FUNCTIONAL OUTCOME OF MINI IMPLANTS IN CLOSED METACARPAL FRACTURES

Abstract

Background: The incidence of Hand and Forearm fractures accounts for 1.5% of all Emergency cases. They are the 3rd commonest hand fractures next to distal forearm and phalanges. Closed multiple metacarpal fractures are found to be highly unstable and are more prone for poor functional outcome when they are managed conservatively. In this study we assessed the functional and radiological outcome of Mini Implants for closed metacarpal diaphyseal fractures.

Patients And Methods: In our study we had 22 patients with closed metacarpal fracture which were treated with open reduction and internal fixation with mini screws and plates. Functional outcomes were assessed clinically using TAF (Total Active Flexion) and ASSH (American Society for Surgery of Hand) Scoring system and radiologically using RUST scoring system at 6 weeks, 3rd month and 6th month.

Result: Union rates of 100% were achieved in all cases. The average time period of union in our study was 13.3 weeks. Functional outcomes were excellent in all cases with an active range of movement >220 degrees. Two cases developed infection, one was superficial and the another was deep infection. Infection got resolved for both the patients with adequate antibiotics and regular dressings.

Conclusion: In this study we concluded that mini screws and plates is a good option for treating closed diaphyseal metacarpal fractures as it provided a rigid fixation for early mobilization and had a good functional outcome.

Keywords: Hand, Metacarpal fracture, mini implants
Introduction:

Incidence of metacarpal fracture in United States of America is 8.4 fractures annually per 10,000 persons and ranks 3rd in frequency next to distal radius and phalanges in hand fractures. Occurrence of these fractures are inversely proportional to the socioeconomic status of the patients, with increase in low socioeconomic groups. 70% of this fracture occur in 2nd and 5th decade of life due to sports activities or trauma. In relation to sex the incidence is relatively equal in hand fractures, but the metacarpal fractures are seen more in male while female have more preponderance to distal forearm fractures. These fractures usually result from a direct hit over the dorsum of the hand as in assault, boxing, fall, road traffic accidents, etc. Crush injuries and industrial trauma have decreased in these past years due to increased safety measures and advanced robotic machineries. The mode of injury that ensues determine the fracture pattern. Bending, axial load, rotation and combination of these form the fracture pattern. Fortunately, majority of the metacarpal fractures are stable, hence they are mostly treated by closed reduction method for early mobilization. Despite of good results with non-operative management, certain fracture pattern requires operative fixation for better results. With the availability of hand surgeons, advanced surgical techniques and implants, there is an increase in operative treatment for these fractures. There are multiple operative interventions for the management of metacarpal fractures such as open reduction and K-wire fixation, interosseous wiring, External fixator application, Mini Implant osteosynthesis using mini plate & screw fixation. A rigid fixation with proper anatomical reduction is required for fracture union and early mobilization. In this study we evaluated the functional and radiological outcome of mini-implants in closed diaphyseal metacarpal fractures.

Methodology:

This is a prospective observational study. The study population was 22 patients with 30 metacarpals, and it was consecutive sampling. Study was conducted from January 2017 to September 2018 (including the last follow up of 6 months from April 2018). Patients who presented with closed extra articular metacarpal fractures satisfying the inclusion criteria were selected in this study. Patients included in this study were of age (18-60 years), closed diaphyseal metacarpal fractures, patients who presented within 4 weeks of injury (acute and sub-acute cases), patients with 30 metacarpals, and for 2nd metacarpal the incision was made on the radial border and for 5th metacarpal the incision was made on the ulnar border. After anesthesia work up, patients were kept on below elbow volar slab for initial two days in i.v stand elevation for the swelling to subside. After anesthesia work up, patients were taken up for the planned procedure.

Procedure:

All the surgeries were carried under regional anesthesia. Before induction of anesthesia inj. Cefuroxime 1.5gm was given after test dose. Patient was laid in supine position with the shoulder of the affected limb abducted and elbow extended with the hand resting on the arm board. Fractured limb was painted and draped sterile. Tourniquet was applied for all the cases after exsanguinating the blood using esmarch bandage. Skin incision were made longitudinally along the fractured metacarpal through dorsal approach for 3rd and 4th metacarpal and for 2nd metacarpal the incision was made on the radial border and for 5th metacarpal the incision was made on the ulnar border. After incising the skin, subcutaneous tissue and fascia, the fracture site was exposed by retracting the extensor tendon either over the radial side or ulnar side. The fracture was reduced using point reduction forceps and the internal fixation was done as per AO foundation technique using mini plates and screws. Screw size and fracture reduction was confirmed using an image intensifier. After thorough wash, wound was closed in layers with meticulous attention to prevent soft tissue irritation over the plate.
drain was not used for any case. Below elbow volar slab was applied postoperatively.

Post operatively patients were continued with i.v inj. Cefuroxime 1.5gm, 2 doses Q 8th hourly. Post operatively immediate radiographs were taken to assess the position of screws and plates. Limb was kept in i.v stand elevation for the next 2 days to prevent swelling. Wound inspection was done on post operative day 2 and 5. Gentle finger range of movements were started as tolerated by the patient from the post operative day 3. Suture removal was done on post operative day 12. Below elbow volar slab was continued for 2 weeks. Follow up radiographs and clinical assessment were done on 6th week, 3rd month and 6th month. On each follow up, patients were assessed for tenderness at fracture site, signs of infection, joint stiffness and radiological signs of union.

Data collected were entered in data collection proforma sheet and excel (MS excel 2011). This sheet has a visual map which was divided separately for both the genders. Patients social demographic data were also included in the proforma. Statistical analysis was done through SPSS version 20.0 (IBS, SPSS, US) software with regression modules installed. Descriptive values were reported in mean and percentage of continuous variables.

Results:

A total number of 30 closed extra articular metacarpal fractures were selected from 22 patients on the basis of pre-defined inclusion and exclusion criteria after informed consent. We had 15 patients with a single metacarpal fracture, 6 patients with 2 metacarpal fractures and 1 patient with 3 metacarpal fractures. All patients were recruited through the EMS and Out patient department.

### Age distribution:

**Table 1: Age Distribution**

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Age Group</th>
<th>No. Of Patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18-24</td>
<td>7</td>
<td>31.82</td>
</tr>
<tr>
<td>2</td>
<td>25-34</td>
<td>8</td>
<td>36.36</td>
</tr>
<tr>
<td>3</td>
<td>35-44</td>
<td>6</td>
<td>27.27</td>
</tr>
<tr>
<td>4</td>
<td>45-54</td>
<td>1</td>
<td>4.55</td>
</tr>
</tbody>
</table>

The table 1 above shows the distribution of patients according to their age. It shows that the majority of patients were between 25-34 years.

### Distribution of Gender:

**Table 2: Distribution by Gender**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Incidence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>19</td>
<td>86.36</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>13.64</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>100</td>
</tr>
</tbody>
</table>

The above table 2 shows the distribution of gender where majority of the patients were male.

### Distribution by Diabetes:

**Table 3: Distribution by Diabetes**

<table>
<thead>
<tr>
<th>Diabetes</th>
<th>Incidence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5</td>
<td>22.73</td>
</tr>
<tr>
<td>No</td>
<td>17</td>
<td>77.27</td>
</tr>
</tbody>
</table>

The above table 3 shows the incidence of Diabetics in this study. 5 patients were diabetic.

### Distribution by History of Smoking:

**Table 4: Distribution by History of Smoking**

<table>
<thead>
<tr>
<th>History Of Smoking</th>
<th>Incidence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6</td>
<td>27.27</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>72.73</td>
</tr>
</tbody>
</table>

The above table 4 shows the incidence of smokers in this study. 6 patients had history of smoking.

### Distribution by Mode of Injury:

**Table 5: Distribution by Mode of Injury**

<table>
<thead>
<tr>
<th>Mode Of Injury</th>
<th>Incidence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Traffic Accident</td>
<td>18</td>
<td>81.82</td>
</tr>
<tr>
<td>Sports (Boxer)</td>
<td>1</td>
<td>4.55</td>
</tr>
<tr>
<td>Assault</td>
<td>3</td>
<td>13.63</td>
</tr>
</tbody>
</table>

The above table 5 shows the distribution of mode of injury. Majority of the patients in this study sustained RTA (Road Traffic Accident).

### Distribution by Delayed Unions:

**Table 6: Distribution by Delayed Union**

<table>
<thead>
<tr>
<th>Delayed Union</th>
<th>Incidence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>3</td>
<td>13.64</td>
</tr>
<tr>
<td>No</td>
<td>19</td>
<td>86.36</td>
</tr>
</tbody>
</table>

The above table 6 shows the incidence of Delayed Union. 3 patients in this study had delayed union.

### Distribution by Prevalence of Infection:

**Table 7: Distribution by Prevalence of Infection**

<table>
<thead>
<tr>
<th>Infection</th>
<th>Incidence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>2</td>
<td>9.1</td>
</tr>
<tr>
<td>No</td>
<td>20</td>
<td>90.9</td>
</tr>
</tbody>
</table>

The above table 7 shows the prevalence of infection in this study. 2 patients developed infection, which resolved in the due course of this study.

### Association of smoking with fracture union

**Table 8: Association of smoking with fracture Union**

<table>
<thead>
<tr>
<th>History Of Smoking</th>
<th>Union</th>
<th>Delayed Union</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoker</td>
<td>3</td>
<td>3</td>
<td>0.01</td>
</tr>
<tr>
<td>Non Smoker</td>
<td>16</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The above table 8 shows the association of delayed union with smoking with a significant p-value of 0.01. 50% of patients with history of smoking...
smoking had delayed union, but the non-smoker group did not develop delayed union.

**Association of diabetes with fracture union:**

**Table 9: Association of diabetes with fracture Union**

<table>
<thead>
<tr>
<th>Diabetes</th>
<th>Union</th>
<th>Delayed Union</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetic</td>
<td>0</td>
<td>3</td>
<td>0.01</td>
</tr>
<tr>
<td>Non Diabetic</td>
<td>19</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The above table 9 shows the association of delayed union with diabetes with a significant p-value of 0.01. 60% of patients with diabetes had delayed union. The non-diabetic group did not develop delayed union.

**Association of diabetes with infection:**

**Table 10: Association of diabetes with infection**

<table>
<thead>
<tr>
<th>Diabetes</th>
<th>Infection</th>
<th>No Infection</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetic</td>
<td>2</td>
<td>3</td>
<td>0.01</td>
</tr>
<tr>
<td>Non Diabetic</td>
<td>0</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

The above table 10 shows the association of infection with diabetes with a significant p-value of 0.01. 66.67% of the patients with diabetes developed infection which was noted only in diabetic group and the non-diabetic group did not develop infection.

There were no non-union in our study. All the patients achieved full range of movements with an excellent ASSH (American Society of Surgery for Hand) TAF (Total active flexion) score of > 220 degrees. Patients on an average showed signs of union by 3rd month and union rates were achieved by 13.3 weeks. 1 patient developed delayed union due to inadequate anatomical reduction who had union ultimately at the end of 6 months. The factors which further influenced for the delay in union time were his smoking habit, infection and diabetes. These patients had 100% recovery of functional range of movements by the end of 3rd month. 2 patients developed infection at the wound site, 1 patient had superficial infections and the other patient had deep infection.

**Case - 1**

Case-2

Case-3
Discussion:
Metacarpal fractures are the 3rd commonest bone to be fractured in the hand. The method used for fracture reduction and stabilization still remains controversial with several options such as non-operative treatment by closed reduction and splinting followed by early mobilization.[10,13] Only a lesser group has unstable fracture with unsatisfactory outcome with non-operative treatment. There is a 77% incidence in loss of function in all closed metacarpal fractures managed with closed reduction and splint application.[14] These are the fractures which require open reduction and internal fixation which accounts for 5% of entire hand fractures.[11,12]
Surgeries are usually indicated in unstable open fractures, segmental bone loss, displaced intra-articular fracture, severe soft tissue injury, polytrauma, multiple hand and wrist fractures.[15] In isolated closed metacarpal fracture, operative management is indicated on failed closed reduction, fracture angulation of more than 10 degrees in index finger or middle finger metacarpal or angulation more than 30 to 40 degree in ring and small finger of metacarpal. The most commonly practiced surgical option is open reduction and K-wire fixation in unstable fractures. The major drawback is, it provides less rigid fixation and less rotational stability. There are also other exposed K-wire related complications associated with this management. Interosseous K-wiring even though provides rigid fixation comparable to plate fixation, their indications are limited with transverse diaphyseal fractures. Shehodi et al[16] used external fixator for metacarpal fracture fixation with 100% recovery in total range of movements. External fixators are the most common preferred method of operative management in open metacarpal fractures with bone loss. These are not used so often due to its cumbersome, as it leads to loosening of implant, pin tract infection and difficulty in applying them.
Closed multiple metacarpal fractures are highly unstable, they have to be fixed with stable fixation.[17] In multiple metacarpal fractures there are chances of shortening causing instability.[18,19] Instability is more commonly seen in 2nd and 5th metacarpal than in 3rd and 4th metacarpal as the latter are attached to both the sides of metacarpal head.[20] Multiple metacarpal fractures are usually associated with soft tissue injury compared with single metacarpal fracture. Hence mini implant osteosynthesis will help in anatomical reduction and stable fixation for preventing stiffness and to return for work early.

Social Demography:
The most common age group affected in this study were between 25-34 years. 19 out of 22 patients 86.36% were male in this study group. There were 5 diabetic patients, 4 hypertensive patients and 6 smokers in this study group. The commonest mode of injury was road traffic accident similar to a study by Pugazhenthi et al[21].
We had a good functional outcome of 100% for all patient assessed by ASSH (American Society of Surgery for Hands) TAF (Total active flexion) score of >220 degrees in all patients. In a study by Souer et al[17], they also had 100% of functional outcome. There were no complications in a study by Dabezies and Schutte et al[22], in 27 unstable metacarpal fractures operated with mini implant osteosynthesis.

Complications:
Factors Influencing Union:
The average union time in our study were 13.3 weeks (1 ½ month – 6 months). The union time in another study was 7.2 weeks by Pugazhenthi et al[21]. We had three cases with delayed union in our study which were influenced by history of smoking with significant p-value of 0.01. The same group of patients were also diabetic who also had a significant p-value of 0.01. We also had one patient with delayed union due to implant failure because of improper surgical technique which got united at the end of sixth month at 24 weeks. In a study.
by Souer et al\cite, there were similar results in which they had a patient with history of smoking who developed delayed union. In a study by Fuset et al\cite there were 29.6% of incidence of non union in transverse fractures whereas only 7.4% of other fractures failed to unite. This is due to decreased contact at fracture ends in transverse fractures. In a study by Stern et al\cite contact at fracture ends in transverse fractures failed to unite. This is due to decreased contact at fracture ends in transverse fractures. In a study by Stern et al\cite, he had 3 cases of non union in 17 shaft fractures. In a study by Stern et al\cite, he had 3 cases of non union in 17 patients.

**Factors Influencing Infection:**

We had 2 cases of infection, one patient had superficial infection which resolved with oral antibiotics by the end of post operative day 8. Another patient developed infection on post operative day 12 after suture removal which was a deep seated infection. We treated the deep infection with daily i.v antibiotics and regular dressings. The infection settled after two weeks duration. Both of these patients were diabetic and which significantly influenced with p-value of 0.01 This patient with the deep infection was the one who also had implant failure. In a study by Ashwani soni et al\cite he had an infection rate of 23.80% in which 2 patient had deep infection and 3 patient had superficial infection. In another study by Chow et al\cite and McIain et al [26] they had an infection rate in closed metacarpal fractures with 0.5%.

**Conclusion:**

The present study was done to analyze the functional and radiological outcome of mini-implants for closed diaphyseal metacarpal fractures. All the cases were followed up for a period of 6 months. The fractures were united in an average of 13.3 weeks in our study. Mini- implant fixation had proper anatomical reduction with rigid fixation. These fixations were stable enough for early mobilization for all patients in our study. Though this procedure requires hand specialty surgeons, we had good results with experienced surgical hands.

**Limitations In This Study:**

Small sample size.
No randomization was done.
Single centre study.
Multicentric large studies have to be carried out to improve the outcome of results.

**Reference:**


16. Shehadi SI. External fixation of metacarpal and phalange-