

Comparison between K-wiring Versus K-wiring with External Fixation (JESS) in Compound Intra-articular and juxta-articular Metacarpal and Phalangeal Fractures of the Hand: A Randomized Control Study

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Abstract

Background: The fracture of the hand results in significant disability and leads to long term negative functional sequelae including loss of ability to work and live at pre injury level. Most of these fractures can be treated conservatively. However, conservative treatment has poor outcome in unstable, intra-articular and compound fractures, making operative means a necessity for such cases. **Materials and Methods:** A prospective randomized control study was undertaken in our institute consisting of 100 cases of intra-articular and juxta-articular fractures of the small long bones of the hand who were treated with either simple K-wiring versus K-wiring with external fixation over a period of 12 months from January till December 2020. The cases were evaluated for functional outcome at the end of 12 months of follow up. **Results:** 100 cases with 129 fractures of the metacarpals and phalanges of hand were randomized and treated with either K-wires or Joshi's External Stabilisation System (JESS) fixator. The mean age of the cases was 31-40 years with male predominance. Motor vehicle accidents were the commonest cause of trauma. The operative time for JESS fixation was longer than K-wiring alone, which was statistically significant. Functional outcome was assessed based on Modified Mayo Wrist Score and ASSH-TAF scores. At the end of 12 months, JESS fixation had statistically and functionally better results. **Discussion:** The authors advocate the early management of hand fractures with JESS Fixation compared to K-wiring alone. The outcomes were also dependent on the age, gender and compliance of the patients.

Keyword: Hand fractures; K-wire; JESS

Introduction

"The reputation of a surgeon may stand as much in jeopardy from a fracture of the proximal phalanx of the finger as much as from any fracture of the femur"- Sir John Charnley [1].

Hand is a specialized structure interacting with the external environment and is especially sensitive to functional impairment [2]. It is an organ of such versatility that its uses range from lifting heavy objects, to grasping, to delicate pinch and hook actions such as threading a needle [3]. Consequently, the human hand is one of the most injury prone parts of the body.

Hand injury is extremely common and accounts for about 15% of the attendance at the emergency department [2]. Metacarpals and phalanges are the frequently fractured bones and amount to a prevalence of about 10-15% [4].

Most of these injuries are neglected and considered trivial and treated with plasters and splints which later on functionally limit the hand. The conservative treatment has a poor reputation in unstable, comminuted, juxta-articular and open fractures as it causes higher incidences of malunion, stiffness, impalement of skin and other soft tissue. These cases have a delayed return to their pre-injury functional state. Thus, surgical intervention comes to the fore.

K-wire has been a standard primary treatment of hand fractures worldwide since its introduction [5]. K-wires can be used singly or can be used in conjunction with an external fixation device like Joshi's external stabilization system (JESS). JESS works on the principle of ligamentotaxis. With bony stabilization, JESS induces conditions necessary for brisk soft tissue healing without further damage of the microvasculature of the area, therefore making the chances of infection significantly less and making wound care easier in cases of open fracture [6].

The purpose of this study is to compare and report the outcomes of compound intra-articular and juxta-articular fractures of metacarpals and phalanges of the hand treated using JESS and K-wire technique and to determine which of the two techniques provide better functional results.

Materials and Methods

A hospital based prospective single-blinded randomized clinical study was undertaken in the Department of Orthopaedics of Gauhati Medical College & Hospital, Guwahati among the patients admitted for hand injuries. A total of 100 patients with compound intra-articular and juxta-articular metacarpal and phalangeal fractures over a period of 12 months from January 2020 till December 2020 constituted the study sample. Ethical clearance was obtained from the governing authority. A bilingual, written and informed consent was obtained from all the cases before they were included in the study.

Inclusion criteria

1. Age group 18-60 years.
2. Open fractures (Type 1, 2, 3A and 3B) [as per Gustilo Anderson classification of open fractures].
3. Intra-articular and juxta-articular fractures.
4. Patients physically fit for surgery.
5. Patients who have given their written informed consent for the procedure.

Exclusion criteria

1. Severely crushed hand injuries and Gustilo Anderson type 3C injuries.
2. Fractures with associated neurovascular injuries.
3. Patients with spondylo-arthropathy involving hand.

Cases that fulfilled the inclusion criteria were randomized into two groups on the basis of a predetermined randomization table and allocated into:

Group A: Joshi's external stabilization system (JESS) Fixation (n=50).

Group B: Kirschner-wire (K-Wire) Fixation (n=50).

Both the operative techniques were carried out under LA/RA.

Patient preparation

After ruling out other musculoskeletal and visceral injuries, adequate history is taken which includes the time elapsed since injury, mechanism of trauma, hand dominance, previous hand trauma/surgery and functional status of the limb, occupation, last meal and events leading up to the injury.

Initial thorough wound wash is done with normal saline and disinfectant like hydrogen peroxide. After initial evaluation, x-rays of the injured parts are done along with basic preoperative blood parameters like routine blood and viral markers. After evaluation in terms of wound contamination and tissue damage, gross contaminants are removed and a gentle wash given with normal isotonic fluid. An antiseptic dressing was applied till the time the patient could be taken up for surgery. Also, the hand is supported with a splint and kept strictly elevated to reduce the soft tissue oedema.

Operative technique

K-Wire

Smooth, trocar tipped K-wires of the size 1-1.4mm are used for the phalanges while 1.2-1.8mm for the metacarpals respectively. K-wires are applied in different configurations, i.e. intramedullary K-wires, crossed k-wires, transverse k-wires, etc. as per the necessity of the individual fractures.

Firstly, meticulous debridement of the wound is done preserving as much of the healthy soft tissue coverage as feasible. Fracture pattern is then observed under C-arm guidance followed by manipulation, reduction and K-wire application. Smaller fracture fragments are held with retrograde k-wire insertion. Neurovascular bundles are avoided and extensor tendons retracted before K-wire insertion wherever possible. K-wires are bent and cut close to the skin and anti septic pin dressings applied.

JESS fixator

After initial wound wash and debridement, the ideal position for pin placement and application of the external frame configuration is decided upon. This is done very precisely, so as to facilitate successive dressings and carry out secondary procedures like skin and bone grafting whenever necessary.

Under C-arm guidance, the fracture is reduced using traction and manipulation and further aligned. The assistant maintains the reduction while the surgeon applies the pins sequentially. To maintain reduction, percutaneous K-wires (1.2mm, 1.5mm, 1.8mm) were inserted proximal and distal to the fracture site with bicortical purchase. Across I.P. joints connecting rod is maintained in extension. Fractures involving metacarpophalangeal joints, fixators are applied with MCP joints at 70 - 80 degrees of flexion (in functional position). The K-wires are applied following the safe zones as advised by Dr. B. B. Joshi [6] and associates. In the proximal and middle phalanges, K-wires are inserted in the dorsolateral configuration. This could impale the oblique retinacular ligament or the lateral bands. These structures however recover their function after the frame and pins are removed. We used dorsal or dorsolateral pins in the metacarpal fractures. Superficial veins are pushed away with the lax overlying skin to avoid any injury during pin insertion. Extensor tendons are identified and retracted on either side, while the wires are passed, without transfixing the tendons.

A space of 5-7 mm is kept between connecting systems and skin. This distance allows easier wound and pin tract dressing without much hindrance from the overlying frame. All wires are trimmed and only 4-5mm wire should be projecting beyond the link joints. The ends of the wires and pins are capped with plastic tubing. The link joints and clamps are tightened and the frame is kept as close to the

skin as possible. A closer frame imparts greater stability. Adding another external rod further improves stability.

Post operative protocol

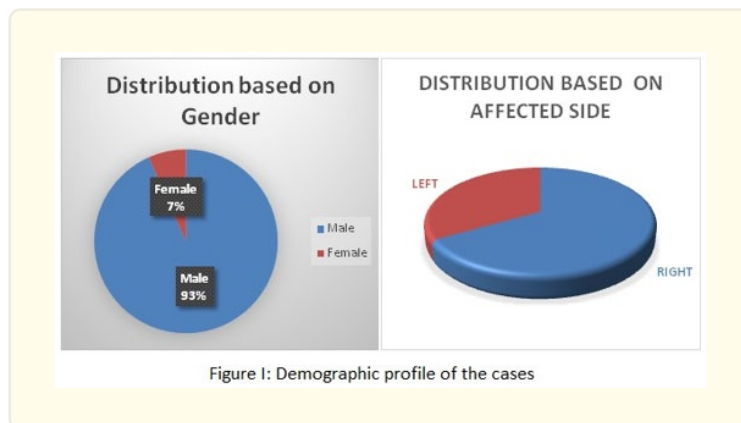
1. Immediate limb elevation from the day of surgery.
2. Non-operated fingers and free joints of the operated fingers were mobilized with exercises from day 1 or when pain was tolerable.
3. Antibiotics for all post operative cases.
4. Daily pin site and antiseptic dressing.
5. External fixator/ K-wire removal at 3-4 weeks.

Patients were called for periodic evaluation at 2 weeks (stitch removal was done), 4 weeks, 6 weeks and 8 weeks on OPD basis. Functional outcomes were measured based on Modified Mayo Wrist Score and American Society for Surgery of Hand-Total Active Flexion (ASSH-TAF) score. Final assessment was done after 12 months of post operative period had elapsed. The qualitative data was presented as frequencies and percentages and quantitative data was presented as mean and standard deviations. Paired t-test and p-values were used as test of significance for the qualitative data.

Results

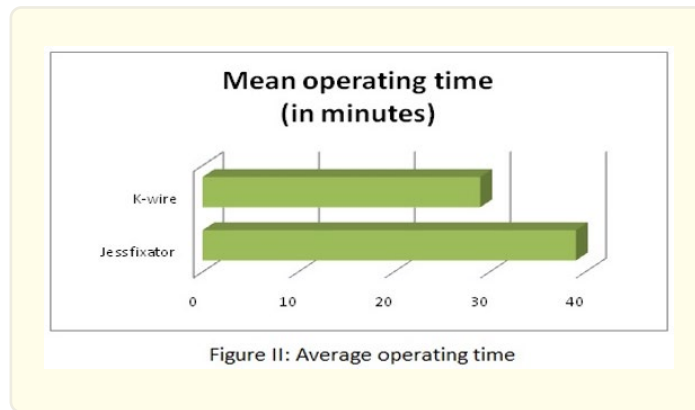
In the present prospective randomized study, 100 patients with 129 intra-articular ad juxta-articular fractures of the small long bones of the hand were treated with either K-wiring or K-wiring with external fixator (JESS fixator) and followed up for a minimum of 12 months.

The mean age of the patients was 32.96 years and majority of them were males with right handed (dominant) injuries (Figure I). About 33% of the cases were manual labourers working in farms, industries and machinery goods. Road traffic accidents were the primary mode of injury (48%) followed by industrial accidents (32%). Majority of the fractures involved the phalanges only 58% while 32 % cases involved the metacarpals and 10% cases involved both. Among both the phalanges and metacarpals, the border digits were most commonly affected accounting for about 30% of the cases.



Almost 90% of the cases were operated within the same day of the traumatic event. Late interventions were mainly due to delay in presentation or associated visceral injuries requiring prior stabilization and optimization before bony stabilization.

On an average, JESS fixation took a longer operating time compared to K-wiring alone (38.7±9.7 minutes versus 28.7±6.4 minutes). This difference was statistically significant with a p-value<0.05 (Figure II). The average soft tissue healing period was however equivocal.



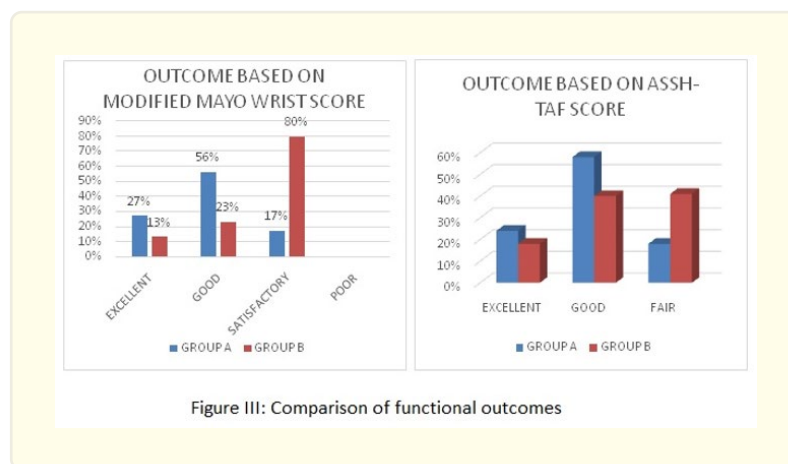
K-wires were removed at an average of 25.2±3.2 days while JESS fixator was removed by 28.7±1.8 days. This difference was however statistically insignificant (p-value >0.05).

Functional outcomes were calculated on the basis of Modified Mayo Wrist Score and ASSH-TAF scores respectively. At the final assessment done at 12 months (Table I):

Functional Outcome Measurement		
	Jess Fixator	K-Wire
Modified Mayo Wrist Score (out of 100)	84.6 ± 9.7	77 ± 9.8
ASSH-TAF score	198.3 ± 27.04	170.33 ± 31.7

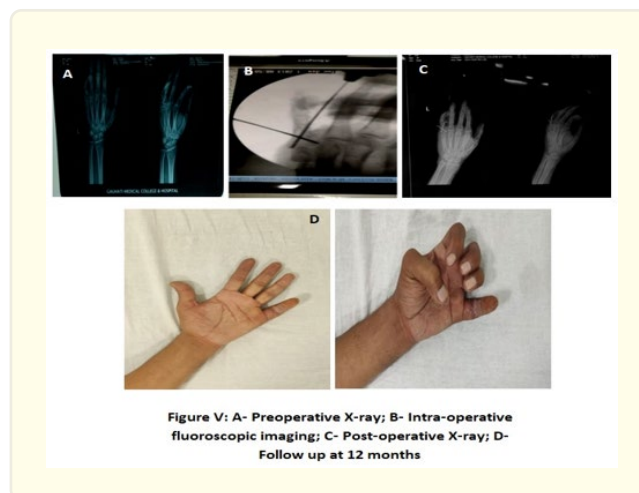
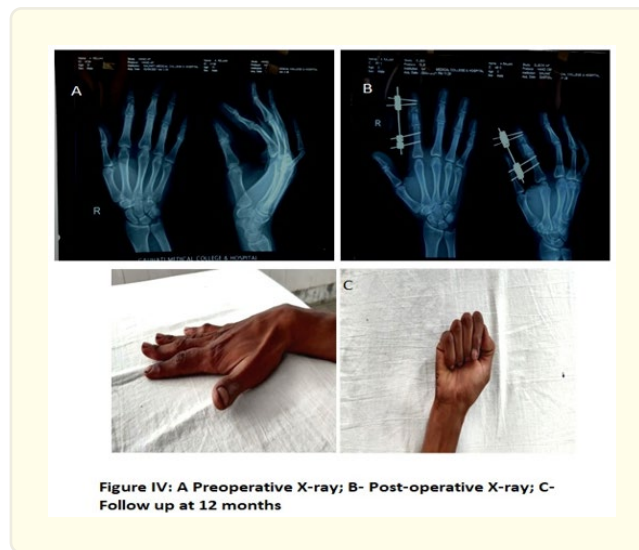
Table I: Assessment of functional outcomes.

The difference in outcome assessment in both the scores is statistically significant with p-value<0.05 (Figure III).



Pin tract loosening and infection were the common complications following JESS fixation. Pin tract infection was however superficial and resolved after removal of the pins and antibiotic coverage. There was no instance of osteomyelitis in our study. Almost 27% of the cases of intra-articular phalangeal fractures treated with K-wiring alone had post-operative stiffness.

(Figure IV and V represent clinical photos of cases treated with JESS and K-wire fixation respectively).



Discussion

The hand being a specialized structure is sensitive to functional impairment [2]. The sophisticated structure of the hand makes it vulnerable for multiple fractures. The fracture of the hand results in significant disability and leads to long term negative functional sequelae including loss of ability to work and live at the pre injury level. Most of these fractures can be treated conservatively [7]. There is loss of function in about 77% of fingers in cases of unstable fractures treated with closed conservative methods as reported by James et. al [8]. Hence operative fixation is desirable in unstable and intra-articular fractures of the metacarpals and phalanges as meticulous reduction and fixation is required to achieve the ideal position for osseous healing and to permit early rehabilitation [9].

The ultimate goal is to aim for quick return of the patient to his or her normal functional activities while also restoring the hand's structure and function to as close to normal as feasible.

The modes of treatment include K wire fixation, mini plates and external fixator application systems. Whenever surgical treatment is indicated, the proper application of the principles of external fixation and a semi-rigid system allowing early mobilization are critical for a good functional outcome [10].

K-wires are the most adaptable, simple, and affordable technique of treating hand injuries. They can be introduced percutaneously without exposing the fractures. It is sufficiently stable to allow early motion without subjecting the hand to the surgical trauma of open reduction [5].

The simple, adaptable and light weight design of JESS fixator with the advantage of possible conversion to dynamic mobilization units and amalgamation of splints adds to its versatility [11]. JESS provides rigid fixation of bones when other forms of immobilization like plasters are not appropriate e.g., open fracture. It is possible to compress, neutralize or distract the fracture fragments and thus allowing aggressive and simultaneous treatment of both bony and soft tissue lesions [6]. Joshi's external stabilisation system (JESS) uses thin, smooth wires to create a stable skeletal environment that aids quick soft tissue healing by establishing microvascular circulation while permitting instantaneous active and passive movement of the uninjured adjacent joint [11].

Fractures of the hand are commonly seen in young and middle-aged individuals. The average age in this study was 32.9 years, with most patients belonging to the second to fourth decade and males outnumbering the females. This was mainly due to the lifestyle and working environment of the males, making them more vulnerable to accidents and injuries.

Road traffic accidents continue to be the leading cause of such injuries in the given demographic area. About a third of the patients in our study were manual labourers, including agricultural workers and workers in various industries, dealing with heavy machinery and goods. Their working environment made them prone to a variety of injuries, especially to the hands, requiring urgent intervention. Also these patients were dependent on the proper functionality of their upper limbs for carrying out their daily livelihood.

Among the phalanges, the proximal phalanx was more involved (50%) than the rest. The study found that the border rays (second and fifth digits) were the most affected among all the digits. These digits due to their positioning were vulnerable for more injuries. The demographic variables in the present study were comparable with previous studies of Mishra et al [9] and Jindal et al [12].

Trocar tipped K-wire (four angled facets) have better holding power and were preferred over the diamond tipped ones. Improper drilling has a propensity to cause thermal necrosis. K-wires were inserted using power or hand drill at slow drilling speeds to prevent this. In their work, Dr. B. B. Joshi and colleagues used sharp, trocar-tipped K-wires and demonstrated the utility of drilling trocar-tipped K-wires in thick cortical bone, preferring two pins in each fragment [6]. Drenth and Klasen [13] used threaded pins prebent to 40-60° for their mini-Hoffman frames to avoid interfering with other finger movements. Gary M Lonne and Robert E Lins, who used Jacquet external fixator for static external fixation in the hand and carpus, used threaded pins for their external minifixator [14].

JESS Fixation, which used multiple K-wires, had a higher average operating time for each case compared to a single or cross K-wire procedure. This was mainly due to the relatively complex nature of the procedure, with the use of multiple K-wires and link joints, compared to the much simpler K-wiring technique.

The thumb rule and empirical teaching is that the hand fractures heal in four weeks. The average period of removal of K wires was 3-4 weeks and JESS fixator was 4-5 weeks.

Excellent to Good results were seen in about 80% of the phalangeal and metacarpal fractures treated with JESS fixator as per both ASSH-TAF score and Modified Mayo Wrist Score. Excellent to Good results were seen in about 58% of the cases treated with K-wire fixation alone as per ASSH-TAF Score and 40% by Modified Mayo Wrist score respectively.

JESS fixator proved to be statistically better treatment option, especially in cases with intra-articular or juxtra-articular fractures, wherein external fixation could preserve the joint movement and function and provide early rehabilitation for the same. Metacarpal fractures gave better functional results than phalangeal fractures because of the difference in the type of injury and function. External fixation with JESS provides an excellent foundation for bone healing, but cannot alone guarantee good functional outcomes. The severity of accompanying soft-tissue injuries play a major role in further rehabilitation as shown by our fair or poor results in five patients in whom phalangeal fractures were associated with tendon injuries.

The outcomes were significantly better in open intra-articular phalangeal and metacarpal fractures, fractures with bone loss and multiple fractures. Also, younger patients had a much earlier return to working state compared to the older ones. Adherence to strict post-operative physiotherapy regimen was another important variable in the said equation.

Issues with external fixation like K-wire loosening and infection are well-known, although they are thought to be linked to bone thermal necrosis [15]. Hastings [16] 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, restriction of tendon gliding and motion, and encroaching with adjacent digits by the fixator. Post-operative stiffness following K-wiring was dealt with aggressive physiotherapy and acceptable range of movements were achieved in the long run.

In this study, the basic principle of external fixation was the same as that advocated by Ilizarov [17]. Controlled differential distraction gradually corrects deformities and realigns the osseous structures, while physiological traction and stress over the tissues encourage histogenesis and osteogenesis [18].

The authors advocate the use of K-wiring with external fixation (JESS fixator) in the management of intra-articular and juxta-articular fractures of the small long bones of the hand. A tabulated comparison with previous studies conducted on the use of mini- external fixation for hand injuries elicits similar comparable results with the present study: (Table II).

	<i>Drenth & Klasen [13] (1998)</i>	<i>Parson [19] (1992)</i>	<i>Naidu [11] (2018)</i>	<i>Mishra [9] (2019)</i>	<i>Present study</i>
Gender	Male 80%	Male 87%	Male 82%	Male 82%	Male 87%
Mode of injury	RTA 30%	RTA 55%	RTA 30%	Machinery accidents 45%	RTA 48%
Fracture healing	5-6 weeks	4.8 weeks	6 weeks	6 weeks	4-5 weeks
Outcome	Good 85%	Good 71%	Excellent 76%	Excellent 73%	Good to excellent 80%
Mean follow up	4.4 years	13 weeks	1 year	1 year	1 year
Complication	Pin loosening	Stiffness	Swelling	Pin tract infection	Stiffness

Table II: Comparison with previous studies.

Conclusion

We have compared the outcomes of fixation with JESS fixator and K-wire fixation respectively in the conducted study. Both the treatment modalities provide satisfactory results in terms of clinical and functional outcomes for phalangeal and hand fractures. However, considering the overall results, we're of the opinion that JESS fixator has a statistically significant edge over fixation with K-wire alone in metacarpal and phalangeal fractures with an intra-articular or juxtra-articular component. They also had a relatively lower incidence of post-operative complications than K-wire fixation. The outcomes were also dependent on the age, gender and compliance of the patients. Patients who followed a rigorous follow up rehabilitation protocol had a significantly better outcome compared to their peers.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation

(institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from all patients for being included in the study.

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