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To Study Functional Outcome for Upper Limb Phalanx Fracture Treated by JESS Fixator

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Abstract

Purpose: To study functional outcome for upper limb phalanx fracture treated by Joshi's External Stabilizing System (JESS) fixator. **Material and Methods:** 68 patients were operated for Upper limb phalynx fracture in a tertiary health care setup with JESS fixator and were reviewed at 3 weeks, 6 weeks and 3months. After the procedure, the patients were assessed for the functional outcome using DASH (Disabilities or Arm, Shoulder and Hand) scoring scale. **Results:** Mean Adjusted DASH scores of the operated finger over consequent visits at 3 weeks, 6 weeks, and 3 months. We found that the mean adjusted DASH score improved in each consequent visit as compared to the first visit for all the joints ($p<0.001$). Out of the total 68 study participants, 63 had no complications (92.65%). Only 5 study participants had complications, out of which 2 each had joint stiffness (2.94%) and superficial pin track infection (2.94%) while 1 had pin loosening (1.47%). **Conclusion:** From the results, we can safely conclude that JESS is an effective alternative treatment for fractures of the phalanges. It is cheap and easily available. Technically, also it is less demanding. Also there is a good functional outcome as suggested by our study findings in terms of improvement in the range of motion as well as the mean adjusted DASH scores over a period of three follow up visits planned at 3 weeks, 6 weeks and 3 months with very few complications.

Keywords: Dash Score, Joshi's External Stabilizing System (JESS) Fixator, Phalanx Pinning, Upper Limb Phalanx

1. Introduction

The human hand has evolved into a prehensile organ capable of performing extremely complex movements and manipulation. Hands play a distinct and important role. It is an organ that can perform both powerful grasping functions, such as lifting heavy objects, and delicate pinch and hook functions[1].

The most common hand fracture is a phalanx fracture. However, it is difficult to treat due to the proximity of two important joints and the crossing of a long tendon. If the fracture is not properly managed, even a seemingly minor fracture can result in long-term deformity due to a reduction in range of motion in adjacent joints[2]. It is more common in males between the ages of 20 and 29 years[3]. Road traffic accidents, industrial injuries, fall, sports related injuries and assault are the most common causes of phalanx fracture[4]. The incidence of upper limb phalanx fracture is 2.9%[5]. The conservative approach is the preferred method of treatment. These are fractures that are incomplete, non-displaced, or can be reduced to maintain acceptable alignment and stability without operative fixation. Fixation is required in unstable fractures, multiple fractures, intra articular fractures, and open fractures in order to achieve the best position for bone healing and to allow for early movement.

The best surgery and aftercare are more important in Hand disabilities than in any other region of the body. Various treatment methods have been used so far such as K wire fixation[5], mini plates[6], external fixator application[7]. The primary goals of phalangeal fracture treatment are anatomy restoration and function preservation. Given that the annual cost of lost productivity due to phalange fractures exceeds $2 billion, the goal is to reduce recovery time and accelerate return to activity[8]. The preferred treatment restores anatomy, reduces soft tissue injury,

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and allows for mobilization of the injured digit as soon as fracture stability allows[9].

An external stabilization system is an effective treatment modality for unstable and compound injuries. Joshi's External Stabilizing System (JESS) creates a stable skeletal environment that promotes rapid soft tissue healing by establishing microvascular circulation and allowing for immediate active and passive mobilization[10].

2. Aims and Objectives

To study the functional outcome for upper limb phalanx fractured treated by JESS fixator.

3. Methodology

3.1 *Study duration:*

June 2018 to December 2020

3.2 Inclusion criteria

1. All patients having either a shaft fracture of phalanx, or a fracture around proximal-interphalangeal joint, distal interphalangeal joint, and middle phalanx irrespective of their age.
2. Time since fracture <2 weeks.
3. Patients who have voluntarily given their written informed consent for the procedure.

3.3 Exclusion criteria

1. Isolated fracture of distal part of distal phalanx and proximal part of proximal phalanx.
2. Compound fracture of fingers.
3. History of previous fracture to same finger.
4. Fracture associated with neurovascular injuries.
5. Both thumb.
6. Multiple finger fracture.
7. Time since fracture >2 weeks.
8. Fractures associated with Tendon injuries.

3.4 Methodology

Closed reduction was achieved by traction and manipulation (Figure 1). To maintain reduction, external fixator was applied by passing at least two trocar K wires proximally and two K wires distal to the fracture by avoiding the injury to the neurovascular structure (safe zone). Juxta-articular and intra-articular fractures were fixed with only one pin in each fragment and enough stability was obtained with joint spanning frames. No more than 1 or 2 mm of displacement or shortening is acceptable. Up to 10 degrees of angulation is acceptable but no amount of rotation is permitted. These two constructs were connected using connecting rods. Distraction was given if required. Image intensifier was used as a guide for the steps mentioned above (Figure 1-4).

The pins were removed at 3 weeks which was followed by a passive range of motion for a week. This was subsequently followed by an active range of motion. A post-operative follow-up was done at 3 weeks, 6 weeks, and 3 months to capture the information under the following categories:

1. Radiological Evaluation – Signs of union were seen based on callus formation and visibility of fracture line on the AP and lateral radiographs.

Figure 1. Closed reduction achieved by traction and manipulation.

Figure 2. Structure of JESS.

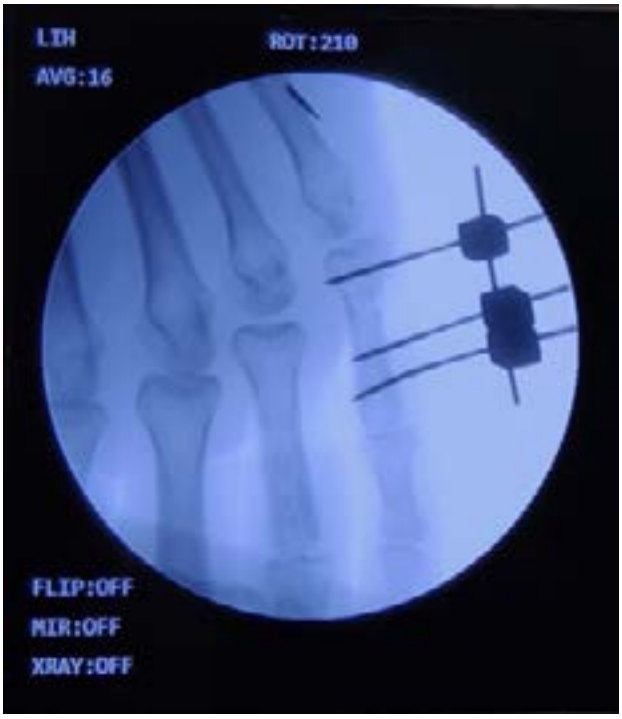

Figure 3. A. C arm image – AP.

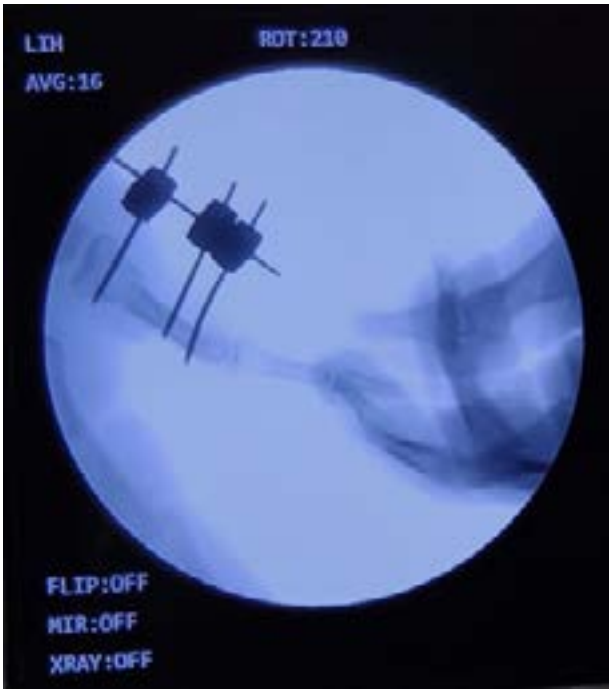

Figure 4. B. C arm image – Oblique.

2. Range of motion was measured using goniometry procedure. The part proximal to the joint was stabilized and the joint was positioned in the zero position. The joint was then moved to the end of the range of motion and end feel was taken to determine the quality of movement. Further, the bony landmarks were identified and the goniometer was aligned with these landmarks while holding the joint at the end of range. The goniometer reading was noted and recorded in the study tool.
3. Assessment of the DASH score - The Disabilities of the Arm Shoulder and Hand (DASH) symptom scale can be used to evaluate a patient with a disorder of the upper extremity. It can be used to monitor the patient over time and to determine the effectiveness of an intervention.

Measures:

1. Opening a tight or new jar.
2. Writing.
3. Turning a key.
4. Preparing a meal.
5. Pushing open a heavy door.
6. Placing an object on a shelf above the head.
7. Doing heavy household chores.
8. Gardening or doing yard work.

9. Making a bed.
10. Carrying a shopping bag or briefcase.
11. Carrying a heavy object (over 5 kilograms).
12. Changing a light bulb overhead.
13. Washing or blowing drying the hair.
14. Washing the back.
15. Putting on a pullover sweater.
16. Using a knife to cut food.
17. Recreational activities that require little effort.
18. Recreational activities that require taking some force or impact through the arm shoulder or hand.
19. Recreational activities that require moving the arm freely.
20. Managing transportation needs (getting from one place to another).
21. Sexual activities.
22. Social activities.
23. Work and other daily activities.
24. Pain.
25. Pain when performing activities.
26. Tingling.
27. Weakness.
28. Stiffness.
29. Difficulty in sleeping.
30. Impact on self-image.

Table 1. DASH scoring system

Response	Points
No difficulty or no symptom	1
Slight difficulty or mild symptom	2
Moderate difficulty or symptom	3
Severe difficulty or symptom	4
Unable to perform or very severe symptom	5

Where,

- Pain (item 24) may refer to pain at rest.
- Alternatively, the points may be assigned from 1 to 5.
- Total score = SUM (points for all 30 items).
- Adjusted score (if scored from 1 to 5) = ((total score for patient/30) – 1) *25.

Interpretation:

- Minimum score (using 1 to 5 scales): 0
- Maximum score (using 1 to 5 scales): 150
- Minimum adjusted score: 0
- Maximum adjusted score: 100

Adjusted Score	Disability Level
0	No disability
100	Extreme disabilities

4. Results

The mean age of the study participants was 40.41 ± 11.67 years. The youngest study participant was 20 years old while the eldest was 70 years old. Most (29.41%) of our study participants came from the age group 40-50 years, followed by those in the age group of 20-30 years (26.47%) of participants, 23.53% from the 30-40 years and 13.24% from 50-60 years age group. We had 7.35% participants equal to and above the age of 60 years.

The study participants were predominantly males (80.88%) with 19.12% females.

In majority of the study participants middle phalanx (45.59%) was involved which was followed by the involvement of the proximal phalanx (35.29%) while distal phalanx (19.12%) was least involved amongst all the fractures of phalanx.

Out of the 68 total study participants having fracture of upper limb phalanx, 23 had spiral fracture (33.82%), 21 had oblique (30.88%), 17 had transverse (25.00%) while 7 had comminuted fracture (10.29%).

The fifth finger was involved in 35.29% of our study participants having the fracture of upper limb phalanx which was also the most common finger to be involved. This was followed by the involvement of the second finger (29.41%), the fourth finger (19.12%) and the third finger (16.18%).

Out of the total 68 study participants having a fracture of upper limb phalanx 62 had no joint involvement while 6 had some joint involved. Out the 6 study participants who had the joint involvement, 4 had the involvement of proximal interphalangeal joint, while the 2 participants had a distal interphalangeal joint involvement.

The study participants had a mean hospital stay of 2.5 days with a minimum stay of 1 days and a maximum stay of 3 days. Figure 9 is a box and whisker plot showing the distribution of the study participants according to the hospital stay.

Table 1 shows the trend of appearance of the signs of union in the consequent visits at 3 weeks, 6 weeks, and at 3 months. A Pearson's chi-square test was calculated for comparing the frequency of patients showing the signs of union at each visit. We found a statistically significant

association between the frequency of the presence of the signs of union in the consequent visits ($\chi 2$ (2, n=68) = 62.63, p = <0.001). The patients of upper limb phalanx fracture who participated in our study disproportionately showed a higher frequency of the presence of the signs of union in the third visit as compared to the second and the first visit.

Table 2 shows the trend of range of motion in the joints of the operated finger over consequent visits at 3 weeks, 6 weeks, and at 3 months. Depending on the phalanx involved, the range of motion (ROM) at Meta-Carpo-Phalangeal (MCP) joint the Proximal Inter-Phalangeal (PIP) joint, and the Distal Inter-Phalangeal (DIP) joint was affected. For each proximal phalanx involvement, the ROM at MCP and PIP were involved, for each middle phalanx involvement, the ROM at PIP and DIP were involved whereas for each distal phalanx involvement, the ROM at DIP was involved. Further where there was a fracture around the PIP joint, the ROM at MCP, PIP and DIP was measured while for a fracture involving the DIP joint, the ROM at PIP and DIP was measured. Hence, the range of motion was affected over a total of 26 MCP joints, 55 PIP joints and 46 DIP joints. We found that the mean range of motion improved in each consequent visit as compared to the first visit for all the joints (p<0.001) (Table 3).

Table 4 shows the trend of adjusted DASH scores of the operated finger over consequent visits at 3 weeks, 6 weeks, and 3 months. We found that the mean adjusted DASH score improved in each consequent visit as compared to the first visit for all the joints (p<0.001).

Out of the total 68 study participants, 63 had no complications (92.65%). Only 5 study participants had complications, out of which 2 each had joint stiffness (2.94%) and superficial pin track infection (2.94%) while 1 had pin loosening (1.47%).

5. Discussion

This study was designed to assess the functional outcome of the patients operated using JESS technique for managing the upper limb phalanx fractures. A total 60

Table 2. Trend of appearance of the signs of union in consequent visits

n		Visit 1		Visit 2		Visit 3	
		%	n	%	n	%	
Signs of union	Present	18	26.47	33	48.53	63	92.65
	Absent	50	73.53	35	51.47	5	7.35
	Total	**68**	**100.00**	**68**	**100.00**	**68**	**100.00**
Pearson Chi-Square value = 62.63 (p = <0.001)							

Table 3. Range of motion in the joints of the operated finger over consequent visits

Joint	n	Type	Visit 1		Visit 2		p value	Visit 3		p value
			Mean	SD	Mean	SD		Mean	SD	
MCP	26	Active	14.42	11.46	39.23	9.68	<0.001	65.96	10.29	<0.001
		Passive	24.23	11.07	47.50	9.12	<0.001	72.31	9.12	<0.001
PIP	55	Active	19.91	12.04	50.91	12.29	<0.001	80.82	13.10	<0.001
		Passive	26.73	12.14	58.55	12.74	<0.001	88.27	13.49	<0.001
DIP	46	Active	14.02	8.82	28.59	10.51	<0.001	44.13	11.99	<0.001
		Passive	21.41	9.48	35.76	10.68	<0.001	50.98	12.10	<0.001

Table 4. Adjusted DASH scores of the operated finger over consequent visits

	Visit 1		Visit 2		p value	Visit 3		p value
	Mean	SD	Mean	SD		Mean	SD	
Adjusted DASH score	64.62	7.92	37.22	5.82	<0.001	17.16	6.51	<0.001

patients with upper limb phalanx fracture were included in this study.

Drenth and Klasen[11] 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). We found that the majority of the patients with upper limb phalanx fracture were young and belonged to the age group 20-30 years. The incidence of fractures in our study was more common in males (80.88%) 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. 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%). This was similar to what we found in our study that is the majority of our patients had the fracture due to RTA and least due to assaults. In Drenth and Klasen[11] 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 the present study, most of the fractures involved middle phalanx. However, the Drenth and Klasen[11] study constituted 21 proximal fractures, 8 middle phalanx fractures and 7 metacarpal fractures. No cases of distal phalanx were managed by them. 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.

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 which explains the stay of hospital duration ranging from a minimum of 1 day to a maximum of 3 days with a mean of 2.5 days. The delay in treatment was either because of late reporting or associated injuries. 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 have 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[11] and they have showed the usefulness of drilling trocar tipped K-wires in tough cortical bone and preferred two pins in each fragment. Drenth and Klasen[11] have used threaded pins for his mini-Hoffman frames, which were present to 40-60° to prevent interference of the other finger movements[12].

Ashmead *et al.*[13] used threaded pins for Jacquet external mini-fixator for static external fixation in the hand and carpus. 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[13] 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[14]. However, we found that all of our patients improved their range of motions and DASH scores over the period of the three consecutive visits planned at 3 weeks, 6 weeks and 3 months. This may be due to the fact that in the 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 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[11] studies, mean period of treatment of phalangeal fractures was 7 months and of metacarpal fractures was 5 months. The mean follow-up was 4.4 years. Our study was 18 months long and a follow up was planned for the patients after 3 weeks, 6 weeks and 3 months of undergoing the

procedure. The study by Drenth and Klasen[11] showed that the fracture healing occurred in most of the cases within 12 weeks total to 56.76%. In our study, the mean range of motion as well as the DASH scores improved over the course of the visits. Reviewing the literature, the average radiological healing of phalanges and metacarpals is 4-5 months, which ranges from 1-17 months[11]. Functional outcome of our study participants improved in a period of 3 months.

A study by Hsu *et al.*[14] found that 39 patients experienced postoperative complications involving 58 K-wires (14% of all pins). Most complications were minor, commonly superficial pin track infection (24 pins, 6% of all pins). Major complications occurred less frequently (11 pins, 3% of all pins) and included complications that led to additional surgery (deep infection, malunion, or nonunion) and fractures through the pin track[14]. We found that out of those having complications, most common were joint stiffness and superficial pin track infection followed by pin loosening.

6. Summary and Conclusion

This hospital-based cohort study was conducted in the wards under the care of the department of orthopaedics in a medical college and tertiary care centre to study the functional outcome for upper limb phalanx fracture treated by JESS fixator. The eligible patients having fracture of phalanx were asked to participate in the study during the period of June 2018 to December 2020. A total of 68 such patients were enrolled in the study upon taking the written informed consent. A detailed patient profile with clinical history, complete general examination, systemic examination, local examination, and pre-operative investigation findings were noted as per the predesigned, and pre-tested proforma. For the enrolled patients, JESS was used to fix their fractures. First, the closed reduction was achieved by traction and manipulation. Then to maintain the reduction, an external fixator was applied by passing at least two K-wire proximally and two K-wire distal to the fracture and these were connected using the connecting rods. If required, distraction was given. Further, an image intensifier was used to guide the accuracy of the procedure. After, the upper limb phalanx fracture of the patient enrolled under the study was fixed using the JESS technique, the patient was given daily pin track dressing. The pins were removed at 3 weeks which was followed by a passive range of motion for a week. This was subsequently followed by an active range of motion. A post-operative follow-up was done at 3 weeks, 6 weeks, and 3 months. At each of these visits, radiological evaluation, and range of motion assessment was done followed by the assessment of the DASH score. The analysis was done to see whether there was improvement in the functional outcome in terms of the adjusted DASH scores and the range of motion of the operated finger. We found that there was a significant improvement in the mean adjusted DASH scores as well as the mean range of motion in the fingers that were operated using JESS procedure.

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