FUNCTIONAL OUTCOME EVALUATION OF PHALANGEAL AND METACARPAL FRACTURES TREATED WITH JESS FIXATION

Mukharjee G. S[1], Vindhya K[2]

[1]Associate Professor, Department of Orthopaedics, Rangaraya Medical College, Kakinada, Andhra Pradesh.
[2]Associate Professor, Department of Anaesthesia, Rangaraya Medical College, Kakinada, Andhra Pradesh.

ABSTRACT

BACKGROUND

Fractures of metacarpals and phalanges are the most common fractures of the upper extremity and account for 10% of total such cases. The outer rays of the hand are most commonly injured. The incidence of metacarpal and phalangeal fractures is 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. Unfortunately, the metacarpal and phalangeal fractures are often neglected or regarded as trivial injuries. The Proximal Phalanx (PP) of the fingers, fractures are more frequently than the middle or distal phalanges. The deformity with considerable displacement is typical when the PP is fractured. Most fractures are functionally stable either before or after Closed Reduction (CR) and fare well with protective splint and early mobilisation. Closed treatment has gained a poor reputation in unstable comminuted, juxtaarticular and open fractures because of problems of malunion, stiffness and sometimes loss of skin or other soft tissues. Open reduction and internal fixation with K wires, plates and screws further compromises injured soft tissues and leads to infection and stiffness. On the other hand, external fixation allows fracture reduction to normal bone length via a rigid external support. Stiffness can be prevented by mobilisation of joints proximal and distal to the fracture.

MATERIALS AND METHODS

This prospective study was done from October 2012 to August 2014. 30 patients with 23 phalangeal and 14 metacarpal fractures were treated with external minifixation using JESS fixator at the Department of Orthopaedics, Government General Hospital, Kakinada. Age ranging from 10 years to 60 years. All patients were followed for a minimum of 6 months. The data was analysed with proportion, mean and standard deviation. Functional assessment was done based on total active range of movements in degrees of each injured finger separately according to Duncan et al.

RESULTS

Age of patients ranged from 10-60 years with most of the patients belonged to 21-40 years age group. Majority of the patients were male (M:F=26:4). The sample size reflected the population visiting the trauma section of our department. Most of the fractures were caused by RTA and were on right hand. Majority of the fractures occurred in proximal phalanx, followed by metacarpal. All patients were followed for a minimum of 6 months and the mean follow-up period was 33.77 weeks. The mean fracture healing in our study was 12.77 weeks. Reviewing the literature, the average radiological healing of phalanges and metacarpals was 4-5 months, which ranged from 1-17 months. The fracture healing time in our study compares favourably with those reported in the literature. Mean duration of implant (JESS) application was 4.42 weeks. Complications like pin tract infection encountered in 5 patients with 3 pin loosening, 1 total stiffness and 10 of them had partial stiffness.

CONCLUSION

JESS fixation provides an adequate basis for bone healing is a good and simple alternative to standard treatment, especially in open, intraarticular, comminuted and multiple phalangeal and metacarpal fractures.

KEYWORDS

External Fixators E07.858.442.660.430, Hand Injuries C26.448, Metacarpal Bones A02.835.232.087.319.550.

HOW TO CITE THIS ARTICLE: Mukharjee GS, Vindhya K. Functional outcome evaluation of phalangeal and metacarpal fractures treated with JESS fixation. J. Evid. Based Med. Healthc. 2018; 5(3), 271-275. DOI: 10.18410/jebmh/2018/55

BACKGROUND

Work in Switzerland in mid 1970s by Jacquet resulted in the first commercially available mini-fixator suitable for hand and carpus. He has used his fixator for various indications like unstable fractures of phalanges, metacarpals, carpal bones, intra-articular fractures, high velocity injuries to hand with segmental bone loss, osteomyelitis of hand, arthrodesis, delayed unions and nonunions. Dickson in 1975 suggested if the three ulnar metacarpals are all fractured rigidity of fixation can be achieved by leaving the K-wire protruding through the skin and bonding with Methyl Methacrylate (MMA) and a longitudinal interconnecting K-wire strut. Similarly, Prisch et al in 1977 developed a method of manipulation and external fixation of metacarpal fractures bonded with acrylic resin. Although, easily constructed from

Financial or Other, Competing Interest: None.
Submission 26-12-2017, Peer Review 03-01-2018,
Acceptance 11-01-2018, Published 13-01-2018.
Corresponding Author:
Dr. Vindhya K,
Associate Professor, Department of Anaesthesia,
Rangaraya Medical College, Kakinada, Andhra Pradesh, India.
E-mail: vindhyakakula@gmail.com
DOI: 10.18410/jebmh/2018/55

readily available supplies, these constructs had the disadvantage of not being readjustable. Disposable external fixators are commercially available, but are still expensive and not always accessible. Other 'alternative' external fixators using methyl methacrylate and rods or K-wires as both the bars and pins held by orthopaedic or dental cement were well recognised. However, even here, a packet of cement was used, which was relatively expensive. K-wires were passed through the polymer and into the bone acting as cantilever pins. The polymer sheath was slender and stable, so was not cumbersome. The method was simple, cheap and effective, and the materials were always available. Dr. B.B. Joshi and his associates from Bombay (now Mumbai) introduced a mini-external fixator in early 1990s as JESS (Joshi's External Stabilisation System) for stabilisation of unstable fractures of hand since conceptualisation of the fixator system, which is JESS today became recognisable to the orthopaedic surgeons everywhere.

Aim and Objectives

1. Evaluation of overall functional outcome of hand treated with JESS fixation for metacarpal and phalangeal fracture.
2. To study the complications associated with their management.

MATERIALS AND METHODS

This prospective study was conducted on 30 patients suffering from fractures of hand fulfilling the inclusion criteria. They were treated as both inpatients and outpatients in the Department of Orthopaedics, Rangaraya Medical College, Kakinada. Sample size was 30 (n=30). The fractures were classified according to Swanson et al classification for open fractures of hand. Both open and closed injuries were examined meticulously for injury to adjacent tendons, nerves and blood vessels. Peripheral circulation was assessed by noting colour, temperature, capillary filling and patency of collateral circulation by Allen test. Radiography were taken in two views as Anterior-Posterior (AP) and Oblique (OBL) and if necessary Lateral (LAT) views. The level and pattern of fracture, amount of displacement and angulation were noted. Radiography of other parts was performed when indicated for associated injury. These fractures were classified according to Swanson et al classification for open fractures of hand. Gustilo Anderson classification was not applied for these fractures.

Swanson et al Classification for Open Fractures of Hand-

Type I - Clean wound without significant contamination or delay in treatment. No significant systemic illness.

Type II - Contamination with gross dirt/debris delay in treatment longer than 24 hours significant systemic illness including diabetes.

Once the patient's general condition was stable, patient was taken for JESS fixator application. All the patients were operated under regional anaesthesia under tourniquet control. The regional blocks were all brachial plexus blocks either supraclavicular or axillary depending on the choice of the anaesthetist with patients consent. A thorough debridement of the wound was done in open injuries. The desired pin placement and frame configuration was decided first depending on the fracture pattern. Pin placement was chosen as per the safe zones and also to facilitate subsequent dressing changes in open injuries. Pins were inserted directly using a hand drill or power drill with slow speed. Skin and fascia were incised prior to pin insertion. The clamps and side rods were applied. The distractor/compression device was applied and compression or distraction at the fracture site, whichever necessary was done and the fracture reduced. The frame was then tightened. In case of intra-articular fracture, we followed the principle of ligamentotaxis. Check x-rays of hand AP and oblique views were taken to study the reduction. Postoperatively, the limb was elevated to reduce oedema. In case of open injuries, the wounds were dressed daily. Active and passive movements of the joints proximal and distal to the fixator were carried out. After about 3 weeks, a radiological examination followed by removal of critical connecting rods and clinical testing for union was performed. In the absence of abnormal mobility or undue pain, the frame was removed. If there was excruciating pain and abnormal motion at the fracture site, the frame was re-applied. The test was repeated next week and the frame removed. Associated injuries were treated simultaneously and the patients were followed regularly for a further period of about 1 year. The maximum follow-up in this study was about 52 weeks and minimum was 17 weeks. The majority of cases were followed up to 6 months. Complications such as pin tract infection, pin loosening, joint stiffness, malunion and osteomyelitis were looked for and noted. Functional assessment was done based on total active range of movements in degrees of each injured finger separately according to Duncan et al.

Functional assessment based on total active range of movements in degrees of each injured finger separately according to Duncan et al.

Fingers	Thumb	Results
220-260	120-140	Excellent
180-220	100-120	Good
130-180	70-100	Fair
<130	<70	Poor

Inclusion Criteria

1. Patients in the age group of more than 12 years.
2. Unstable fractures of hand.
3. Intra-articular fractures and juxta-articular fractures.
4. Open fractures.
5. Multiple fractures.

Exclusion Criteria

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

RESULTS

Most of the patients (66.67%) were in the age group between 21-40 years. The youngest was 20 years old, whereas the oldest one was 52 years old. The average age of the patient was 32.03 ± 9.87 years. In our study, 86.67% cases were males and 13.33% cases were females. Most of the patients were worker by occupation 40%. Most of the cases came with RTA (46.67%) followed by industrial accidents (30%) and agricultural accidents (13.33%). Thirty percent of the patients had associated injuries involving the other systems or other bones. In the present study, fractures were classified according to Swanson et al classification for open fractures of hand. Most of the open fracture was type II comprising 55.55% (Table 1).

Parameters	Number	Percentage
Type I compound	4	13.33
Type II compound	5	16.67
Closed	21	70
Grand Total	**30**	**100**

Table 1. Distribution Based on the Open Fractures

Out of the 37 fractures, 19 of them were involving shaft of the small bone, 10 fractures were juxtaarticular and another 8 were involving in the intra-articular joint surface. Out of them, proximal phalanx fractures were 48.65%, metacarpal fractures were 37.83% and middle phalanx fractures were 13.52%. Majority of the cases (86.67%) were operated within first 3 days, 13.33% were operated between 4 to 7 days after injury. Out of 9 open fractures, soft tissue healing occurred in first 2 weeks in 55.56% cases (Table 2).

Duration	Number	Percentage
1-2	5	55.56
2-4	3	33.33
>4	1	11.11
Grand Total	**9**	**100**

Table 2. Soft Tissue Healing in Case of open Injuries (Duration in Weeks)

In most of the fractures, radiological union occurred within 12 weeks. The mean follow-up period was 33.37 ± 7.50 weeks. Duration of JESS fixator in situ was 5-6 weeks in 63.33% of the cases, 3-4 weeks in 33.33% cases, whereas in one patient, it was found 6-8 weeks. Mean duration of JESS application was 4.41 ± 0.70 weeks (Table 3).

Duration	Number	Percentage
3-4	10	33.33
4-6	19	63.33
6-8	1	3.33
Grand Total	**30**	**100**

Table 3. External Mini-Fixator (JESS) In Situ (Duration in Weeks)

Five cases had minor pin tract infection and 3 among them pin loosening. Other complications include malunion (2), partial stiffness (10) and pin loosening (3) (Table4).

Complications	Yes		No		Grand
	No.	%	No.	%	
Malunion	2	6.67	28	93.33	30
Nonunion	0	0	30	100	30
Osteomyelitis	0	0	30	100	30
Partial stiffness	10	33.33	20	66.67	30
Pin loosening	3	10	27	90	30
Pin traction infection	5	16.67	25	83.33	30

Table 4. Complications

Ten cases had partial stiffness. 2 cases had malunion. The results were found excellent in 35.13%. Good in 40.55% cases, fair in 18.92%, whereas poor results were seen in 5.40% of fractures (Table 5).

Results	Number	Percentage
Excellent	13	35.13
Good	15	40.55
Fair	7	18.92
Poor	2	5.4
Grand Total	**37**	**100**

Table 5. Final Results

DISCUSSION

Drenth and Klasen studied 33 patients with 29 phalangeal and seven metacarpal fractures by external fixation using a min-Hoffman device. Their mean age was 35 years (15-69).[1] Pritsch and Engel studied 36 metacarpal fractures with a method of external fixation using Kirschner wires bonded with acrylic resin. Most of the patients were young men aged between 20-30 year old.[2] The youngest patient was 12 years and oldest is 52 years. The incidence of fractures in our study was more common in males (86.67%) and this rightly corresponds to the risk of ambulant life led by males. In Drenth and Klasen series of 33 patients, 27 were men and 6 were women.[1] In 66.67% of the cases, the dominant hand was involved in our study as compared to Drenth and Klasen study only 30% involved the dominant hand. The mode of injury out of 30 patients with the present study, 14 patients had sustained injury due to road traffic accident amounting to 46.67%, followed by industrial accident like fall or machinery leading to crushing of hands in 9 patients (30%), injuries in agricultural fields in 4 patients (13.33%) and assault in 3 patients (10%). In Drenth and Klasen studies, most had blunt injury; 9 were caused by RTA (27%), 90 were by machinery (27%) and 10 were falling or cutting objects (30%).

In our study, associated injuries were seen in 9 patients (30%), 4 patients had long bone fractures and other patients had injuries involving other systems like chest injuries (II and III rib fractures) and one head injury in all these patients. Most of the fractures of the phalanges and metacarpals were seen in the dominant hand.[1] Associated injuries were considered in the present study because that coincident delay the timing of surgery. In case of head injury, the surgical procedure was delayed till the patient recovered from head injury. With the present study, open fractures were classified according to Swanson et al.[3] In our study by following Swanson et al classification, there were 4 cases of type I (13.33%) and 5 cases of type II (20%). No

injury with vascular impairment was noted. In Drenth and Klasen study, there were 27 open fractures; 25 of them were with severe soft tissue injuries out of 36 fractures, and in 12 cases, partial or completely divided tendon injury was noted.

In the present study, out of the 9 open fractures, most of them involved proximal phalanx. Two cases had severe soft tissue injury. Most of the fractures involved proximal phalanx - 18 out of 37 fractures (48.65%), followed by 14 metacarpal fractures (37.83%) and middle phalanx of 5 (13.52%).[1] We have not treated any distal phalanx fractures. Drenth and Klasen studies constituted 21 proximal fractures, 8 middle phalanx fractures and 7 metacarpal fractures. No cases of distal phalanx were managed by them.[1] The pattern of fractures was studied with x-rays in both posterior, anterior and oblique views. In some cases, oblique view was specially asked for better study of fracture pattern. The site of fractures with the present study mainly involved shaft of the bone in 19 patients (51.35%), 8 cases (27.03%) were intraarticular and another 10 cases (28.32%) were juxta-articular fractures. In Drenth and Klasen studies, 19 fractures involved the shaft. Most of them were comminuted and short oblique fractures (56.77%) and another 16.20% were intra-articular fractures and 21.63% were juxtaarticular and transverse type fractures. 25 fractures were comminuted, 6 were transverse, 3 were oblique and 2 intra-articular fracture.[1]

In our institution, we planned and performed JESS fixation as an emergency procedure. Most of the cases in the present study were operated within first 3 days (86.67%). Rest of cases (13.33%) were operated within 4-7 days following trauma. The delay in treatment was either because of late reporting or associated injuries. Those cases which have operated after 5 days, especially open injuries developed complications like delay in soft tissue healing, pin tract infection and decreased range of movements ultimately resulting in poor results. In most of the cases, smooth K-wires were used. Trocar tipped K-wires (four-angled facets) were preferred over the diamond tipped wire (two-angled facets) because of better holding power of trocar-tipped wires. Usually, 2 wires were placed in each fragment. Most of the fractures had enough space for passing 2 wires. Most of the juxta-articular and intra-articular fractures were fixed with only one pin in each fragment and enough stability was obtained with joint spanning frames. Two pins were used in each fragment more often. K-wires drilling has a propensity to cause thermal necrosis; therefore, they were inserted at slow drilling speeds using power or hand drill. Dr. B. B. Joshi and associates used sharp trocar tipped K-wires in their study and they have showed the usefulness of drilling trocar tipped K-wires in tough cortical bone and preferred two pins in each fragment.[4] Drenth and Klasen have used threaded pins for his mini-Hoffman frames, which were present to 40-60° to prevent interference of the other finger movements.[1]

Ashmead D et al used threaded pins for Jacquet external mini-fixator for static external fixation in the hand and carpus.[5] They proved that to protect the soft tissues and to avoid damage to the neurovascular bundles and flexor sheaths, wires should be placed dorsal to the mid lateral line. Some authors have objected the use of external fixation because of the dorsal fixation of the extensor hood, which hinders active movement and predisposes to permanent adhesions. Some advocates of external fixation have also acknowledged that there is limitation of movement, whereas others claim that extensor tethering is not a problem. Halliwell has shown that a dorsal placement of pin caused less mean reduction in the amount of flexion of proximal interphalangeal joints than the lateral (10 o'clock) position.[6]

In present study, we have followed the safe zones advised by Dr. B. B. Joshi and associates and our soft tissue complications due to pin placement were negligible. We have used dorsolateral K-wires at proximal and middle phalanges, which may impale the lateral band or oblique retinacular ligament, but these structures recover their function after removal of the frame. Transverse wires were used for border fingers in which neurovascular bundles lie anterolaterally. In metacarpals, we used dorsal or dorsolateral pins taking care to avoid superficial veins, which were easily moved away with the lax overlying skin. Extensor tendons were identified and the wires passed on one or the other side of the tendon without transfixing them. In present study, the bulk of the cases involved the proximal phalanx and the proximal interphalangeal joint confirming the experience of other studies. In these, we have used dorsal oblique frames. In fractures of middle phalanx, unilateral or coplanar frames were used. In juxta-articular and intra-articular fractures, we utilised Vidal's principle of ligamentotaxis to provide reduction and this has been reported to provide good results by many authors. Reinforcement of the assembly was achieved in most of the cases by adding another connecting rod parallel to the first. In Drenth and Klasen studies, mean period of treatment of phalangeal fractures was 7 months and of metacarpal fractures was 5 months. The mean followup was 4.4 years. Fracture healing occurred in most of the cases within 12 weeks totalling to 56.76%. Healing took more than 20 weeks in one case, which had multiple fractures, delay in surgery timing and old age. Mean fracture healing with our study was 12.77 weeks. Reviewing the literature, the average radiological healing of phalanges and metacarpals is 4-5 months, which ranges from 1-17 months.[1] Fracture healing time in our study compares favourably with those reported in the literature. The pattern of hospital stay in our study revealed that 65% of the cases were in patients who were discharged on the first or second postoperative day. At the same time, we have managed 35% of the cases on an outpatient basis without any complications. There were 2 major complications and few general complications in our JESS fixator study. The most common complication was joint stiffness, which was either partial or total stiffness. A joint was considered partially stiff when the range of motion was <100° in case of thumb and if range of motion was <130° in case of fingers. Less than 70° motion in case of thumb was considered total joint stiffness.

CONCLUSION

Most phalangeal and metacarpal fractures can be treated conservatively. Patients with multiple fractures, open fractures and intra-articular fractures require operative reduction and stabilisation to obtain optimal position for bone healing and to allow early movement. JESS is an adequate treatment modality for unstable phalangeal and metacarpal fractures, which are open, intraarticular, multiple and comminuted. JESS is simple to operate, has less complication rate and can be used by an average surgeon in an average operating environment. The learning curve is comparatively small. JESS simplifies the postoperative management of both injured finger and limb. It allows early mobilisation, which prevents joint stiffness. Pin tract infection and pin loosening are the main disadvantages of JESS fixation. Understanding the biochemical principles and correct application methodology is essential for optimal use of available equipment. JESS method is a simple and good alternative to other established methods of management of small bone fracture.

REFERENCES

[1] Drenth DJ, Klasen HJ. External fixation for phalangeal and metacarpal fractures. J Bone Joint Surg Br 1998;80(2):227-230.
[2] Pritsch M, Engel J, Farin I. Manipulation and external fixation of metacarpal fractures. J Bone Joint Surg Am 1981;63(8):1289-1291.
[3] Swanson TV, Szabo RM, Anderson DD. Open hand fractures: prognosis and classification J Hand Surg Am 1991;16(1):101-107.
[4] Swanson AB, Goron-Hagert C, de Groot Swanson G. Evaluation of impairment in the upper extremity. J Hand Surg Am 1987;12(5 Pt 2):896-926.
[5] Ashmead D, Rothkopf DM, Walton RL, et al. Treatment of hand injuries by external fixation. J Hand Surg Am 1992;17(5):954-964.
[6] Halliwell PJ. The use of external fixators for finger injuries: pin placement and tethering of the extensor hood. J Bone Joint Surg Br 1998;80(6):1020-1023.