STABILISATION OF PHALANGEAL AND METACARPAL FRACTURES WITH JESS FIXATION

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ABSTRACT

BACKGROUND

The human hand is the most vulnerable part of the body prone to a variety of injuries especially in industries, agricultural fields and adding to this increased road traffic accidents resulting in high incidence of phalangeal and metacarpal fractures particularly mutilating hand injuries, open fractures, comminuted fractures and intra-articular fractures. The purpose of the study is to evaluate the overall functional outcome of hand treated with JESS fixation for metacarpal and phalangeal fracture and to study the complications associated with their management.

MATERIALS AND METHODS

We have studied 30 patients with 37 fractures of metacarpals and phalanges of hand with JESS mini external fixator at Department of Orthopaedics, Rangaraya Medical College. The study was done from October 2012 to August 2014. Age of the patients range from 10-60 yrs. with most of the patients belong to 21-40 yrs. age group. The 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 are caused by RTA and on right hand. Majority of the fractures are occurred in proximal phalanx, followed by metacarpal.

RESULTS

All patients were followed for a minimum of 6 months and the mean follow-up period was 33.77 wks. The mean fracture healing in 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. The fracture healing time in our study compares favourably with those reported in the literature. Mean duration of implant (JESS) application was 4.42 wks. Complications like pin-tract infection encountered in five patients, three pin loosening, one 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

JESS, Phalangeal Fractures, Comminuted Fractures.

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BACKGROUND

Sir John Charnley stated that "The reputation of a surgeon may stand as much in jeopardy from a fracture of the proximal phalanx of the finger as from any fracture of the femur." The human hand is the most vulnerable part of the body prone to a variety of injuries especially in industries, agricultural fields and adding to this increased incidence of road traffic accidents. Fractures of metacarpals and phalanges are the most common fractures of the upper extremity and account for 10% of total such cases.[1] 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[2] - 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.[3] The Proximal Phalanx (PP) of the fingers is fractured more frequently than the middle or even distal phalanges. The deformity with considerable displacement is typical when the PP is fractured.[4] Most fractures are functionally stable either before or after Closed Reduction (CR) and farewell with protective splintage and early mobilisation. The closed treatment has gained a poor reputation in unstable, comminuted, juxta articular and open fractures because of problems of malunion, stiffness and sometimes loss of skin or other soft tissues. Open reduction and internal fixation

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with K wires, plates and screws further compromises injured soft tissues and leads to infection and stiffness.

As Dr. Alfred B. Swanson as put it very well that 'Hand fractures can be complicated by deformity from no treatment, stiffness from overtreatment and both deformity and stiffness from poor treatment.' This suggests that we must choose the treatment, which is most appropriate to each particular fracture. On the other hand, external fixation allows fracture reduction to normal bony length via a rigid external support.[5] Stiffness can be prevented by mobilisation at joints proximal and distal to the fracture can be achieved across the external apparatus and good results with different formal external fixator sets are reported.[6,7]

There have been few reports of the use of JESS mini-externa fixator for metacarpal and phalangeal fractures. Therefore, this study has been undertaken at Department of Orthopaedics, Rangaraya Medical College, Kakinada, to evaluate the functional outcome hand in metacarpal and phalangeal fractures managed with JESS mini-external fixator in order to assess their usefulness in different fracture types and to make recommendations regarding potential applications.

MATERIALS AND METHODS

Since most of the fractures of hand are caused by road traffic accidents, makes it imperative to assess both the fracture and the patient as whole. In our study, a treatment protocol with the priority list was followed.

Priority I- A patient sustaining a fracture of hand is likely to have multiple fractures involving major long bones resulting in shock either hypovolaemic or neurogenic, which takes the first priority. Shock was combated with fresh blood transfusion, intravenous plasma expanders and intravenous fluids. Once the cardiopulmonary status was stable, the next step in the treatment protocol was carried out.

Priority II- Assessment of injury/ chemoimmunoprophylaxis. Assessment of the injury was done by grading the open injuries of hand into two grades as per Swanson et al.

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

Type II- (Any one or more of the following) Contamination with gross dirt/debris delay in treatment longer than 24 hrs. Significant systemic illness.

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 Aliens test. Radiography were taken in two views as Anteroposterior (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 were taken when indicated for associated injury. Pain was alleviated by analgesics. Broad-spectrum antibiotics and anti-tetanus prophylaxis were started in case of open injuries.

Priority III- JESS application- Once the patients general condition was stable, patient was taken for JESS fixator application. 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 is necessary was done and the fracture reduced. The frame was then tightened.

In case of intra-articular fracture, we follow 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 wound was dressed daily. Pin sites were cleaned daily with spirit and Betadine solution. Sterile gauge pieces soaked in Betadine solution were placed around pin sites. Active and passive movements of the joints proximal and distal to the fixator were carried out.

Priority IV- Rehabilitation- Active and passive movements of the joints proximal and distal to the fracture were continued. After about 3 weeks, a radiological examination followed by removal of critical connecting rods and clinically testing for union. Frame is removed depending upon presence of pain and abnormal mobility. Associated injuries were treated simultaneously and the patient was followed regularly for a further period of about one year.

Priority V- Recording of results- 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. The complications such as pin-tract infection, pin loosening, joint stiffness, malunion, 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. This adds the active flexion of metacarpophalangeal, proximal interphalangeal and distal interphalangeal joints, then subtracting the sum of extension deficits of these three joints.

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

Thus, the best treatment modality for small bone fractures should be one, which would offer.

1. Stability to injured bone and soft tissues.
2. Would not jeopardise the soft tissue envelope.
3. Possibility of placement of fixation in safe zones in phalanges and metacarpals.

4. Neutralise gravitational, rotational and angulatory forces and maintain the hand in functional position.
5. Permit observation of soft tissue response to healing.
6. Ensure complete relief of pain so that soft tissue management could be carried out without repeated anaesthesia.

JESS FIXATOR

Dr. B. B. Joshi and his associates from Bombay (now Mumbai) introduced a mini-external fixator in early 1990's as JESS (Joshi's external stabilisation system) for stabilisation of unstable fractures of hand. Since, conceptualisation of the fixator system, which of JESS today become recognisable to orthopaedic surgeons everywhere.

Component of JESS Fixator-

The inventors of JESS fixators set out to produce a fixator that would be versatile, simple, stable and cost effective. 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.

Types of Configurations

Although, a large variety of configuration are possible using the JESS components, five basic types are-

1. Unilateral frame.
2. Bilateral or coplanar frame.
3. Joint spanning frame.
4. Distraction frame.
5. Dorsolateral or dorso-oblique frame.

Care of JESS Frame and General Principles of Post-Fixation Management

Care of Frame-

There is a grave and definite danger of the patient moves his hand and forearm forcefully towards his face. Injuries to the eye during this period by the wires is a possibility. Thus, all wires must be trimmed and only 4-5 mm wire should be protruding beyond the link joints and capping the protruding wires with plastic tubing is essential.

Elevation

The limb should be kept elevated above the level of heart to facilitate gravitation of body fluids into the circulation and should be advised full range of movements of adjacent joints.

Dressings

Closed injuries- Dressing of the pin tracts are changed on the first or second postoperative day.

Open injuries- The care of the frame is the same as described for the closed injuries. The dressings are changed every day.

Mobilisation

Mobilisation of every joint, which is not involved in the frame should start from the very first day.

Mobilisation of Injured Digits and Immobilised Digits

Injured digits and immobilised joints are mobilised usually after 4 weeks of the procedure. It must be ascertained that the fractures are stable and that the healing is progressing satisfactorily. All wounds should have healed prior to starting mobilisation if the wounds are extensive or the fractures are unstable at the end of three weeks, it is better to defer, mobilisation for a further period of a week.

Frame Removal

The thumb rule and empirical teaching is that the hand fractures heal in four weeks. At 4 weeks, radiological examination followed by removal of connecting rods and clinically testing for abnormal mobility are done. If there is excruciating pain and abnormal motion at the fracture site, the frame is re-applied. The test is repeated next week and frame was removed once clinical union was guaranteed.

In open injuries or in cases multiple fractures, it is better to defer this first testing to four or five weeks. Frame removal can be done in dressing room without anaesthesia except in cases of extremely apprehensive patients who may require anaesthesia. After removal of all K-wires, the pin tracts are squeezed and pinched up until mouth of the tract points outwards.

RESULTS

Parameter	N	Mean	Std. Dev.	Min.	Max.
Age	30	32.03	9.87	20	52

Table 1a. Distribution Based on the Age Group

Parameter	Number	Percentage
11-20	3	1
21-30	11	3
31-40	9	3
41-50	6	2
51-60	1	3
Grand Total	**30**	**1**

Table 1b. Distribution Based on the Age Group

Parameter	Number	Percentage
Male	26	8
Female	4	1
Grand Total	**30**	**1**

Table 2. Distribution Based on the Gender

Parameter	Number	Percentage
RTA	14	46.67
Agri	4	13.33
Industrial	9	30
Assault	3	10
Grand Total	**30**	**100**

Table 3. Distribution Based on the Mode of Injury

Parameter	Number	Percentage
Dominant (Right)	20	66.67
Non-Dominant (Left)	10	33.33
Grand Total	**30**	**100**

Table 4. Distribution Based on the Incidence in Dominant/Non-Dominant Hand

Parameter	Number	Percentage
Metacarpal	14	37.83
Proximal phalanx	18	48.65
Middle phalanx	5	13.52
Distal phalanx	0	0
Grand Total	**37**	**100**

Table 5. Distribution Based on the Part of Hand (Including Thumb)

Parameter	Number	Percentage
Shaft	19	51.35
Juxtaarticular	10	27.03
Intraarticular	8	21.62
Grand Total	**37**	**100**

Table 6. Distribution Based on the Site of Fractures

Parameter	Number	Percentage
Comminuted	16	43.24
Intra-articular bicondylar	3	8.10
Intra-articular avulsion	1	2.70
Intra-articular unicondylar	2	5.40
Juxtaarticular	5	13.52
Shaft short oblique	7	18.92
Shaft transverse	3	8.10
Grand Total	**37**	**100**

Table 7. Distribution Based on the Fracture Pattern

Parameter	Number	Percentage
Type-I	4	13.33
Type-II	5	16.67
Type-III	21	70
Grand Total	**30**	**100**

Table 8. Distribution Based on the Open Fractures

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

Table 9. Soft Tissue Healing in Case of Open Injuries (Duration in Weeks)

Parameter	Number	Percentage
8-12	21	56.76
12-16	10	27.03
16-20	5	13.51
>20	1	2.70
Grand Total	**37**	**100**

Table 10. Fracture Healing (Duration in Weeks)

Most of the cases were followed up for a minimum of six months.

The mean follow-up period was of 33.77±7.50 weeks.

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

Table 11. External Mini Fixator (JESS) In Situ (Duration in Weeks)

	Yes		No		Grand
Complication	**Number**	**Percent**	**Number**	**Percent**	
Malunion	2	6.67	28	93.33	30
Non-Union	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-tract infection	5	16.67	25	83.33	30

Table 12. Complications

Parameter	Number	Percentage
Excellent	13	35.13
Good	15	40.55
Fair	7	18.92
Poor	2	5.40
Grand Total	**37**	**100**

Table 13. Final Results

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.

Figure 1 and 2. Preoperative Clinical Photographs

Figure 3 and 4. Preoperative X-Rays

Figure 5 and 6. Postoperative Clinical Photograph and X-Ray

Figure 7 and 8. Follow Up Clinical Photograph and X-Ray

DISCUSSION

It must be emphasised that this study is only short-term followup of maximum of about 54 weeks and the mean follow up of 33.77 weeks and therefore the discussion that follows is essentially a preliminary assessment.

The aim of this study is to evaluate the functional outcome of hand as a whole in fractures of phalangeal and metacarpals treated with JESS fixator, particularly in open fractures, intra-articular fractures, unstable fractures and multiple fractures.

Most phalangeal and metacarpal fractures are treated conservatively. Patients with unstable fractures require operative reduction and stabilisation to obtain the optimal position for bone healing and to allow early movement. In all our cases, the fractures were either open or involving the joint surface or multiple fractures, which were difficult to manage conservatively. So, we have used JESS fixation technique to tackle the above fractures as well as to avoid any additional injury to the bone and soft tissues. From October 2012 to August 2014, we treated 30 patients with 23 phalangeal and 14 metacarpal fractures by external mini fixation using JESS fixator and includes patients ranging from 10 yrs. to 60 yrs. The maximum incidence of fractures was between 21-40 yrs. and mean age was 32.03±9.87 yrs.

Drenth and Klasen[8] studied 33 patients with 29 phalangeal and seven metacarpal fractures by external fixation using a mini-Hoffman device. Their mean age was 35 yrs. (15-69). Pritsch and Engel[9] studied 36 metacarpal fractures with a method of external fixation using Kirschner wires bonded with acrylic resin. Most of the patients were young men between 20-30 yrs. old, the youngest patient was 12 years and oldest is 52 years.

The incidence of fractures in our study were more common in males (86.67%) and this rightly corresponds to the risk of ambulant life led by males. In Drenth and Klasen[8] series of 33 patients, 27 were men and 6 were women.

In 66.67% of the cases, the dominant hand was involved in our study as compared to Drenth and Klasen[8] study only 30% involved the dominant hand.

The mode of injury out of 30 patients, 14 patients had sustained injury due to road traffic accident amounting to 46.67% followed by industrial accident like fall of machinery leading to crushing of hands in nine patients (30%), injuries in agricultural fields in four patients (13.33%) and assault in three patients (10%). In Drenth and Klasen[8] studies, most had blunt injury, nine were caused by RTA (27%). Nine were by machinery (27%), 10 were falling or cutting objects (30%).

In our study, associated injuries were seen in nine patients (30%). Four patients had long bone fractures and other patients had injuries involving other systems like chest injuries (II and III rib fracture) and one head injury. In all these patients, most of the fractures of the phalanges and metacarpals were seen in the dominant hand associated injuries are considered because their coincidence delays the timing of surgery. In case of head injury, the surgical procedure was delayed till the patient recovered from head injury.

The open fractures were classified according to Swanson et al,[10] Gustilo's classification of open fractures and its subsequent modifications has been widely accepted by orthopaedic surgeons after reviewing a large series of patients having hand fractures. Swanson and co-workers concluded that Gustilo's classifications is not readily applicable to open fractures in the hand because their study indicated that key factors influencing an increased likelihood of infection were wound contamination, delay in treatment

longer than 24 hrs. and systemic illness, they offered a separate classification for open 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.

In our study by following Swanson et al[10] classification, there were four cases of type I (13.33%) and 5 cases of type II (20%). No injury with vascular impairment was noted.

In Drenth and Klasen[8] study, there were 27 open fractures, 25 of them were with severe soft tissue injuries in out of 36 fractures and in 12 cases partial or completely divided tendon injury was noted. In present study, out of the nine 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%). We have not treated any distal phalanx fractures.

In Drenth and Klasen[8] studies 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.

The site of fractures in our study, mainly involved shaft of the bone in (19) 51.35% of the cases, (8) 27.03% of intraarticular and another 26.32% (10) of juxta articular fractures.

In 19 fractures involving 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. In Drenth and Klasen[8] studies, 25 fractures were comminuted, 6 were transverse, 3 were oblique and 2 intra-articular fracture.

In our institution, we planned JESS fixation as an emergency procedure and it was done in most of the cases on the day the patient was seen. Most of the cases were operated within first 3 days (86.67%), 13.33% of cases in 4-7 days following trauma. The delay in treatment in last group is because of late reporting or associated injuries, which delayed the treatment plan. Those cases which have operated after 5 days especially open injuries had developed complications like delay in soft tissue healing, pin-tract infection, 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 better holding power of trocar tipped. Usually, two wires were placed in each fragment in most of the fractures, which had enough space for passing two wires. Most of the juxta articular and intra-articular fractures, only one pin in each fragment was used and enough stability was obtained. In 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 best 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.

Drenth and Klasen[8] have used threaded pins for his mini-Hoffman frames, which were prebent to 40-60° to prevent interference of the other finger movements.

To protect the soft tissues, wires should be placed dorsal to the mid lateral line to avoid damage to the neurovascular bundles and flexor sheaths. Some authors have objected to 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[11] 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). For the middle phalanx, a true midline position is recommended.

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 this structure recover their function after removal of the frame and transverse wires were used for border fingers in which neurovascular bundles lie anterolaterally. In metacarpals, we used dorsal or dorsolateral pins by taking care to avoid superficial veins, which are easily moved away with the lax overlying skin. Extensor tendons must be 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 dorso-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.

The soft tissue injuries healed in the first two weeks in 55.56% (5 cases) of the cases in 33.33% (3 cases) healed in 3-4 weeks and in 11.11% (1 case) of cases healed after four weeks. Soft tissue healing was delayed in cases where there was delay in treatment, multiple fractures and open fracture associated with severe soft tissue injury.

The fractures were considered clinically united when there was no pain or motion at the fracture site when stress was applied. In most of the cases, JESS fixator was removed once clinical union was achieved. JESS fixator was removed in minor OT or dressing room without any anaesthesia except in apprehensive patients in whom the fixator was removed under sedation (calmpose and midazolam).

In present study, fixator was removed in 63.33% (19 cases) of the cases during 5-6 weeks, 33.33% (10 cases) in 3-4 weeks and 3.33% in 6-8 weeks. The mean duration of JESS fixation in situ was 4.42 weeks.

The fixator was removed early in transverse fractures as compared to comminuted fractures and intra-articular fracture because to avoid the chances of collapse of fragments.[12,13] In Drenth and Klasen[8] studies, the fixator device had been removed at a mean 5.8 weeks after a phalangeal fracture (3-11 wks.) and 6.1 weeks after a metacarpal fracture (2-12) weeks.

Most of the fractures were followed up for a minimum of 6 months. The longest follow up was for a case compound fracture proximal phalanx of left thumb with juxta-articular extension was 54 weeks. The mean follow-up period was 33.77 weeks. Around 6.67% of the patients were followed up <24 weeks because of loss of follow up of patients.

In Drenth and Klasen[8] studies, mean period of treatment of phalangeal fractures was seven months and metacarpal fractures was five months. The mean follow-up was 4.4 yrs.

Fracture healing occurred in most of the cases within 12 weeks totalling to 56.76%. Healing took more than 20 weeks in case, which had multiple fractures delay in surgery timing and in old patient. The mean fracture healing in 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. The 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 discharge on the first or second postoperative day. At the same time, we have managed 35% of the cases on outpatient basis without any complications. There were two major complications and few general complications in our JESS fixator study.

Stiffness, which was either partial or total stiffness. A joint was considered partially stiff when the range of motion in that particular finger was <180° in case of fingers and <100° in case of thumb and those cases range of motion <130° in case of fingers and <70° in case of thumb was considered total joint stiffness.

In present study, 11 cases (10 partial and 1 total) developed joint stiffness. Most of the cases, which went for stiffness were open injuries, cases reported late, multiple fractures or intra-articular comminuted fractures.

Reviewing the Drenth and Klasen[8] studies, 11 fractures out of 36 had developed partial or total stiffness. The other most common complication was pin-tract infection in about five fractures. In our series, most of the fractures were superficial infections. The pin-tract infections healed promptly by antibiotics.

Pin-tract infections were reduced by following methods.

1. By adequate skin stab for pin placement.
2. Inserting the pin by hand drill, which eliminates the heat necrosis of soft tissues and bone.
3. Effective pin and frame care.

No case went for osteomyelitis at pin site.

Malunion was a problem in two cases due to lack of accurate reduction or post reduction collapse. In case of comminuted fractures and multiple fractures, because of lack of accurate reduction, it resulted either in axial or rotational malunion. None of the malunited fractures caused significant disability in present study. In present study, three fractures developed pin loosening, which did not affect the healing of the fractures. All the cases, which had been pin loosening had infection of pin site prior to loosening and all the cases of pin loosening have occurred after 3 weeks. Results were declared as per criteria described earlier into excellent/good/fair and poor.

Out of the 18 fractures involving proximal phalanx, 6 were excellent, 5 good and rest of the cases were 5 fair and 2 poor. Among 5 middle phalanges, 3 excellent, 2 were good. Among 14 metacarpal fractures, 4 had excellent results, 8 were good and 2 fair.

Among 13 cases operated in 1-30 years age group, 10 had excellent/good result, whereas 17 cases operated in the age group 31 to 60 years, 2 had excellent, 8 had good and 5 are fair. Among 10 open fractures, 4 out of 3 type I open fracture were excellent/good result, whereas out of 5 type II, 4 cases were good or fair and 1 case was poor.

In the present study, the results were compared with the study of Drenth and Klasen[8] studies in most of the parameters.

Parameter	N	Mean	Std. Dev.	Min.	Max.
Age	30	32.03	9.877	20	52
Soft tissue healing	9	2.61	0.858	2	4.5
(Weeks)					
Fracture healing	37	12.77	3.33	8.2	20.1
(Weeks)					
Follow Up (Weeks)	30	33.77	7.491	17	54
JESS in Situ (Weeks)	30	4.417	0.69	3.5	7.2

Table 14. Showing Mean and S.D. of Various Parameters Used in the Study

The results and parameters in present study are comparable with Drenth and Klasen study.

CONCLUSION

1. Hand fractures are a common entity because they are peripherally placed. Most of the patients were males because of the ambulant life they lead.

2. Most phalangeal and metacarpal fractures can be treated conservatively.
3. Patients with multiple fractures, open fractures, intra-articular require operative reduction and stabilisation to obtain the optimal position for bone healing and to allow early movement.
4. JESS is an adequate treatment modality for unstable phalangeal and metacarpal fractures, which are open, intra-articular, multiple and comminuted.
5. 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.
6. JESS simplifies the postoperative management of both injured finger and limb. It allows early mobilisation, which prevents joint stiffness.
7. Pin-tract infection and pin loosening are the main disadvantages of JESS fixation.
8. Understanding the biochemical principles and correct application methodology is essential for optimal use of available equipment.
9. JESS method is a simple and good alternative to established methods of management of small bone fracture in open, intraarticular, comminuted and multiple fractures.

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