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# Evaluation of different modalities of osteosynthesis in metacarpal fractures in adults

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## Abstract

**Background and Objectives:** 107 Metacarpal fractures in 81 patients were treated in Index Hospital, Indore from January 2015 to June 2016, with the objective of studying clinically and radiologically, the incidence, mechanism of injury, types of fracture and various treatment aspects. Results were compared to assess the efficacy of different treatment modalities and compare their functional outcomes of the metacarpal fractures of hand.

**Materials and Methods:** 107 metacarpal fractures in 81 patients were enrolled from January 2015 to June 2016. The treatment modalities were broadly categorized into two groups, Group A consisted of conservative treatment, and Group B consisted of surgical treatment. Group A included 38 fractures treated with cock-up splint (n=33) and thumb spica(n=5), while 69 fractures were treated in Group B, which included closed or open reduction (OR) and internal fixation (IF) with K-wires (n=52), OR and IF with miniplate and screws (n=17). Total active range of motion as Suggested by the American society for surgery of hand and Gingrass's criteria were used for functional assessment and to assess the efficacy of conservative and surgical modalities for metacarpal fractures of the hand.

**Results:** Final evaluation of the patients done at the end of three months. The excellent to good results seen in Group A and B were 76.3% and 89.9%, respectively. Six Complications were seen in Group A, which included four cases with malunion and two cases with stiffness. Four complications were seen in Group B, which included two cases with stiffness and one each of pin tract infection and operative wound infection.

**Conclusion:** Conservative treatment is an inexpensive method, particularly suitable for stable fractures, and in patients who are poor candidates for surgery. Surgical modalities have distinct advantage of stable fixation but with added risk of stiffness. Both conservative and Surgical modalities have good efficacy when used judiciously, Single fractures have shown better grade of total active range of motion compared to multiple fractures.

Treatment objective may be compromised if post-treatment physiotherapy and rehabilitation using systemic protocol is not followed.

**Keywords:** Metacarpal fracture, Hand, Closed reduction, Open reduction, Conservative and Surgical treatment.

## Introduction

Fractures of metacarpals and phalanges are the most common fractures of upper extremity and accounts for 10% of total such cases.(1) The outer rays of hand (thumb and little finger) were the most commonly injured. The metacarpal fractures are 3rd most common and comprising 30-40% of all hand fractures.(5) The incidence of metacarpal and phalangeal fractures are most common in males and peaks at the age of 10-40 years – a time when the athletic injury and industrial exposure is the greatest. Hand fractures can be complicated by deformity from no treatment, stiffness from overtreatment and both deformity and stiffness from poor treatment. Modern techniques and materials for internal fixation have become incredibly sophisticated and are far superior to old methods. Certain fractures require operative fixation. Selection of optimal treatment depends on fracture location (intra-articular vs extra-articular), fracture geometry (transverse, spiral, oblique or comminuted), deformity (angular, rotational or shortening) whether open or closed or associated with soft tissue injury and fracture stability.

The fracture fragments of bones are comparatively tiny and mostly comminuted with some possibility of combined dislocation. Reduction and its maintenance is thus extremely hard to achieve, subsequently leading to malunion, incongruity or joint space narrowing. Another critical factor affecting treatment includes damage in tendons, ligaments and articular capsule at the time of injury. Basic principle in treating this type of fracture include anatomical reduction, stable fixation and early mobilization.(6,7)

Goal is full and rapid restoration of hand function. Prolonged immobilization is to be avoided due to risk of permanent deformity and stiffness.

## Classification

It is convenient to divide metacarpal fractures into articular and non-articular injuries. Articular injuries include head or condylar fractures, comminuted intra-articular fractures, fracture dislocations, shaft or base fractures extending into joint. Extra-articular fractures include fractures of neck, base or shaft. Metacarpal fractures can be classified as stable and unstable, based on clinical & radiographic findings.

**Table 1: Criteria for fracture stability[18]**

| Stable | Unstable |
|---|---|
| • Angulations <15° for 2nd & 3rd and<br>• <30° for 4th and <50° for 5th MC<br>• <5 mm of shortening<br>• >50% bony contact<br>• <1 mm of step in joint fractures<br>• No rotational deformity<br>• No collapse | • Rotated spiral and long oblique<br>• Fractures<br>• Multiple fractures<br>• Severely displaced fracture<br>• Multi-fragmentary fracture<br>• Open fractures<br>• Displaced intraarticular fractures<br>• Failure to maintain acceptable reduction |

## Material & Methods

107 Metacarpal fractures in 81 patients were treated at Index Medical college hospital & Research Centre, Indore. Patients were divided into 2 groups, group A consisting of conservative treatment & group B of surgical treatments. Group A consisted CR with cock-up splint /cast and thumb spica, while Group B consisted of CR/OR and IF with k-wires, OR and IF with miniplate & screws.

All modes of treatment were augmented with cock-up splint & thumb spica for thumb fractures. Study was done on patients with mature skeleton of both sexes with closed metacarpal fractures of hand. Clearance was obtained from ethical committee.

**Source & Selection of Cases:** During the period from January 2015 to June 2016, all cases of closed metacarpal fractures fulfilling inclusion criteria were managed by conservative or operative methods.

**Inclusion criteria:** All patients with closed metacarpal fractures (Intraarticular and extra articular) of mature skeleton and any sex managed by conservative or surgical methods.

**Exclusion criteria**

- All open metacarpal fractures
- Pathological fractures

**Method of treatment:**

**Non-operative management:** All patients with stable fractures were treated conservatively with closed reduction and immobilization in

1. **CR and Cock-up splint:** Displaced fractures that are malaligned can often be manipulated into alignment and stabilized by closed reduction. Hematoma or local block is given with 1% lignocaine. For metacarpal neck - Axial traction is used to disimpact 1`the fracture, followed by digital flexion to 90° at the MCP and 90° at the proximal interphalangeal joint. The proximal phalanx then functions as a joystick for the fractured head because of the tightness of the MCP ligaments in flexion. Immobilization in the intrinsic plus position (MCP joint flexed 90°, IP joints in extension and wrist in 30° dorsiflexion) with a dorsal/volar plaster slab reduces the deforming forces of the interosseous muscles, maintains fracture rotation, and places the collateral ligaments under proper tension.

   For shaft -longitudinal traction, dorsal pressure at the fracture site, & rotation as needed. Three point molding is useful for transverse patterns: dorsal pressure at the fracture site & palmar pressure proximally & distally. Metacarpal head & extra-articular base fractures typically require longitudinal traction only.
2. **CR and Thumb spica:** The closed reduction technique consists of thumb traction combined with metacarpal extension, pronation, and abduction. Thumb spica is applied in position of wrist 20-25° extension, forearm neutral & thumb in a position of function (holding can).

**Operative management:** All patients with unstable fractures were operated. Closed reduction was tried under IITV guidance. For OR and IF dorsal approach was the most preferred surgical approach. All patients were treated by one of the following methods.

1. **CR/OR and IF with K-wires:** After CR/OR, several pinning techniques can be used for metacarpal head, neck, shaft & base fractures.

   Transfixion pinning of the fractured metacarpal to an intact adjacent metacarpal -two transfixion pins are recommended distally and at least one proximally. Placing distal pins out of plane can add rotational stability, & pin divergence can be used to reduce lateral translation of distal fragment.

   Cross K-wire fixation - antegrade with an entry point on the dorsal metacarpal surface or retrograde from the MCP joint. By flexing MCP joint to 90°, retrograde pins can enter near origin of the collateral ligaments (dorsal, volar or central) & avoid injury to the articular surface. Pins should cross each other proximal or distal to the fracture site for maximal stability.

   Bennett fractures: transarticular pinning - Placing one or 2 pins from metacarpal shaft into the trapezium while maintaining reduction can counteract the deforming force of abductor pollicis longus.
2. **OR and IF with Miniplate and Screws:** Plates were placed on dorsal surface in order to function as a tension band; but to avoid disturbance to gliding of extensor tendon dorsolateral is preferred to midline dorsal. Periosteal sleeve should be elevated with care to be replaced after completion of plating.
   Pre-bending of plate slightly beyond the normal metacarpal bow allows restoration of the anterior cortical buttress & avoids opposite cortex distraction as well as fatigue of plate.
   Pre-fixation with assistant help or k-wire or reduction clamps is necessary as there is a minimal

chance for mistake. Wrong placement of plate will cause rotational deformity which cannot be corrected except removing the plates.

**Post-operative rehabilitation:** Active Finger and wrist movements were encouraged post operatively to promote better circulation and to reduce edema. Post-operative radiographs were taken on the next day. Check dress was done on 2nd and 10 post op days.

Review of the patient was done for every 2 weeks for 3 to 4 months & examined thoroughly. Immobilization was discarded at the end of 3 to 5 weeks.

At 4 to 6 weeks post operation, any external hardware in the form of k-wires were removed and x-rays were repeated. Grip strength, pinch strength, and TAM and untoward complication of the treatment were also noted. Final results were noted according to the % TAM score for 2nd to 5th metacarpals and Gingrass criteria for thumb metacarpal.

**Table 2: % TAM Score[72] suggested by American society for surgery of hand(for 2nd to 5th Metacarpal)**

| Result | %TAM compared to normal 260 degrees |
|---|---|
| Excellent | 85-100% |
| Good | 70-84% |
| Fair | 50 -69% |
| Poor | <50% |

TAM: Total flexion at MCP joint + PIP joint + DIP joint - Extension deficit of all three joints

**Table 3: Gingrass Criteria[73] for assessment of 1st metacarpal**

| Palmer Abduction | Excellent | Good | Fair | Poor |
|---|---|---|---|---|
| >45° | TF>100° | TF 60°-100° | TF 0-60° | - |
| 40°-45° | - | TF>75° | - | - |
| 30°-40° | - | - | TF>80° | - |
| <30° | - | - | - | TF<80° |

**Fig. 1: Case 76 exposure for 1st metacarpal base**

**Fig. 2: Case No. 27 exposure for 5th metacarpal shaft miniplate & screw fixation**

**Fig. 3: Case 61 exposure for 1st metacarpal base**

## Observation and Results

107 Metacarpal fractures in 81 patients were treated at Index Medical college, Hospital and research centre indore by conservative and surgical methods from January 2015 to June 2016. 16 Patients had multiple fractures. Each metacarpal bone was considered as a separate entity in multiple fractures and treated as same. There were 5 patients with loss of follow up and they were not included in the study.

Fifth metacarpal was the most commonly injured, followed by fourth, first, third and Second. Chi-square revealed a significant difference ($X^2$-10.678; $p<0.030$) among the frequencies of the rays injured. In our study, shaft was maximally affected region of bone (53%), followed by base (36%), neck (9%), and head (2%). Chi-square revealed a significant difference ($X^2$=6.403, p=0.007) among the frequencies of the location of the fracture. 26% of fractures were transverse, 45% were oblique, 20% were comminuted and 9% were spiral type. Chi-square revealed a highly significant ($X^2$=7.929, p=0.047) difference among the frequencies of different fracture patterns. 35% of the fractures were treated conservatively, while the other 65% were treated operatively 49% by k-wire and 16% by miniplate fixation.

Chi-Square revealed a minimal significance ($X^2$=4.654, p=0.031) difference among the frequencies of treatment modalities.

26% of the fractures had excellent, 50% had good, 16% had fair and 8% had poor end result in conservative treatment. 25% of the fractures treated with k-wire fixation had excellent, 63% had good, 2% had fair and 4% had poor end result. 82% of the fractures treated with miniplate fixation had excellent, 12% had good, 6% had fair and none had poor end result. Overall 35% of the fractures had excellent, 50% had good, 8% had fair and 7% had poor end result.

**Table 4: Comparison of End result in Three Treatment Group**

| Treatment | Results | | | | Total |
|---|---|---|---|---|---|
| | Excellent | Good | Fair | Poor | |
| Conservative | 10 | 19 | 6 | 3 | 38 |
| | 27% | 35% | 67% | 43% | 34% |
| K-Wire | 13 | 33 | 2 | 4 | 52 |
| | 35% | 61% | 22% | 57% | 50% |
| Miniplate | 14 | 02 | 1 | 0 | 17 |
| | 38% | 4% | 11% | 0% | 16% |
| Total | 37 | 54 | 9 | 7 | 107 |
| | 100% | 100% | 100% | 100% | 100% |

Contingency coefficient=.165; P=.408

The results obtained were almost equal for the conservative and operative treatment. In conservative treatment 76.3% (n=29) excellent to good results, 6 fair and 3 poor results were seen, while in operative treatment 89.9% (n=62) excellent to good results, 3 fair and 4 poor results were seen. A non-significant (CC=0.165, P<0.408) association was observed between the type of treatment given and the results. Single fractures have shown better grade of total active range of motion as compared to multiple fractures.

Mean duration of immobilization in all fractures was average 4 weeks, and the mean union in weeks overall was 6 weeks. Mean TAM for four fingers with all modalities of treatment was 214 degrees, while mean TF for thumb was 99 degrees. Mean PIP joint and MCP joint motion was 96 and 63 degrees respectively. Mean grip strength was 54 while mean pinch strength was 13 pounds.

90% of fractures (n=97) had no complications with all the modalities of treatment considered together, while 10% (n=l0) had some kind of complications. Different complications included 4 stiffness, 4 malunion, 1 pin tract infections, and 1 post-operative Wound infection. Chi-square revealed a highly significant ($X^2$=9.465, p<0.014) difference among the frequencies of different complications.

Weeks of work loss were found less than 4 weeks in 8 patients, 4-6 weeks in 59 patients and more than 6 weeks in 14 patients. A significant association ($X^2$=45 .54, p<0,000) was observed in work loss period of metacarpal fractures.

**Table 5: Distribution of the sample by Work Resumed**

| Work | Number of Patients | Percentage |
|---|---|---|
| Original | 79 | 97.53 |
| Change | 2 | 2.47 |
| Total | 81 | 100 |

Chi-square=9.924; P=.007

97.53% of the patients retained their original work and 2.47% of the patients had to undergo change in their job. A significant association was observed in sample distribution by the work resumed or changed.

**Statistical analysis:** Data analysis was done using IBM SPSS Statistics 20. Chi-square test was applied to determine the significance of the outcome. p-value was <0.04 signifying strong statistical significance of results.

## Discussion

107 fractures of the metacarpal of hand in 81 patients were treated at Index Medical college, Hospital and research centre Indore by conservative and surgical methods. Each fracture was considered as a separate entity in a multiple injured hand and treated as same, 20% (17) patients had multiple fractures. Feehan LM et al[75] reviewed 72,481 fractures and found 8% cases were of multiple metacarpal fractures. In our study most common mode of injury was RTA (50.6%), followed by fall/Household accident (37.6%). In a study of 72,481 hand fractures by Feehan LM et al[75] most common mode of injury was RTA (48%), followed by fall at work related injuries. In less than 20 yrs age group sports related injuries were common. In our study shaft fractures were most common (51.35%), followed by base(36.94%), neck (9.01%) and head (1.8%), 85.6% Of fractures were extra articular, while 14.4% were intraarticular (5.94:1).

Gupta et al[72] found that 80% were extra articular fractures and 20% intraarticular fractures (4:1). Stanton et al[74] found extraarticular fractures 85.5% were common than intraarticular fractures 14.5% (5.2: 1).

In our study 35% (n=38) of fractures were treated conservatively, while the rest 65% (n=69) were treated surgically. 95.83% of stable fractures were treated conservatively, 82.76% of unstable fractures were operated. The reason for non-surgical treatment for unstable fractures was either negligence in polytrauma patients or unfit for the surgery. 4.17% of the stable fractures were operated depending on the surgeon preference. Overall 89.2% fractures had no complications, while 10 fractures had some kind of complication (6 with conservative and 4 with surgical). 76.3% excellent to good results were seen in conservative, and 89.9% with surgical treatment.

In a study of 1602 fractures by Prokop et al[84] 67.4% were treated conservatively and 32.6% were treated surgically of which 94% had excellent to good results while 85% with surgical treatment.

In our study, the average duration of immobilization was 3.95 weeks and the average time for fracture union was 4.58 weeks. Harris et al[22] studied 59 fractures and concluded that all fractures united radiologically at 5 weeks, average immobilization time was at 3.5 weeks.

Omokawa et al[76] found average duration of union was 8 weeks. Roth and Auerbach et al[33] reviewed 37 patients with metacarpal fractures & found that average union time was 7 weeks. In our study 33 fractures were treated by Cock-up splint /cast. 6 complications were seen included 4 malunion and 2 stiffness. According to the %TAM, 31 (93.94%) fractures had excellent to good results, 1 fair and 1 had poor results. 5 fractures were treated by thumb spica, One stiffness was noted. According to Gingrass criteria, 4 (80%) had excellent to good results and l had poor results.

In a Study of 113 metacarpal fractures by Knopp et al[17] after conservative treatment by cock-up Splint and strapping, the functional results were excellent to good in 92.7%, while 5.8% had satisfactory and 1.5% had poor functional results. In a study by Prokop et al[84] 94% had excellent to good results in cases treated by cock-up splint. Gonzalez et al[25] studied 98 metacarpal fractures treated by CRIF with K-wire. All fractures went on to heal, 3 complications occurred.

In our study 10 fractures were treated with ORIF with K-wire. No complications were seen. 9 fractures (90%) had excellent to good results, l had fair result and no poor results.17 fractures were treated by ORIF with miniplate and screws 1 complication of post-operative wound infection was seen.10 (76.9%) had excellent to good results, l fair and 2 poor results. In study of 14 fractures by Ozer et al[8l] no complications were seen and average TAM was 228 degrees. Mokawa et al[76] studied 51 fractures treated with ORIF with miniplate and screws and concluded that 43 (84.31%) fractures had excellent to good, 5(9.8%) fair and 3 (5.9%) had poor results.

At the end of 3 months, the mean TAM for 2nd to 5th metacarpals with all treatment modalities considered together was 213.88 degrees, while mean total flexion of the thumb was 98.86 degrees. Mean grip strength was 54.02 pounds, while mean pinch strength was l3.48 pounds. Mean PIP joint and MCP joint motion Was 95.90 and 62.58 degrees respectively.

In the study of 50 fractures by Gereli et al[78] an average TAM was 220 degrees and mean loss of grip strength was 7.8%. In the study of 52 fractures by Ozer et al[81] an average TAM was 232.5 degrees and grip strength was 60.5 pounds. Gupta et al[72] studied 45 fractures and concluded that 60% had excellent TAM (>215) with CR and IF with K-wire.

**Fig. 4: A-G case no. 69 treated by miniplate for 1st metacarpal showing good ROM**

## Conclusion

In the management of metacarpal fractures of hand by various treatment modalities,

1. It is important to categorize various fracture patterns into the most suitable treatment options available.
2. Conservative treatment modalities are sufficient for most stable fractures, but surgical treatment gives best result for most unstable and multiple fractures.
3. Both conservative and surgical modalities of treatment have good results when judicious approach is considered.
4. The most preferable treatment for closed multiple metacarpal fractures are OR and IF with k-wire or miniplate and screws.
5. For a reducible, unstable fracture,closed pinning is the most commonly done surgical procedure as it is simple, cost effective and rapid procedure and is well tolerated with added advantages of decreased incidence of malunion, early bone healing and lesser infection rate.
6. If post-treatment physiotherapy and rehabilitation using systemic protocol is not followed, the treatment objective may be compromised.
7. In elderly age groups, conservative treatment is a reliable and inexpensive modality, but associated with complication of malunion and stiffness.

## Competing interest

The authors declare that they have no competing interests'.

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