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Functional evaluation of various surgical modalities in treatment of hand fractures

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Abstract
Background: "Hand fractures can be complicated by deformity from no treatment, stiffness from over treatment, both deformity and stiffness from poor treatment." - Swanson. Fracture of metacarpal bone of the hand constituting between 14-28% of all visit to hospital following trauma by various means like assault, road traffic accidents, industrial accidents, agriculture accidents etc. Fracture of the bones of hand are among the commonest fracture in humans, but their management varies widely in the different regions of world. This variability is due to many reasons, including availability of resources, social factors, geographic constraints, surgeon preference and experience, and local practice patterns. Among the spectrum of hand and wrist injuries, fractures of the wrist rank first in terms of frequency and morbidity, with an estimated incidence of 400 fractures per 100,000 inhabitants per year[3]. [3] Fracture healing in the hand is not an isolated goal; rather the functional result is of paramount importance. Recent studies have shown good functional results with surgical treatment of metacarpal fractures using K-wires, bicondylar plates and screws as compared to conservative treatment.
Material and Method: The sample size of the study was 28 patient in 12 patient in k-wire group, 8 patient in jess group and 8 in plate group. The functional outcome was assessed by calculating Total active range of motion (TAM) as suggested by the American Society of Surgery of Hand. At every follow up TAM (total active range of motion) will be calculate as follows TAM= (Active flexion at MCP+PIP+DIP)-Extension deficit at MCP, PIP, DIP. Recovery was calculated as percent regained in motion compared to normal range of digital motion (260 degree).
Result: Fracture healing in the hand is not an isolated goal; rather the functional result is paramount importance. JESS, Plating and K-wire comprised of 8, 8 and 12 subjects respectively. Mean age (in years) of the subjects in JESS group was 41.75±21.93 while the mean age of the subjects in plating and K-wire group was 39.12±20.18 and 43.83±21.84 respectively. 14.35, 21.4% and 17.9% of the subjects in JESS, Plating and K-wire group respectively were injured due to fall from height. Road traffic as mode of injury was reported in 14.3%, 7.1% and 25% of the subjects in JESS, Plating and K-wire group respectively.
Conclusion: Plate and screw fixation is a good option for treating closed unstable metacarpal fractures, where other modalities of fixation are less effective, the rigid stable fixation provided by plating which withstands load without failure allowed early mobilization and achieved good functional results.

Keywords: Functional evaluation, various surgical modalities

Introduction
Phalangeal fractures are the most common fractures of upper extremities. It accounts for approximately 1/3 of fractures involving the hand. Outer rays of hand especially thumb and little fingers are most commonly involved. These are often neglected or regarded as trivial injuries.
Fractures of the metacarpal bones of the hand constituting between 14-28% of all visits to the hospital following trauma by various means like assault, road traffic accidents, industrial accidents, agricultural accidents etc. [1].
Too often these metacarpal and phalangeal fractures are neglected or treated as minor injuries and results in major disability and deformity with permanent disability.
Among the spectrum of hand and wrist injuries, fractures of the wrist rank first in terms of frequency and morbidity, with an estimated incidence of 400 fractures per 100,000 inhabitants per year [2].
Wrist fractures are not equally prevalent at all ages. There is a bimodal age distribution, with

peak in adolescence and a second peak in the population of 50 years and older. The incidence of paediatric fractures is higher in boys than in girls, which appears to coincide with the age of growth spurt, while the second peak in the older population is more likely related to reduced bone strength [3].

Hand fractures can be complicated by deformity from no treatment, stiffness from over treatment and both deformity and stiffness from poor treatment [2]. Fracture healing in the hand is not an isolated goal; rather the functional result is of paramount importance.

Aim

The aim was to study the functional evaluation of various surgical modalities in treatment of hand fracture (K-wire, External fixator, screw and plate).

Objectives

1. To evaluate the functional outcome,
2. To evaluate the radiological union at each follow up and
3. To evaluate the post-operative complication for these surgical technique in treatment of hand fracture.

Material and Methods

The present study was conducted in the Department of Orthopaedics surgery of SRMS-IMS, Bareilly for a period of 18 months from November 2017 to June 2019 among the patients having fracture of hand after obtaining approval from Hospital Ethics Committee.

Inclusion Criteria

1. Patient in the age group of 15-70 years
2. All fracture of small bones of hand (Metacarpals and Phalanges)
3. Open fracture (1,2,3A)
4. Fracture dislocation

Exclusion Criterion

1. Severely crushed hand injuries
2. Fractures associated with tendon injuries
3. Fractures with associated neurovascular injuries
4. Avulsion Fracture

Methods of treatment

Implant Profile

1 mm AO mini plate: Composition: stainless steel. AO stainless steel implants are produced from implant quality 316L stainless steel which typically contains iron (62.5%), chromium (14.5%), nickel 2.8%), molybdenum and minor alloy elements, Length: range from 28mm to 50mm,Breadth: 5mm,Thickness: 1mm,Holes: 4-8 holed, Con figuration: straight plate (for shaft fractures), L – plate& T – plate (for periarticular fractures),Type: non compression, Screws composition – stainless steel, Screw type: non self tapping type, round headed with single slot, Screw pitch: 0.5mm,Screw length: 8-16mm

Technique of Fixation

Kirschner wire technique: regional or digital block anesthesia was used, Using an H-shaped incision, dissection is made through the dorsal subcutaneous tissue. Reduction was obtained by anatomic realignment of the dorsal cortex of the distal phalanx, A 1.5 mm Kirschner wire (K wire) was passed retrograde through the dorsal third of the fracture surface in the distal phalanx in such a way that the wire passes through the distal phalanx just below the sterile matrix of the nail bed and avoids the undersurface of the nail. Next, the dorsal fragment was anatomically reduced with the DIP joint in neutral position, and the pin was driven back across the fracture site. This secures both the fragment and the DIP joint. The second pin was passed through the fragment into the distal phalanx as an added stabilization force.

Screw and plate: Metacarpal fractures are approached by dorsal incision made on radial. border for the first and second metacarpal, ulnar border for the fifth metacarpal. For the 3rd and 4th metacarpals the approach is made using a dorsal longitudinal. incision made between these bones. Then extensor tendons were retracted and anatomical reduction of the fracture fragments are carried out. Reduction is held using point reduction forceps or a stabilizing K wire. Interfragmentary lag screws were used in long spiral and oblique fractures. Plate configuration were chosen according to the fracture pattern (straight plate for shaft fractures, T or L configured plates were used for periarticular fractures) and fixed with screws.

External Fixation

Jess fixator: It consists of three components like link joints (clamps (Alpha clamp, Beta clamp), Kirschner wires and connecting rods (Knurled rods). The JESS fixator provides a stable skeletal hold using smooth, thin diameter K-wires (0.8-2.5 mm). This hold is utilised to construct a frame, which stabilises fractures and positions intervening joints in the functional attitude.

Follow Up

Patient were followed after 3 weeks,6 weeks, 3 month and final evaluation done at 6 month Removal of Kirschner wire/external fixator usually at four to six weeks. On each subsequent visit clinical and radiological examination will be done. Functional outcome was assessed at the final follow up on the basis of TAM score

TAM= (Active flexion at MCP+PIP+DIP)-Extension deficit at MCP, PIP, DIP

Recovery is calculated as percent regained in motion compared to normal range of digital motion (260 degree)

According to this patient are classify as follows on basis of TAM

85-100%=Excellent

70-84%=Good

50- 69%=Fair

<50% =Poor

Observations and results

In present prospective study we included 28 patients with metacarpal and phalanx fractures from November 2017 to June 2019 in department of orthopaedics, Sri Ram Murti Smarak Institute of Medical Sciences Bareilly. From the study observations made

Table 1: Diagnosis distribution among the study groups

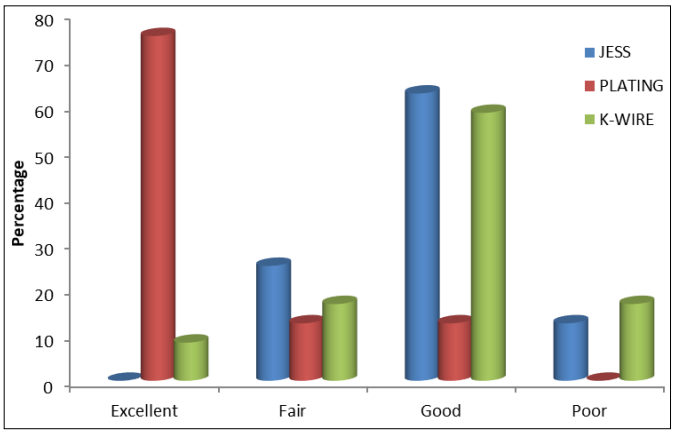
Groups	JESS	PLATING	K-WIRE
	N	N	N
Proximal Phalanx	5	1	1
Middle Phalanx	2	2	4
Distal Phalanx	0	0	1
Metacarpal	6	9	8
Chi square	2.38		
p value	0.24		

Fracture of metacarpal was the most common diagnosis among all the groups. Fracture of distal pharynx was the least common diagnosis among all the groups with insignificant difference (table1)

Table 2: 6m_TAM comparison among the study groups

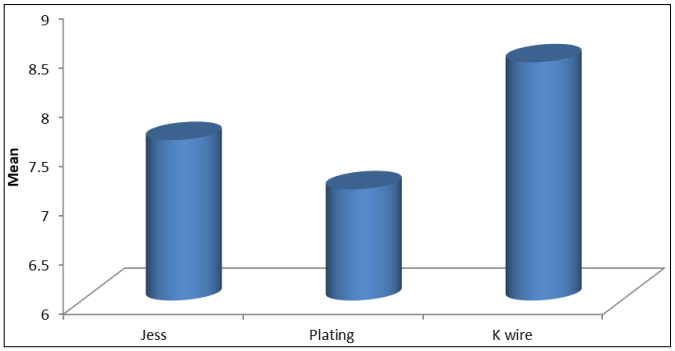
Groups	Mean	SD
Jess	173.25	20.02
Plating	227.00	21.75
Kwire	179.58	28.79
Total	191.32	33.16
Anova test	4.92	
p value	0.02*	

Mean 6m Tam was highest in plating group i.e. 227±21.75. Minimum 3m Tam was lowest in Jess group i.e. 173.25±20.02. In the K-Wire group, mean 6m Tam was found to be 179.58±28.79 as shown in table 2,. When mean 6m Tam was compared statistically among the groups using anova test, it was found to be statistically significant as $p< 0.05$



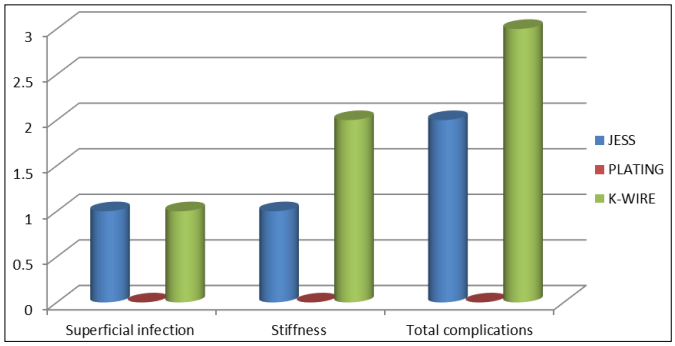
Graph 3: Outcome by total active range of motion score comparison among the study groups

Excellent outcome was reported maximum in plating group (75%) followed by K wire group (8.3%). Poor outcome was found in 16.7% of the subjects in K-wire group followed by Jess group (12.5%). None of the subject in the plating group was found to have poor outcome. When outcome was compared statistically among the groups, it was found to be statistically significant as $p< 0.05$ (graph 3).



Graph 4: Comparison of union time (in weeks) among the study groups

Mean union time was 7.63±2.07, 7.13±1.73 and 8.42±2.35 in JESS, Plating and K-wire group respectively. When mean union time was compared statistically among the three groups, it was found to be statistically insignificant as p>0.05 as shown in graph 4.



Graph 5: Complications comparison among the study groups

No complication was found in plating group. Superficial and stiffness complication was found in one subject each in the JESS group. In the K-Wire group, Superficial infection and stiffness complication was reported in 1 and 2 subjects respectively as shown on table 15, graph 15. When complications were compared statistically among the groups using chi square test, it was found to be statistically insignificant.

Case Records

Pre op

Post op

6th month

Case 2

Pre Op X Ray

Immediate Post Op X Ray

6 MONTH

Clinical photographs

Discussion

Hand fractures are common injuries, which poses difficulties for hand surgeons. The treatment has to be individualized depending on site and pattern of fracture, with goals to restore congruity, stability and alignment thus allowing early range of motion and preventing stiffness and arthritis [4]. Most of the metacarpal and phalangeal fractures can be treated conservatively, but in a relatively small number of patients such as unstable, intraarticular and open fracture soperative treatment is indicated. There has been diversity of operative techniques demonstrated for their treatment.

Kirschner wire

It can be used in almost any setting to stabilise open fractures. Wires can be used for intramedullary or transcortical fixation of fractures. Advantages are pin fixation is easy; it requires minimal dissection and is universally available. It can be used to supplement other forms of fixation. Kirschner pins may loosen and may distract the fracture fragments. Furthermore, pin tract infections may develop secondary to skin irritation or loosening and pin protrusion may make therapy and splintage awkward[5].

Plates and screws

Plates and screws provide rigid fixation of fracture. It allows early mobilisation of the hand. The application of complex hardware often requires wider exposure and manipulation. In addition, proper instrumentation and a complete assortment of screws size and plate configurations must be available [5].

External fixation (JESS)

External skeletal fixation devices are also now available and have been improved to the point where they are more adaptable and useful for the stabilisation of hand fractures. Examples include highly comminuted fractures with or without bone loss and open fractures associated with injury to the soft tissue structures [6-9]. The advantage of external fixation is that fracture fragments are not stripped of periosteal blood supply and further devascularised. External

fixation does not cause osteopenia seen with more rigid systems, such as plating. There is adequate stability to permit early mobilisation. External fixators are adjustable and a second reduction can be carried out if the initial reduction is unstable or has secondarily shifted. Finally, external fixation permits ready access to the wound for debridement as well as for reconstructive surgery [9-11].

As there are different treatment modalities available for the management of hand fractures, so the present study was planned to evaluate functional outcome of different modalities i.e. JESS, plating and K wire in treatment of hand fracture. In the current study, JESS, Plating and K-wire comprised of 8, 8 and 12 subjects respectively.

Fracture site

Fracture of metacarpal was the most common diagnosis among all the groups. Fracture of distal phalanx was the least common diagnosis among all the groups in the current research. Similar results were reported by Rakesh Gupta *et al*. [1] in their study. Khan FH *et al*. [12] in their study found that majority involved phalanges of 3rd and 4th digits(528), meta-carpals of 3rd (145), 4th (128), and 5th (156). One hundred and eighty-seven (10.6%) of carpal fractures, 42 (22.4) had scaphoid fractures, 29 (15.5) had lunate fractures and 28 (14.9%) had crush injuries of carpal rows.

Complications

Complications in our study were minimal. In the current study, no complication was found in plating group. Page and Stern[13] (n=82) have, however, reported a high incidence of complications with plate fixation, especially in phalangeal fractures. Superficial infection and stiffness complication was found in one subject each in the JESS group. In the K-Wire group, Superficial and stiffness complication was reported in 1 and 2 subjects respectively. When complications were compared statistically among the groups using chi square test, it was found to be statistically insignificant. Similar results were found by Kishore Kannan *et al*. [14] in their study. Rakesh Gupta *et al*. [1] stated that a total of 22 complications were observed in10 patients out of a total of 31. Finger stiffness (15.56%) and deformity (7%) were the most commonly observed complications [15]. Bradway JK *et al*. [16] and Jupiter JB *et al*. [17] reported a complication rate of 30% and 36% respectively. Schmelzer N *et al*. [18] reported a complication rate of 46.67% in the external fixator group as compared to 10% in the plating group, which is dissimilar to our study. But they had also compared non-locked and locking palmar plating, which was not done in our research.

Total active movements (tam)

In the present study, mean 3 week Tam was highest in plating group i.e. 177.13±13.22. Minimum 3 week Tam was lowest in Jess group i.e. 141.63±23.29. In K-wire group, mean 3 week Tam was found to be 148.33±23.15. Mean 6 week Tam was highest in plating group i.e. 193±16. Minimum 6 week Tam was lowest in Jess group i.e. 149.50±22.66. Mean 3month Tam was highest in plating group i.e. 205.38±17.06. Minimum 3month Tam was lowest in K-Wire group i.e. 152.33±54.42. Mean 6m Tam was highest in plating group i.e. 227±21.75. Minimum 3m Tam was lowest in Jess group i.e. 173.25±20.02. In the K-Wire group, mean 6m Tam was found to be 179.58±28.79. When mean Tam was compared at all intervals statistically among the groups using anova test, it was found to be statistically significant as $p< 0.05$. These results are in accordance with the study done by Souer*et al*[19]who showed good functional outcome by total active motion more than 230 degree in 18 of 19 patients for whom plate fixation was done in closed unstable metacarpal fractures. Gupta R *et al*. [1] in their study also reported similar results. Excellent TAM was obtained in all four fractures treated by plate and screw fixation. Bosscha and Snellen [20] (n=43) achieved 92%excellent TAM.Gupta R *et al*. [1] showed of the five fractures treated by Kirschner wire fixation, three achieved excellent TAM (60%). Belskey *et al*. [21] (n=100proximal phalanx fractures) and Green and Anderson [22] (n=26) reported similar results.

Sixty percent (n=6) of the fractures treated by external fixation technique achieved excellent to good TAM in a study done by Gupta R *et al*. [1]. The results are comparable to those reported by Freeland [23] (n=12) (70% excellent to good TAM). However, the results of the present study are inferior to those obtained by Schuind *et al*. [24] (n=63) who reported 96% excellent to good TAM. This is probably on account of the fact that the study of Schuindetal [24] included only closed fractures whereas external fixation was used for only open fractures in the present study and final outcomes definitely expected to be compromised to some extent in open injuries.

Union time

Mean union time was 7.63±2.07weeks, 7.13±1.73 weeks and 8.42±2.35 weeks in JESS, Plating and K-wire group respectively in the current study indicating plating as better option for treating these fractures.

Outcome

Excellent outcome was reported maximum in plating group (75%) followed by K wire group (8.3%). Poor outcome was found in 16.7% of the subjects in K-wire group followed by Jess group (12.5%). None of the subject in the plating group was found to have poor outcome. When outcome was compared statistically among the groups, it was found to be statistically significant as $p< 0.05$. These finding were in accordance with the study done by Gupta R *et al*. [1] and Aditya Kekatpure *et al*. [25] in their studies. Aditya Kekatpure *et al*. [25] got excellent functional results according to the G and O'Brein Functional scoring system in 11 (55%)patients treated with Plating as compared to 4 (20%) patients in the JESS group, good results in 5 (25%) patients in the plating group as compared to 06 (30%) patients in the JESS group. They got fair result in 8 (40%) patients in the JESS group as compared to 4 (20%) patients in the Plating group. They got poor result in 2 (10%) patients of the JESS group and none in the plating group. There was a significant difference in the mean value of the functional result in the plating group (76.5) as compared to JESS group (89.5). Excellent anatomical results was found among 11 (55%) patients in the plating group as compared to 04 (20%) patients in the JESS group, Good results in 10 (50%) of patients in the JESS group and 08 (40%) patients in the ORIF group. 06 (30%) patients in the JESS group and 01 (5%) in the Plating group had fair anatomical results [25].

Considering the fracture pattern, plating showed better results as compared to JESS and K wire in the present study. Plating also allows for early mobilization of patients. Therefore in metacarpal fractures, plate fixation is a better option for several reasons:

1. They provide stable fixation in all unstable metacarpal fractures thus allowing early mobilization of fingers;
2. Shortening seen in multiple metacarpal fractures which are corrected by plating restores the power of interossei

muscle there by retaining the grip strength of hand.
3. Multiple metacarpal fractures are usually associated with severe soft tissue injury. In these unstable metacarpal fractures, treatment with plate osteosynthesis provides anatomical reduction of fracture with rigid stabilization allowing early mobilization of joints without loss of reduction thus preventing stiffness and yields good functional results.

Conclusion

Plate and screw fixation is a good option for treating closed unstable metacarpal fractures, where other modalities of fixation are less effective, the rigid stable fixation provided by plating which withstands load without failure allowed early mobilization and achieved good functional results.

Detailed clinical and radiological assessment of fracture, careful preoperative planning, meticulous dissection, precision in surgical technique (coverage of plate with soft tissue) and choosing the correct implant (low profile plate) are critical in achieving good results and minimising the complication.

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