IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 20, Issue 5 Ser.5 (May. 2021), PP 56-61
www.iosrjournals.org

A Study on Syringe Barrel External Fixator for Phalageal Fracture of Hand

BorthakurBipul[1], Dhar Arijit[2], Rajbangshi Ujjal [3]
[1]*Professor and HOD, Department of Orthopaedics, Silchar Medical College, Silchar, Assam, India*
[2]*Associate professor, Department of Orthopaedics, Silchar Medical College, Silchar, Assam, India*
[3]*Junior resident ,Department of Orthopaedics, Silchar Medical College, Silchar, Assam, India*
Address of correspondence: Dr. Ujjal Rajbangshi
S/O Harish Rajbangshi Pathakhati , howly-2,pin-781316
Barpeta, Assam, India

Abstract:
Introduction: *Complex fractures of phalanxof the handare very difficult to treat conservatively. There are twotypes of fixation: internal according to AO standards, andexternal for a selected group with open unstable fracturesor severe soft-tissue injuries.External fixation is an effectivemethod of treatment mainly when internal fixation is not possible because of comminution and associated soft tissue injury.A variety of commercial fixators are available for thetreatment of hand fractures. However, these fixatorsare costly and need a sufficient degree of expertiseand familiarity for their use.Here We describe a very simple fixator which is stable,lightweight and can be easily constructed with materials readily available in most orthopaedics operation theatres.****Materials and Methods:*** *In this descriptive study of fifteenpatients, suffering from simple or complexphalangeal fractures, two K wires (size1-1.5 mm) andan empty syringe barrels (2.5cc,5cc or 10 cc) were used . TheK wire with the barrel was inserted into the proximal and distal to the fracture sitethrough dorsolateral plane. Patients withrestricted joint motion were advised aggressivephysiotherapy.All the 15 patients were followed up for a mean duration of 24 weeks. Final evaluation was done according to DASH and TAM criteria.* ***Results :****All the patients achieved radiographic fracture union at a meanduration of 6 weeks (average 4-8 weeks). At the final follow-up, the mean DASHscore was 13.9 (range from 11─38), the ASSH score for thedigit TAM was excellent result in 11 patients (73.33%), good in three (20%), fair in one (6.66%) , and poor in none(0%).****Discussion:*** *The stability of a external fixator increases with larger pin diameters, the number of pins applied on either side of the fracture fragments, decreasing the distance of the side bar from the bone and decreasing the spaces between of the pins. Our external fixator addresses all these criteria.* ***Conclusions:*** *The use of an external devicereduces further damage to the soft tissues andbone, allows wound care and enables physiotherapy of the fingerjoints at an early stage.*

Keywords: *external fixator , phalanx, syringe barrel,*

Date of Submission: 02-05-2021 Date of Acceptance: 16-05-2021

I. Introductions

Complex fractures of the phalanges involvehighly comminuted fractures with significant intraarticular extension. These mostly present asopen fractures associated with neurovascular damage, tendon injury and sometimes fracturedislocation of the nearby joint. A variety of injuries may causes fractures of to the phalanx and metacarpals bonesespecially in industrial, agricultural, and other work places. Small bones of thehand(phalanx and metacarpals), either closed or open, represent almost 10% of upperlimb fractures.[1] The thumb and little fingers are the commonest injured digits. The peak occurrenceseen between the 10 to 40 years of age. Despite being a common injury, this typeof fracture is often considered as a minor fractures and neglected unlike those of large bones fractures. The lack of corrective actionmay increase further morbidities. One reason whythis types of fractures are not treated immediately is due to limited commercially available hardwares .[2] Improper managementcould result in long duration pain and post traumatic stiffness and arthritis withsubsequent detrimental functional outcomes.[3]Micks and Hagar invented the first mini externalfixator for compression arthrodesis of the digital bones in the 1960s.[4] Jaquet in Switzerlandmade the first commercially available mini externalfixator for the hand and carpus in the mid 1970s.[5-7]Although most injuries of the hand can be treated withconservative management ,but certain injuries involvingsignificant soft tissue injury, extensive comminution require operative fixation. Open reduction and internal fixation are not suitable in comminuted fractures due to the smallsize of fracture fragments and it is should not be usedwhen there is risk of infection due to open woundsand when further soft tissue damage is to be avoided. The major advantage of

external fixation is that we can achieve fracture stabilizationwithout further wound dissection and devascularizationwhile maintaining joint mobility and softtissue care.[8,9]

II. Materils And Methods:

Study design: Randomised prospective study
Study location:tertiary care teaching hospital based study done in Department of Orthopaedics of Silchar Medical College and Hospital, Silchar; Assam.
Study Duration: July, 2019 to December, 2020
Sample size: Fifteen patients with 15 digital fractures
The fifteen patients with digital fracture of hand were managed surgically from using the syringe external fixator technique. The mean age was 35.8 year old (range,19-56 year). Ten patients were men. Eight patientshad injuries in their dominant hands.The study was conducted for a period of 1 and half year .

Inclusion criteria:
a)Patients with closed, displaced and unstable extra-articularphalanx fractures.
b) Patients with open phalanx fractures.
c) Simple, Transverse, oblique, spiral or comminuted phalanxfractures.
d) Patients with phalanx fractures which is less than 3 weeksold
e).Patients aged more than or equal to 18 years and less than 60years with phalanx fractures.

Exclusion criteria:
a)Patients beyond 18- 60 years of age
b)Patients with undisplaced and intra articular phalanx fracture.
c) Patients with complex injuries like tendon injury, neurovascularinjury.
d)Severely crushed hand injuries
e) Patient refusing informed consent.

Procedure methodology: The hardware consisted of a plastic syringe tube with different sizes (2.5 cc, 5 cc, 10 cc depending on the size of the hand) and K- wires of size 1.2-mm or 1.5-mm were used . We used. The terminal ends of the syringe were removed to decrease bulk, and the barrel also was cut to a suitable length. The first K- wire was introduced perpendicularly through both walls of the barrel to protrude by approximately 1 cm (fig 1).

The fixator was placedpercutaneously.Once all four K-wires have been introduced across thebarrel, the implant is ready to apply. Thedorsolateral plane is chosen to avoid tethering tendonsthat would hinder early mobilization. A C-arm served asa guide to the spacing required betweenthe K- wires. By simply holding thesyringe against the C-arm, the markings was made on the sideof the syringe barrel to mark the site ofplacement of subsequent wires. K-wires tip was cleaned with sterile water after passing the syringebarrel . The first K- wire thatwas already passed through the plastic tube was thenadvanced by through the proximal fracture fragment,both cortices were crossed. Then The fracture was reduced with manipulation andconfirmed with the C-arm . The second K-wire was introduced into thedistal fragment while the reduction was held by thebarrel itself. Final reduction was checked with C-arm. Minor corrections if required can be done at this stage. After satisfactory reduction, the remaining proximalanddistal K-wires were introduced in a similarfashion. Drilling must be done slowly so as it mayproduce heat which can make holes on the tube widerand pins becomes loosening. Tip of the k-wires were bent to prevent the slippage of the barrel.Standard pin site dressing and care is maintained inthe postoperative period. Passive and active range of motion isstarted within 3-5 post operativedays.

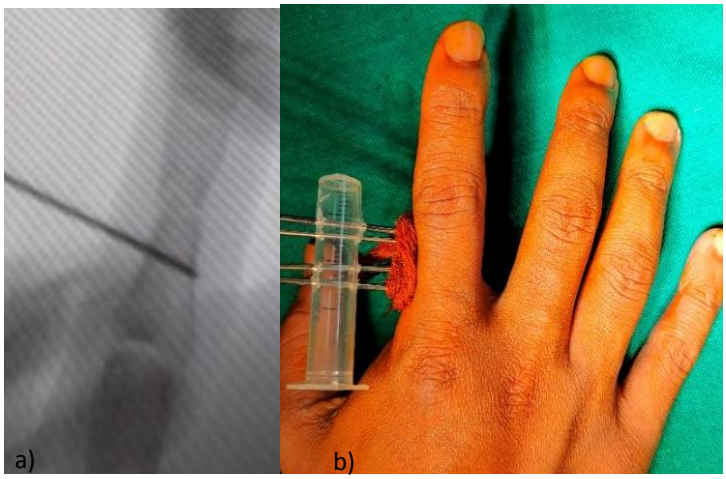

Fig 1:a)Introduction of first wire through syringe barrel. b) Introduction of wire through bone proximal to fracture.

Fig 2 :Low-cost external fixation system using a syringe barrel and Kirschner wires.

III. Results

We did the Follow-up at the OPD clinic at 2, 4, 6, 12,and then 24 weeks. All patients were taught to do passiveand active physiotherapy. At each visit, x-raywere obtained to a check whether reduction is maintained or not and toascertain radiological union of bones. The implantswas removed in the OPD clinics under local anaesthesiaonce the bones is radiologically united.Comparison was done in case of the mobility of the affected digit withthe the opposite hand. Measurementswere taken andexpressed as total active movement (TAM) and DASH score.Final results were defined as:

Excellent: TAM >=220 full painless and unrestricted mobility equal to the uninjured contralateral digit.
Good: TAM >= 180 degree.
Poor: (a) TAM < 130 degree,
(b) angulation >10 degree,
(c) any rotational misalignment,
(d) any secondary intervention .

Excellent to good clinical outcomes were seen in mostof the patients. At the final follow-up, the meanDASHscore was found 13.9 (range from 11 to 38), and the ASSH score for thedigital TAM found an excellent result in 11 patients (73.33%), good in 3 (20%), fair in one (6.66%) , and poor in none(0%) [table 1]. There are 5 cases that developed jointstiffness at the final follow up. Most of the cases which went for stiffness were openinjuries, cases reported late, multiple fractures. Of all fractures 6 patients were developedsuperficial infections. There are no patients with malunion, non union or pin loosening [table 2].

Result of TAM	Percentage
Excellent	73.33% (220-260)
Good	20% (180-219)
Fair	6.66% (130-179)
Poor	0 (<130)

Table 1: Shows results of TAM and its percentage at final follow up

Complication	Number
Malunion	0
Non union	0
Pin loosening	0
Pin tract infection	6
Joint stiffness	5

Table 2: shows various complication with number of patients encountered during study

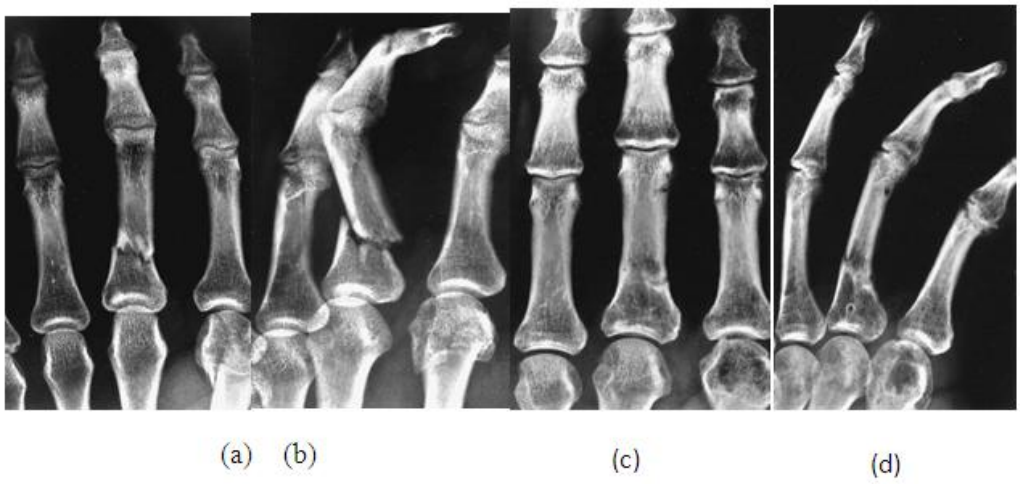

Fig3: a) Anteroposterior and b) oblique view of proximal phalanx showing transverse fracture , c) Anteroposterior and d) oblique view of phalanx after removal of implant e) clinical photograph at final follow up

Fig 4: a) anteroposterior view showing middle phalanx fracture b) K-wire with syringe inserted c) x-ray after implant removal d) clinical photograph

IV. Discusions:

One of the mostimportant factorfor good functional outcomeis allowing early mobilization, as finger immobilization formorethan 3 weeks can lead to increase the incidence ofstiffness.[10] Theexternal fixator system should besimple, causing minimal disturbance to soft tissueand bone. This is anlow cost,verysimple method of external fixation. It can be used in bothclosed and compound fractures. It can be applied under local anaesthetic and removed in the OPDclinic .The concept of external fixation for digital fractureis to achieve adequate bony fixation with early mobilization in compare to fixation with platesand screws.[11]

Lambotte (1904) used first external fixator in hand fractures.[12]In *Drenth&Klasen* studied on 21 proximal ,8 middle phalanx and 7 metacarpal fractures. No distal phalanx weretreated by them. In our study, the fractures involved middle phalanx are -7 out of 15fractures (46.66%) and 8 proximal phalanx (53.33%). We have nottreated any distal phalanx fractures.In *Drenth&klasen* studies, there were 25 comminutedfractures , 6 transverse, 3 oblique and 2 intra articular fracture. In our study , 5 fractures were comminuted, 7were transverse and 3 were oblique fracture.As for similar studies, *Drenth andKlasen*[13] reported 41.7% excellent , 27.8% good ,8.3 fair , and 22.2% poor results. *Ma et al*.reportedexcellent results in seven (25%) patients, good in12 (42.9%), fair in five (17.9%), and poor in four (14.2%) out of28 fractures. *Lu et al*.reported 26 comminuted fractures, and out of which the excellent results were reported in 8 (30.9%) patients, good in 13 (50%) patients, fair in 3(11.5%) patients, and poor in 2 (7.6%) patients.*Drenth&Klasen*reported that, the fixator device had beenremoved at 5.8 weeks (mean) after operation (3-11Weeks).In our study ,fixator was removed in 40% cases during 4-5 weeks, 33.33% cases in 5-6 weeks and 26.66% cases in 6-8 weeks.Fracture healing occurred in most of the patients within 12 weeks. Healing took more than 20 weeks in those patients who had multiple fractures ,delay in presentation and agedpatient. In our study,the mean time for fracture healing was 8.88weeks. The average radiologicalbone healing of phalanges fracturesis 4-5 months, ranges from 1 to 17 months. In our study, the fracture healing time was favourable compare to those reported in theliterature.An association found between the location of a fracture and thefunctional outcome in one study. Inthat study fractures of the middle phalanx achieved betterfunctional outcomes than those of proximal or distal phalanges , but we did not find suchan association.We encountered 2 major complications and few minorcomplications in our study. The most commoncomplication we found was joint stiffness which was either partial ortotal . A joint was said to be partially stiff when therange of motion in that particular finger was<100° in case of thumb and < 180° in case ofother fingers. And those with range ofmotion <130° in case of other 4 fingers and <16° in thumb wasconsidered total joint stiffness.In our study we encountered 5 cases (4 partial and 1 total) developed jointstiffness.*Drenth&Klasen*reported , out of 36 fractures, 11 had developed partial or total stiffness.The other complication was pin tract infectionoccurred in 12 fractures. We found 6patients of the fractures withsuperficial infections.System failure and loosening of pins has been reported in two studies. [14,15]*Schuind et al.* reported systemfailure in 7.5% of cases.*Lenehan et al*. reported onepatient developed pin loosening that required adjustment inthe OPD. In our study, we had not found any system failures orwire loosening of pins.As we used light external fixator in our studythat could be competitive to commercially available external fixators because there isadequate rigidity, it is lightweight, very ease to apply , and itscomponents are readily available in all orthopaedics OT. Inaddition to this, the rod is radiolucent that allows for easier radiologicalassessment intraoperative and postoperative periods.

V. Conclusions

This procedurespreverts the softtissues damage and also the complex intrinsicstructures of digits , thereby preventing open reduction to achievealignment ,syringe external fixator is an good treatment modality forcomplex phalangeal fractures. Itallows early mobilization which can prevent joint stiffness.This system provides secure fixation and allows earlyrehabilitation of the digit. It's cost effective and easily applicable ,make it a reliable alternative against commercially available small external fixators.Pin tract infection is the main disadvantages of syringe external fixation.It is simple to operate, complication rate is also less. Thelearning curve is also small. It can be applied under localanaesthesia.It is simple to apply even with basicorthopaedic experience and all the materialsneeded for theimplant are readily available inmost of the OT. Unlike other commercially available externalfixators, this construct gives a good lateral view x-rayimages as the syringe barrelis radiolucent.

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BorthakurBipul, et. al. "A Study on Syringe Barrel External Fixator For Phalageal Fracture Of Hand."*IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 20(05), 2021, pp. 56-61.