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FUNCTIONAL OUTCOME OF FRACTURE OF METACARPALS AND PHALANGES MANAGED WITH JESS

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Abstract

Background: Fractures of the metacarpal and phalanges have the potential for functional loss that can occur is often under appreciated. The standard treatment of fractures of the hand involve intraosseous wiring, plating & K-wires (Lister, 1978), Plate fixation, etc They have been found to have complications including infection, complex regional pain syndrome and plate loosening.

JESS works on the principle of distraction histoneogenesis. Owing to its simple design, light weight, easy manoeuvrability and low cost, JESS provides stable fixation while avoiding damage to the already injured tissue thereby reducing the chance of infection. Moreover, it permits movement of adjacent joints and permits secondary procedures without disturbing the fracture thereby reducing the incidence of joint stiffness and resulting in achievement of early functional outcome.

Materials and Methods: Fifty patients who suffered from a fracture of the metacarpal and phalanges were admitted in A.J. Institute of Medical Sciences were treated using JESS. Patients were instructed on the method of tightening clamps of the system. Patients were followed up on post-operative day 7, 3 weeks, 6 weeks and ROM were recorded and graded as per Duncan et al grading.

Results: Functional outcome of fractures of metacarpal and phalanges treated with JESS have a good functional outcome. Incidence of stiffness greatly reduced. No incidence of pin tract infection was noted in our study. Terminal outcome of metacarpal fractures was better than fractures of the phalanges.

Conclusion: There is good functional outcome in patients undergoing JESS fixation in fractures of the metacarpal and phalanges. In our study 38% patients had excellent, 32% Good and 26% FairFunctional outcome at the end of 6 weeks. Only a mere 4% had poor functional outcome at the end of 6 weeks. We did note intra-articular fractures had a poor functional outcome at the end of the study as compared to extra-articular fractures with a p value of 0.001.

Keywords: *Joshi External Stabilisation System (JESS), Hand, Phalanges, Fracture, Metacarpal, External Fixator*

Introduction

The hand is a human being's most exquisite part for direct interaction with the surrounding universe. The stability of its small articulations, the fine balance between its extrinsic and intrinsic motors and the complex tendon mechanism are the ultimate determinants of functional outcome after skeletal trauma of the hand. Its orientation in space makes it vulnerable to a number of injuries especially work related.

Nowhere in the body, are the forms and function so closely related to each other than in hand. P. R. Lipscomb in 1963 stated that *"too often these fractures are treated as minor injuries and major disabilities occur"*. Fractures of the hand can also easily result in malunion.

The standard treatment of fractures of the hand involve intraosseous wiring, plating & K-wires (Lister, 1978) etc. This may lead to further damage of the already injured soft tissue, joint stiffness and delay in regaining complete function of the hand. Plate fixation of extra-articular fractures of the metacarpals has been found to have complications rates in up to 33% of patients including infection, complex regional pain syndrome and plate loosening[2].

External fixation is a method of stabilization of bone fractures in which a number of percutaneous metal pins pass through the fractured bone segments with their ends connected to a rigid frame. Joshi's External stabilization system is a widely used external fixation device for various fractures. JESS has been used for treatment of post-burn contractures of the hand and wrist[3], interphalangeal joint contractures in leprosy[4], intra-articular distal radial fractures[5], idiopathic clubfoot[6], hand trauma and its sequels[7], calcaneal fractures[8] and congenital talipes equinovarus[9,10].

JESS works on the principle of distraction histoneogenesis which can be widely used in case of compound fractures involving bone loss which will help in the generation of new bone. Owing to its simple design, light weight, easy manoeuvrability and low cost, JESS provides stable fixation while avoiding damage to the already injured tissue thereby reducing the chance of infection. Moreover, it permits movement of adjacent joints and permits secondary procedures without disturbing the fracture thereby reducing the incidence of joint stiffness and resulting in achievement of early functional outcome.

Materials and Methods

This study was conducted on patients with Metacarpal and Phalanx fractures of the hand at A.J. Institute of Medical Sciences during the period of November 2015 to May 2017. This study was approved by the institutional ethical committee of A.J. Institute of Medical Sciences. At least 50 patients aged more than 10 years were included in the study. Detailed history regarding mode of injury was obtained. Evaluation of the fracture in reference to the digit involved, Phalanx (Proximal, Middle or Distal Phalanx) or Metacarpal involved. Whether fracture is Simple or Compound, Comminuted or Non-Comminuted, fracture geometry (transverse, oblique or spiral), whether fracture involves the joint (Intra-articular or Extra-articular), displacement, angulation and its severity, associated soft tissue injury. Any other systemic illness was also noted.

All patients were assessed clinically and functionally using the Duncan Score. Standard guidelines were utilized to get hand radiographs: Anteroposterior and an Oblique view. Any avulsion injury, bone defects and the quality of bone is assessed along with displacement, angulation, rotation and joint involvement.

All patients after thorough pre-op evaluation were taken up for surgery by the same surgical team under general or regional anaesthesia, patient in supine position with hand resting on an arm board.

Tourniquet was applied at the arm region. Sterile preparation done from arm to finger tips and draped.

Surgical Technique

With the affected hand scrubbed, draped and painted, fracture pattern was visualized under C-arm guidance.

Depending on the fracture pattern and affected bone, K-wires of size 1.2mm to 1.5mm were inserted into the phalanx and frames were made using the smallest link joint (2 x 2) and 2mm connecting rods; whereas, 1.5mm K-wires were used for metacarpals to make frames with the medium link joint (3 x 3) using 2.5mm connecting rods. It was ensured that K-wires were passed as per the safe zones and all necessary precautions undertaken.

Bi-cortical purchase was obtained using the K-wires. Number of K-wires inserted into a fractured fragment depends upon the size of the fragment, however, aim was to insert two K-wires into each fracture fragment. This assures stability of the frame and thus stability of the fracture fixation.

After inserting the K-wire, fracture fragments were reduced using traction and manipulation under C-arm guidance. Upon achieving adequate fracture reduction, external frame was constructed using appropriate link joints and connecting rods as mentioned previously. Finally, the

link joints were tightened using an allen key or 3.5mm screw driver and fixation/reduction was reconfirmed under C-arm guidance ensuring no rotation or angulation of the fractured fragment is present.

Postoperatively Pin tract dressing in the form of gauze soaked in betadine with excess betadine squeezed out was applied around the pin tracts. No other form of dressing or bandage was applied unless warranted (as in case of compound fractures) to ensure freedom of movement. Oral antibiotics were administered for a period of three days following surgery.

Patient was encouraged to move the affected digits on post-operative day one and was also taught passive and active motion exercises of the affected joint. Patient was also educated on method of tightening the link joints using an allen key provided to them at home.

JESS was usually removed on the post-operative day 21 after confirming anatomical union by radiography. Range of Movements were assessed on post-operative day 7, 21 and 42.

Results

The mean age of the patients in our study was 30.9 years. The study included 39 male and 11 female patients. 8% of the patients had a compound fracture, 12% had an intra-articular extension of the fracture. Using the McNemar test, comparing the functional outcome of patients on the 7th day with 21st post-operative day. It shows a highly significant improvement in range of movement with time. (P = 0.000).

Similar comparison in functional outcome between 7th post-operative day and 42nd post-operative day calculated using McNemar test, showing highly significant improvement. (P=0.000)

Comparing range of movement between 3rd and 6th post-operative week, showing highly significant improvement. (P=0.000). Gender did not have statistically significant relation with the end functional outcome (P=0.138).

Discussion

The hand is a human being‘s most exquisite part for direct interaction with the surrounding universe. The stability of its small articulations, the fine balance between its extrinsic and intrinsic motors and the complex tendon mechanism are the ultimate determinants of functional outcome after skeletal trauma of the hand. Fractures of metacarpals and phalanges are the most common fractures of the upper extremity and account for 10% of total such cases. Hand injuries are relatively common and account for 5-10% of emergency department visits.[29,30]

The incidence of metacarpal and phalangeal fractures is most common in males and peaks at the age of 10-40 years[3]. Roughly, 70% of all metacarpal and phalangeal fractures occur between the ages of 11 and 45[29]. In a study done by Pritsch and Engel[30]. Most of the patients were young men between 20-30 years old, the youngest patient being 12 years and oldest 52 years old. In our study 33 patients (66%) were present in the range of 21-40 years. Our study included 46 male and 4 female patients.

Nowhere in the body, are the forms and function so closely related to each other than in hand. P. R. Lipscomb in 1963 stated that *"too often these fractures are treated as minor injuries and major disabilities occur"*. Unfortunately, the potential for functional loss that can occur is often under appreciated. Fractures of the hand can also easily result in malunion.

Over a period of years, several modalities of treatment have been prescribed for the fracture of metacarpals and phalanges. Fixation of hand fractures with K-wires is the least invasive surgical technique, although it is relatively unstable, especially in combined injuries. Plating and screwing may lead to further damage of the already injured soft tissue, joint stiffness and delay in regaining complete function of the hand[33-35]. Furthermore, plate fixation of extra-articular fractures of the metacarpals has been found to have complications rates in up to 33% of patients including infection, complex regional pain syndrome and plate loosening[2]. Hence, it is essential to select correct modality for treatment of hand fractures. As Dr. Alfred B. Swanson has rightly said "Hand fractures can be complicated by deformity from no treatment, stiffness from overtreatment and both deformity and stiffness from poor treatment".[42]External fixation of metacarpals and phalanges has been widely used especially in case of comminuted, intra-articular, compound fractures etc. It is a method of stabilization in which a number of percutaneous metal pins pass through the fractured bone segments with their ends connected to a rigid frame.

A number of external fixators have been developed for the hand, Joshi's External Stabilization System (JESS) being one which is widely used. Margic[47] used a Kirschner pin–external fixation construct in 100 consecutive patients with metacarpal or phalangeal fractures. He achieved good to excellent clinical results in all 24 patients with isolated metacarpal shaft fractures.

The Joshi External Stabilising System (JESS) has been used for bone stabilisation in the Indian subcontinent for 30 years[50]. Owing to its simple design, light weight, easy manoeuvrability, and low cost, it has been used for various reasons as mentioned previously. JESS works on the principle of distraction histoneogenesis which can be widely used in case of compound fractures involving bone loss which will help in the generation of new bone. It is a dynamic system that allows the lengthening of the contracted tissues via slow distraction, causing minimal surgical insult. Physiological tension and stress applied to the tissue stimulates histogenesis of tissues, while controlled differential distraction gradually corrects the deformities and realigns the bones.

Principle is to achieve bony union via ligamentotaxis while trying to avoid immobilization of adjacent joints. Experimentally, it has been shown that tendon injury alone is insufficient to produce adhesions, whereas tendon injury with injury to the synovial sheath combined with immobilization leads to extensive adhesions. Therefore, post-operative rehabilitation can be started usually immediately in most cases treated by JESS, leading to a better functional outcome. Schuind and co-workers[46] stated that the fracture fragments are not stripped of periosteal blood supply and further devascularized hence potentiating healing. They are adjustable with adequate stability to permit early mobilization. When there has been concomitant soft tissue injury, external fixation permits ready access to the wound for debridement and for reconstruction of tendons, nerves, and blood vessels[69].

In JESS, the joint can be immobilized in the optimal functional position avoiding joint stiffness and early recovery as compared to immobilization in a POP slab[54]. However, loosening of K-wires and infection are known complications of external fixation; however, they are thought to be related to thermal necrosis of bone[53].

Hastings[54] identified numerous complications of external fixation, including pin track infection, osteomyelitis, fracture through pin holes after removal, neurovascular injury during insertion, over-distraction with subsequent non-union, loss of reduction, impairment of tendon gliding and motion, and interference with adjacent digits by the fixator.

In our study, we also noted that the duration of surgery in case of JESS was longer when a similar case was treated using only K-wires. However, the benefit of early rehabilitation outweighs the increase in surgery duration.

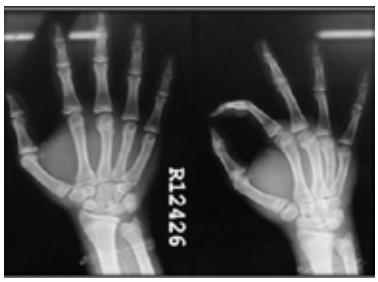
Dr. B. B. Joshi and associates used sharp, trocar-tipped K-wires in their study and they have showed the usefulness of drilling trocar-tipped K-wires in tough cortical bone and preferred two pins in each fragment. We have used trocar tipped K-wires in our study. Drenth and Klasen[33] have used threaded pins for his Mini-Hoffman frames, which were pre-bent to 40-60° to prevent interference of the other finger movements.

No intra-operative complications were noted in any of our cases. Post-operatively, rehabilitation was initiated on the day following surgery. Patient was followed up to note down the ROM on a regular basis; JESS frame was removed after radiological evidence of callus formation and union, which on an average took 4-5 weeks following surgery.

Conclusion

In our study 38 % of patients had an excellent functional outcome at the end of 6 weeks as compared to 6 % on the 7th post-operative day which is a highly significant improvement. Also a mere 4% of the patients had a poor functional outcome at the end of 6 weeks as compared to 24% on the 7th post-operative day. Intra-articular fractures had a poor functional outcome at the end of the study as compared to extra-articular fractures with a highly significant p value of 0.001. No pin tract infections were noted in any patient in our study group. The assessment of functional outcome was done using Duncan score.

Our study concluded that JESS Fixation for the hand had good to excellent functional outcome and is a viable Modality of treatment that should be considered for the above mentioned fractures.

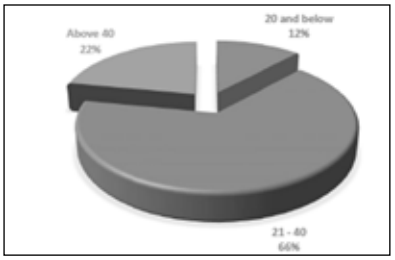


Case X-ray

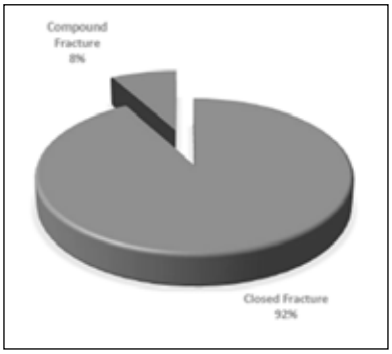
K-Wires placed with link joints and a J Shaped Connecting Rod – The Final Construct

Intra-operative Check X-ray

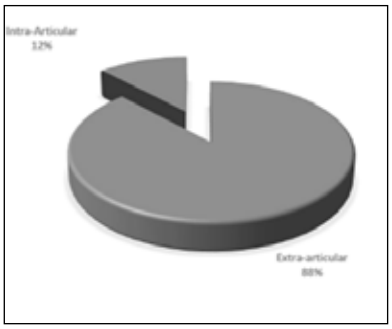
Pre and Post-operative X-ray of a Boxer's Fracture treated with JESS Fixation

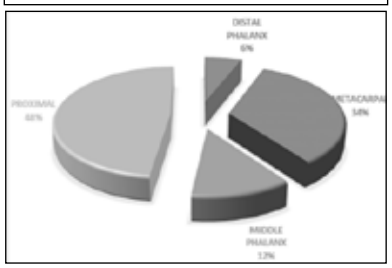


Age Distribution In Our Study



Type Of Fractures In Our Study





Fracture Site In Our Study

Table- 6 Functional Outcome on 7th day

	Frequency	Percent
Poor	12	24.0
Fair	21	42.0
Good	14	28.0
Excellent	3	6.0
Total	50	100.0

Table- 7 Functional Outcome at 3 weeks

	Frequency	Percent
Poor	8	16.0
Fair	12	24.0
Good	23	46.0
Excellent	7	14.0
Total	50	100.0

Table- 8 Functional Outcome at 6 weeks

	Frequency	Percent
Poor	2	4.0
Fair	13	26.0
Good	16	32.0
Excellent	19	38.0
Total	50	100.0

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