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FUNCTIONAL OUTCOME OF MINI IMPLANTS IN CLOSED METACARPAL FRACTURES

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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. Twocases 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[1]. Occurrence of these fractures are inversely proportional to the socioeconomic status of the patients, with increase in low socioeconomic groups[1]. 70% of this fracture occur in 2nd and 5th decade of life due to sports activities or trauma[2]. 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[3]. These fractures usually result from a direct hit over the dorsum of the hand as in assault, boxing, fall, road traffic accidents, et., 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 [4]. 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[5].There are multiple operative interventions for the management of metacarpal fractures such as open reduction and K-wire fixation[6], interosseous wiring[7], External fixator application, Mini Implant osteosynthesis using mini plate & screw fixation[8]. A rigid fixation with proper anatomical reduction is required for fracture union and early mobilization[9-11]. 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. This study was done in a single centre. 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 who gave consent for operative treatment with the follow up period of 6 months. The exclusion criteria were open fractures, age less than 18 years, metacarpal fracture with intra articular extension, pathological fracture, medically unfit to undergo surgical procedure. Study variables used in this study were ASSH (American Society for Surgery of Hand)TAF (Total active flexion) score for clinical assessment and Rust scoring system for radiological assessment.

Pre operatively after receiving the patient in emergency medical service, they were evaluated as per ATLS protocol. Other associated injuries were ruled out after hemodynamic stabilization. All patients were evaluated with blood and radiological investigations. Radiograph of the affected limb with antero-posterior and oblique views were obtained to evaluate the degree of angulation, amount of displacement, amount of shortening and presence of comminution. Additional radiographs were obtained to rule out the other injuries in the body. After confirming the diagnosis with skiagram, 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[12]. 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. Wound

drain was not used for any case. Below elbow volar slab was applied post-operatively.

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

S. N.	Age Group	No. Of Patients	Percentage
1	18-24	7	31.82
2	25-34	8	36.36
3	35-44	6	27.27
4	45-54	1	4.55

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

Gender	Incidence	Percentage
Male	19	86.36
Female	3	13.64
Total	22	100

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

Distribution by Diabetes:

Table 3: Distribution by Diabetes

Diabetes	Incidence	Percentage
Yes	5	22.73
No	17	77.27

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

History Of Smoking	Incidence	Percentage
Yes	6	27.27
No	16	72.73

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

Mode Of Injury	Incidence	Percentage
Road Traffic Accident	18	81.82
Sports (Boxer)	1	4.55
Assault	3	13.63

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

Delayed Union	Incidence	Percentage
Yes	3	13.64
No	19	86.36

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

Infection	Incidence	Percentage
Yes	2	9.1
No	20	90.9

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

History Of Smoking	Union	Delayed Union	P-Value
Smoker	3	3	0.01
Non Smoker	16	0	

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 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

Diabetes	Union	Delayed Union	P-Value
Diabetic	0	3	0.01
Non Diabetic	19	0	

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

Diabetes	Infection	No Infection	P-Value
Diabetic	2	3	0.01
Non Diabetic	0	17	

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 in adequate 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

Pre OP

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 usually has unstable fracture with unsatisfactory outcome with non-operative treatment. There is a 77% incidence in of 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[17], there were similar results in which they had a patient with history of smoking who developed delayed union. In a study by Fusetti et al[23] 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 shaft fractures. In a study by Stern et al[12], 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[24] 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[25] and Mclain 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:

1. Karl JW, Olson PR, Rosenwasser MP. The epidemiology of upper extremity fractures in the United States, 2009. J Orthop Trauma. 2015;29(8):e242–e244.
2. Emmett JE, Breck LW. A review and analysis of 11,000 fractures seen in a private practice of orthopaedic surgery, 1937–1956. J Bone Joint Surg Am. 1958;40-A(5):1169– 1175.
3. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg Am. 2001;26(5):908–915.
4. Pratt DR. Exposing fractures of the proximal phalanx of the finger longitudinally through the dorsal extensor apparatus. Clin Orthop. 1959;15:22–26.
5. Stener B. Skeletal injuries associated with rupture of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb: a clinical and anatomical study. Acta Chir Scand. 1963;125:583–586.
6. Lutz R, Sailer M, Zimmermann R, et al. Closed reduction transarticular Kirschner wire fixation versus open reduction internal fixation in the treatment of Bennett's fracture dislocation. J Hand Surg [Br] 2003;28(2):142-7.
7. Gropper PT, Bowen V. Cerclage wiring of metacarpal fractures. Clin Orthop Relat Res 1984;188:203-7.
8. Ozer K, Gillani S, Williams A, et al. Comparison of intramedullary nailing versus plate-screw fixation of extra-articular metacarpal fractures. J Hand Surg Am 2008;33(10):1724–31.
9. Ouellette EA, Freeland AE. Use of the minicondylar plate in metacarpal and phalangeal fractures. Clin Orthop Relat Res 1996;327:38-46.
10. Wright TA. Early mobilization in fractures of the metacarpals and phalanges. Can J Surg 1968;11(4):491–8.
11. Amadio PC. Fractures of the hand and the wrist. In: Jupiter JB. (eds.) Flynn's hand surgery. Williams & Wilkins, Baltimore, 1991:122–85.
12. Stern PJ. Fractures of the metacarpals and phalanges. 4th edn. In: Green DP. (eds). Operative hand surgery. Vol 1. New York, Churchill Livingstone, 1999:711–71.
13. Barton N. Conservative treatment of articular fractures in the hand. J Hand Surg Am 1989;14(2 Pt 2):386–90.
14. James JIP (1962) Fractures of the proximal and middle phalanges of the fingers. Acta Orthop Scand 32:401–412
15. Strauch RJ, Rosenwasser MP, Lunt JG. Metacarpal shaft fractures: the effect of shortening on the extensor tendon mechanism. J Hand Surg [Am]. 1998;23:519–23.
16. Shehadi SI. External fixation of metacarpal and phalange-

al fractures. J Hand Surg Am 1991;16(3):544– 50.
17. Souer JS, Mudgal CS (2008) Plate fixation in closed ipsilateral multiple metacarpal fractures. J Hand Surg Eur 33(6):740–744
18. Eglseder WA Jr, Juliano PJ, Roure R (1997) Fractures of the fourth metacarpal. J Orthop Trauma 11:441–445
19. Meunier M, Hentzen E, Ryan M et al (2004) Predicted effects of metacarpal shortening on interosseous muscle function. J Hand Surg Am 29:689–693
20. Freeland AE, Orbay JL (2006) Extraarticular hand fractures in adult. Clin Orthop Relat Res 445:133–145
21. Pugalenthi PV, Ravichandran K, Thanappan N, et al. Functional outcome of closed metacarpal fractures treated with mini fragment plates and screws. J. Evolution Med. Dent. Sci. 2017;6(33):2752-2761, DOI: 10.14260/Jemds/2017/593
22. Dabezies EJ, Schutte JP (1986) Fixation of metacarpal and phalangeal fractures with miniature plates and screws. J Hand Surg Am 11:283–288
23. Fusetti C, Meyer H, Borisch N, et al. Complications of plate fixation in metacarpal fractures. J Trauma. 2002;52:535–9.
24. Ashwani Soni • Anmol Gulati • J. L. Bassi • Daljit Singh • Uttam Chand Saini. Outcome of closed ipsilateral metacarpal fractures treated with mini fragment plates and screws: a prospective study. J Orthopaed Traumatol (2012) 13:29–33
25. Chow SP, Pun WK, So YC, et al. A prospective study of 245 open digital fractures of the hand. J Hand Surg (Br). 1991;16:137–40.
26. McLain RF, Steyers C, Stoddard M. Infections in open fractures of the hand. J Hand Surg [Am]. 1991;16:108–12.