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Management of fractures of metacarpals and phalanges of hand with UMEX (universal mini external fixator)

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Abstract
Complex fracture of metacarpals and phalangeal bones in the hand are difficult to treat, external fixator is an effective method of treatment particularly when internal fixation is not possible due to communication and associated soft tissue injury. This particular study is to evaluate the outcome of metacarpal and phalangeal fractures managed with mini external fixator in order to assess their effectiveness, functional outcome and complications and to make recommendations regarding potential applications. In our study we have included 45 cases out of which16 are metacarpal, 15 proximal phalanx, 14 middle phalanx. All cases are followed up at regular intervals of 4 weeks, 8 weeks, 12 weeks, 6 months. The functional results were excellent in 35.55%, good in 37.77%, fair in 13.33%, and poor in 13.33% of cases. We observed that UMEX is an adequate treatment modality for unstable phalangeal and metacarpal fractures which are open, intra-articular. UMEX simplifies the post-operative management of both injured finger and limb and it has better outcome in bony union & soft tissue wound healing particularly compound fractures. It can applied in local anaesthesia. UMEX method is not an alternative to established methods of management of small bone fractures but is an additional and useful tool in management of small bone fractures of hand, especially compound fractures.

Keywords: UMEX - Universal mini external fixator, metacarpal, Proximal phalanx, Middle phalanx.

Introduction
It is important to consider soft tissue healing along with fracture healing in a hand, because successful outcomes require the return of functional integrity to both the tissues. Fractures of metacarpals and phalanges are the most common among upper limb bony injuries and contribute to about 10% of total fractures among them [1]. It is well recognized that soft tissue scarring affects hand function more than fracture healing, and joint stiffness is the most frequent complication of fractures. Successful rehabilitation of hand fractures addresses the need to (a) maintain fracture stability for bone healing [2], (b) Introduce soft tissue mobilization for soft tissue integrity [3], and, (c) remodel any restrictive scar from injury or surgery [4]. The challenges in treating metacarpal and phalangeal injuries of hand is to design intervention protocols that recognize the need to maintain fracture stability for maximal bone healing, while also introducing early, controlled-motion protocols to preserve soft tissue integrity and facilitate scar remodelling Ligamentotaxis in management of metacarpal and phalanges fractures, can be achieved by UMEX (universal mini external fixator) [5]

Methodology
45 patients with metacarpal and phalanges fracture of hand were included in a prospective cohort study,

Inclusion Criteria
1. Patient in the age group of 10-60 years
2. Unstable fractures of hand
3. Intra articular & juxta articular fractures
4. Open fractures
5. Multiple fractures
6. Patients who have given their informed consent for the procedure

Exclusion Criteria
1. Severely crushed hand injuries

2. Fractures associated with tendon injuries
3. Fractures with associated neurovascular injuries

Duncan Criteria
Functional assessment based on total active range of movements in degree of each injured finger separately [6]

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

Follow up
- All cases are followed up to 6 months i.e., on 1st, 2nd, 3rd and finally at 6th month.
- Implant removal done under local anesthesia after satisfactory fracture healing

UMEX Fixator
(universal mini external fixator)

Components of UMEX Fixators [7]
It consists of 3 components:-
1. Link joints(Alpha clamp, Beta clamp,)
2. Kirschner wires and
3. Connecting rods (Knurledrods)

Mechanical Properties
Clamps and the clamping elements in the distractors are built with a patented Teardrop design which ensures three-point fixation of the K-wires Connecting rods are manufactured with specially knurled surfaces to improve the quality of the frictional interface between the insert screw, the connecting rod and the K-wire

Types of configurations
Although a large variety of configuration are possible using the UMEX components, five basic types are
1. Unilateral frame
2. Bilateral or co-planar frame
3. Joint spanning frame
4. Distraction frame
5. Dorso - lateral or Dorso - oblique frame.

Insertion technique
Minimum of two pins in each fragment. However, the middle and terminal phalanx which are small and it may not be possible to pass two wires in each fragment, a single wire in each fragment can be used Low speed high torque motorized drill for driving the K wires into the bone is used. Hand drills tend to wobble a lot and this causes the formation of a larger hole in the bone than the k wires [8]

Pin placement
I. Safe Corridor: The bone lies directly beneath the subcutaneous tissues that contain no neuro vascular or musculotendinous structures.
II. Hazardous Corridor: Contains musculotendinous units but no neurovascular structures.
III. Unsafe Corridor: Both neurovascular and musculotendinous elements are at risk of injury during pin placement [9]

In the central digits, a dorsolateral or dorso-oblique placement is necessarily but lateral pin placement can be used in the border fingers. In the metacarpals, anatomy of hand precludes any configuration other than dorso-oblique pins in III and IV digits but lateral placement is possible in border metacarpals. The Co-planar frames are more rigid than unilateral frames. Bone frame distance: Place the frame component as close to the bone as clinically possible Double stacking i.e. using an additional side rod also improves stability.

Results
Most of the patients (80%) were in the age group between 21-40 yrs. The youngest was 18 years old whereas the oldest one was 58 years old. The average age of the patient was 32.97±10.41years. Good outcome is significantly associated with younger age group with P=0.046

Table 1: Distribution based on part of hand operated

parameter	Number	Percentage
metacarpal	16	35.55
Proximal phalanx	15	33.34
Middle phalanx	14	31.11
Grand total	45	100

Fracture healing (duration in weeks)

Table 2: In most of the fractures, radiological union occurred within 12 weeks (55.55%)

parameter	number	percentage
8-12	25	55.55
13-16	11	25.45
17-20	5	11.11
>20	4	8.88
Grand total	45	100

External mini fixator (UMEX) in situ (duration in weeks)

Table 3: Mean duration of UMEX application was 5.2 ± 0.70 weeks

parameter	number	percentage
3-4	16	35.55
4-5	18	40
6-8	11	24.45
Grand total	45	100

Complications

Table 4: Inference: good outcome is strongly associated with closed fractures compared to open fractures.

Complications	Number
Mal union	6
Non union	0
Osteomyelitis	0
Partial stiffness	15
Pin loosening	12
Pintract infections	12

Final Result

Table 5: The results were found excellent in 35.55, good in 37.77, fair in 13.33, whereas poor results were seen in 13.33% of fractures

parameter	Number	Percentage
Excellent	16	35.55
Good	17	37.77
Fair	6	13.33
Poor	6	13.33
Grand total	45	100

Case: Comminuted fracture of 5th metacarpal

Pre op x-rays AP VIEW Oblique VIEW Post –op x-ray showing implant institution

At 4 weeks, extension flexion Implant removed after 1 month after 6 months

Discussion

The aim of this study is to evaluate the results of UMEX fixator in fractures of phalangeal and metacarpals in hand particularly 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 UMEX fixation technique to tackle the above fractures as well as to avoid any additional injury to the bone and soft tissues.

From june2012 to June 2014, we treated 45 patients with 29 phalangeal and 16 metacarpal fractures by external mini fixation using UMEX 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 32.97 yrs.

Drenth and Klasen [10] 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 &Engel studied 36 metacarpal fractures with a method of external fixation using Kirschner wires bonded with acrylic resin. Most of the patient were young men between 20 -30 yrs old, the youngest patient was 12 years and oldest is 52 years. [11]

The mode of injury out of 30 patients, 12 patients had sustained injury due to road traffic accident amounting to 40% followed by Industrial accident like fall of machinery leading to crushing of hands in 9 patients (30%), injuries in agricultural fields in 5 patients (16.67%), assault in 2 patients (6.67%)

In, Drenth and Klasen studies most had blunt injury; 9 were caused by RTA (27%). 9 were by machinery (27%), 10 were falling or cutting objects (30%).

In our study associated injuries were seen in 8 patients (26.66%). 4 patients had long bone fractures and other patients had injuries involving other systems like chest injuries (II &III Rib fracture) and one head injury. In all this patients most of the fractures of the phalanges and metacarpals were seen in the dominant hand.

The open fractures were classified according to Swanson et al. Gustillo's classification of open fractures and its subsequent modifications has been widely accepted by orthopaedic surgeons [12].

In our study, by following Swanson etal Classification there were 4 cases of Type I (13.33%) and 6 cases of Type II (20%) [13].

In Drenth and Klasen 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 our study, out of the 10 open fractures most of them involved proximal phalanx. Two cases had severe soft tissue injury and one among them had bone loss.

Most of the fractures involved proximal phalanx-21out of 38 fractures (55.26%) followed by 13 metacarpal fractures (34.21%) and middle phalanx of 4(10.55%). We have not treated any distal phalanx fractures.

In Drenth & Klasen studies constituted 21 proximal fractures, 8 middle phalanx fractures and 7 metacarpal fractures. No cases of distal phalanx were managed by them.

The site of fractures in our study, mainly involved shaft of the bone in 55.26% of the cases, 18.42% of intra articular and another 26.32% of juxta articular fractures.

In 21 fractures involving the shaft, most of them were comminuted and short oblique fractures (63.45%) and another 12.55% were intra-articular fractures and 24% were juxta-articular and transverse type fractures. Out of the 5 juxta

articular fractures one were epiphyseal injury and out of 5 intra articular fractures 50% of them were unicondylar.

In Drenth & klasen studies, 25 fractures were comminuted, 6 were transverse 3 were oblique and 2 intra articular fracture.

Halliwell has shown that a dorsal placement of pin caused less mean reduction in the amount of flexion of proximal interphalangeal joints than the lateral (10 'O' clock position).

Halliwell has shown that a dorsal placement of pin caused less mean reduction in the amount of flexion of proximal interphalangeal joints than the lateral (10 'O' clock position). In our study we have followed the safe zones advised by Dr. B. B. Joshi & associates [12] and our soft tissue complications due to pin placement were negligible

Most of the soft tissue injuries healed in the first 2 weeks (50.33%), 43.33% of the cases healed in 3-4 weeks and 6.33% after 4 weeks. The average soft tissue healing was 2.32 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.

In our study fixator was removed in 40% of the cases during 4-5 weeks, 35.55% in 3-4 weeks and 24.44% in 6-8 weeks. The mean duration of UMEX fixation in situ was 5.2± 0.7 weeks.

When correlation co-efficient test was applied between age of the patient and UMEX in situ in 10% of the cases, it was found that there is partial positive correlation between age and UMEX in situ.

In Drenth & Klasen studies, the fixator device had been removed at a mean 5.8 weeks after a phalangeal fracture (3-11Wks) and 6.1 weeks after a metacarpal fracture (2-12) weeks. In our study most the fractures were followed up for a minimum of 6 months (56%)

In Drenth & Klasen16studies, mean period of treatment of phalangeal fractures was 7 months and metacarpal fractures were five months. The mean followup was 4.4 yrs.

Fracture healing occurred in most of the cases within 12 weeks totalling to 66.66%. 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 8.88 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.

There were 2 major complications and few general complications in our UMEX fixator study. The most common complication was joint stiffness which was either partial or total stiffness. A joint was considered partially stiff when the range of motion 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 <16° in case of thumb was considered total joint stiffness.

In our study 16 cases (15 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. One case which had fracture proximal phalanx Lt thumb developed sundeck's osteodystrophy ultimately leading to stiffness of thumb.

Reviewing the *Drenth & Klasen* studies, 11 fractures out of 36 had developed partial or total stiffness.

The other most common complication was pin tract infection in about 12 fractures. In our series most of the fractures were superficial infections.

Malunion was a problem in 2 cases due to lack of accurate reduction or post reduction collapse

We had 12 fractures which 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.

Out of the 15 fractures involving proximal phalanx, 35.55 were excellent, 37.77 good and rest of the cases were 13.33fair and 13.33 poor. Among 14 middle phalanx, 35.55 excellent, 35.77 were good, 13.33 fair.

Among 13 metacarpal fractures, 3 had excellent results, 6 were good, and 4fair.

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 and 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 6 type II, 5 cases were good or fair and 1 case were poor.

Range of movement is inversely proportional to the age of the patient. When correlation test was applied to 10% of the cases, it was found that there is a partial negative correlation between age of the patient and range of movement in this study group (r = -0.4725).

Conclusion

Any attempt to regain good joint function necessitates anatomical reduction of the articular fragments & restoration of joint congruity and a stable functional arc of motion while the fixation device is providing stability for early mobilization Application of principle of ligamentotaxis in injuries of hand fulfills the above mentioned criteria of fixation promoting function This minimally invasive procedures respect the soft tissues and prevent damage to complex intrinsic anatomical structures, thereby preventing open reduction to achieve alignment UMEX is an adequate treatment modality for unstable phalangeal and metacarpal fractures which are open, intra-articular and multiple UMEX simplifies the post-operative management of both injured finger and limb. It allows early mobilization which prevents joint stiffness Average fracture healing is about 11.0467 weeks UMEX has better outcome in bony union & soft tissue wound healing particularly compound fractures Pin tract infection and pin loosening are the main disadvantages of UMEX fixation. UMEX is simple to operate, has less complication rate. The learning curve is comparatively small. It can be applied local anesthesia. UMEX method is not an alternative to established methods of management of small bone fracture but is an additional and useful tool in management of small bone fractures of hand, especially compound fractures.

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