215°	Painful finger movements Non-union Mal-union TAM < 180°
For the first ray		
Excellent	Good	Poor
Pain-free union No deformity TF > 100° PAB > 40°	Pain-free union Minimal deformity (Deformity detected by the surgeon, not noticed by the patient TF 75°-100° PAB 30°-40°	Painful thumb movements Non-union Mal-union TF < 75° PAB < 30°

## Results:

During the study period, 59 patients with 73 metacarpal fractures were enrolled and treated by non-surgical and surgical methods. Of these, 7 patients were lost for follow-up at the final analysis at three months leaving 52 patients with 65 metacarpal fractures for the final analysis.

Males had a significantly higher frequency of metacarpal fractures as compared to females. Majority of the patients were youngsters in the age group of 16-40 years with a mean age of 36 years. The most frequent mode of injury was road traffic accidents followed by domestic falls, sports injuries, work injuries and assaults. The right upper limb was more frequently

involved as compared to the left. 39 of the 52 patients presented with a single metacarpal fracture while 13 patients presented with multiple metacarpal fractures. The fifth metacarpal was the most commonly injured, followed by fourth, third, second and first. Metacarpal shaft fractures were most common followed by base, neck and head. Metacarpal neck fractures were particularly more common in the fifth and fourth metacarpals. Transverse fracture patterns were the most common followed by oblique, comminuted and spiral patterns.

Conservative treatment with closed reduction and volar splint or thumb spica was used for 39 fractures (60%). Surgical treatment was used

in 26 fractures (40%). The surgical methods included CRIF with K-wires (13 patients), ORIF with K-wires (6 patients), CRIF with JESS (4 patients) ORIF with mini-plates (3 patients). The duration of immobilization ranged between 1 and 5 weeks. Patients with JESS and mini-plates were mobilized after one week, as tolerated, under the supervision of a therapist. All other patients were immobilized with a volar splint or thumb spica for 4-5 weeks. The mean duration of immobilization was 3.95 weeks.

During tabulation of the final functional result, each metacarpal bone was considered as a separate entity in multiple fractures. The final results with the conservative line of management were 18 excellent results (46.15%), 17 good results (43.58%) and 4 poor results (10.2%). The results with the surgical methods were 10 excellent results (38.46%), 12 good results (46.15%) and 4 poor results (15.38%). Of the 4 fractures with poor results in the conservative treatment group, 3 had pain, 3 had malunion, 2 had extensor lag and all 4 had stiffness of the involved finger ( $TAM < 180^\circ$ ). Of the 4 fractures with poor results in the operative treatment group, 2 had pain, 1 had malunion, 3 had extensor lag and all 4 had stiffness of the involved finger ( $TAM < 180^\circ$ ). This fact is being mentioned here to highlight the fact that fractures with poor results had more than one complication. 2 patients had superficial pin tract infections which resolved with pin removal and did not need any antibiotics.

The mean TAM for the second to the fifth ray with all modalities of treatment was 220 degrees (range  $120^\circ$ - $260^\circ$ ) while the mean TF for thumb was 106 degrees (range  $45^\circ$ - $140^\circ$ ).

**Table 2: Demographic and fracture characteristics**

Variables			Percentage
Age (n=52)	16-40	31	59.6%
	41-65	19	36.5%
	>65	2	3.8%
Sex distribution (n=52)	Male	43	82.6%
	Female	9	17.3%
Mode of injury (n=52)	RTA	22	42.3%
	Domestic fall	14	26.9%
	Sports	7	13.4%
	Work injuries	5	9.6%
	Assault	4	7.6%
Side involved (n=52)	Right	34	65.3%
	Left	18	34.6%
Metacarpals involved (n=52)	Single	39	75%
	Multiple	13	25%
Ray involved (n=65)	First	10	15.3%
	Second	10	15.3%
	Third	11	16.9%
	Fourth	12	18.4%
	Fifth	22	33.8%
Location of fracture (n=65)	Head	5	7.6%
	Neck	9	13.8%
	Shaft	34	52.3%
	Base	17	26.2%
Fracture type (n=65)	Transverse	30	46.2%
	Oblique	17	26.1%
	Spiral	7	10.7%
	Comminuted	11	16.9%

**Table 3: Results of treatment**

Treatment Modality	Results			Total
	Excellent	Good	Poor	
Conservative	18	17	4	39
Surgical	10	12	4	26
Total	28	29	8	65

**Table 4: Break-up of different treatment modalities**

Treatment Modality	Results			Total
	Excellent	Good	Poor	
Volar splint	16	12	4	32
Thumb spica	2	5	0	7
CRIF with K wires	4	7	2	13
ORIF with K wires	3	2	1	6
CRIF with JESS	2	1	1	4
ORIF with Mini-plates	1	2	0	3
Total	28	29	8	65

### Discussion:

The incidence of metacarpal fractures is third in frequency only to phalangeal fractures and distal radius fractures in the upper limb.<sup>12</sup> Approximately 70% of these fractures

occur during the second and fifth decades of life.<sup>13</sup> The most common mechanism of injury for metacarpal fractures is trauma, with a higher risk while playing sports or while at work. Work injuries are often crush-

type injuries and can result in open fractures. Sporting injuries are more often the result of a rotational torque to the digit causing a spiral or oblique fracture pattern. Trauma induced with a closed fist results in a high frequency of metacarpal neck fractures.

The metacarpals are inherently stable secondary to the origins of the intrinsic muscles of the hand as well as the stout attachments of the deep transverse intermetacarpal ligaments. The third and fourth metacarpals have the most inherent stability secondary to their central location, while the first, second and fifth metacarpals are more prone to shortening, rotation, and angulation. The CMC joints increase in stability and decrease in dorsal-volar mobility when moving from the small to index finger metacarpal. The implications in this mobility are apparent, as the small and ring fingers are far more tolerant to deformity than are the index and middle finger metacarpals. The fifth metacarpal neck is the most commonly fractured metacarpal. The index finger tolerates the least amount of angulation while the small finger can tolerate up to 50 degrees. In isolation, metacarpal neck fractures can be treated without surgery.<sup>14</sup>

A vast majority of metacarpal fractures are inherently stable and can be treated via closed means. The central digits are more protected from deformity secondary to the stabilizing effect of the deep transverse intermetacarpal ligaments. Cadaver studies have demonstrated that for every 2 mm of shortening, there is approximately 7 degrees of extensor lag. As most MCP joints hyperextend by about 20 degrees, a total of 5 to 6 mm of shortening can be tolerated to get the MCP joint to neutral. Angulation in the sagittal plane

(e.g., apex volar/dorsal) has variable tolerability based on each metacarpal bone. The tolerability is decreased moving from ulnar to radial with the index and middle metacarpal shaft only able to tolerate about 10 degrees. The ring finger can tolerate close to 25 degrees while the small finger can tolerate up to 45 degrees. Malrotation or scissoring is the least tolerated of the deformities. Any deformity of greater than 10 degrees which causes the adjacent finger to impinge or cross over requires surgical intervention.

Despite good results with closed treatment, certain fractures necessitate operative fixation for better results. K-wires are the most commonly used fixation devices for metacarpal fractures. K-wires can be used for every type of fracture pattern (transverse, oblique, spiral, comminuted) due to their easy availability, percutaneous insertion, and relative ease of use. However, they often lack significant rigidity, can migrate, are prone to infection, and may be uncomfortable during rehabilitation. Fracture location and geometry often determines the type of pin construct. Intramedullary K-wires (both antegrade and retrograde), cross pinning and transfixation pinning<sup>15</sup> are the commonly used methods. Wherever necessary, lag screws, plate and screw constructs and JESS fixators can offer superior rigidity, allowing earlier range of motion than K-wiring or conservative management. As with any surgical procedure, patient selection remains the key for good outcomes. In our study, a careful selection of cases for surgical management helped us achieve clinical results equal to conservative management considering that conservative management remains the gold standard for comparison of results.

Our study had certain drawbacks. Firstly, though our study had a sizeable number of patients enrolled for the treatment we had a high drop-out rate. This was because many of these patients were migrant labourers who presented to us for initial treatment but were later lost to follow-up. Secondly, the use of TAM for each finger and considering each finger as a single entity for analysis of results may confound the analysis when multiple metacarpals are involved in the same hand. Some studies have suggested that in patients with multiple fractures, the results be presented per hand/patient and not as a sum of the single fractures. The TAM of all injured fingers on one hand is measured and the final result be based on the TAM of the worst of the fingers involved. We have not followed this method of analysis in the present study.<sup>10</sup>

## Conclusion:

Metacarpal fractures remain one of the most common musculoskeletal-related injuries in the young active patient. In the management of closed metacarpal fractures of hand by various treatment modalities, it is important to understand the various fracture patterns to select the most suitable treatment option. Conservative treatment is the mainstay of treatment for most fractures. Fractures treated by this method are sufficiently stable to allow mobilization by 4 weeks thereby avoiding finger stiffness. In some carefully defined fracture patterns, surgical treatment gives the advantage of stability of fixation to allow early mobilization. With a judicious approach to case selection, both conservative and surgical modalities of treatment give comparable results. However, in recent years, the availability of hand surgeons, newer



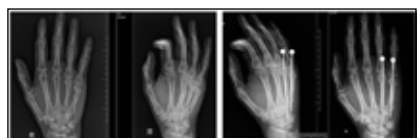
fixation methods and expectations of patients have resulted in a slow trend towards patients seeking surgical management. The aim of the treating physician should be to use the various surgical treatment methods to achieve results comparable to conservative treatment methods and not to replace conservative methods of treatment.



**Figure 1: Conservative management (A) Oblique fracture of third metacarpal. (B) Union at 6 weeks. (C) and (D) Clinical pictures at 6 week follow up.**



**Figure 2: First metacarpal base extra-articular fracture treated by CRIF with K wires**



**Figure 3: Fourth and fifth metacarpal neck fractures with irreducible apex – dorsal angulation treated by ORIF with K wires**



**Figure 4: Transverse fracture of fourth metacarpal treated by ORIF with plate and screws.**



**Figure 5: Complications – (A) Stiffness of fingers (B) Malunion with scissoring of little finger**

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