

Management of Hand Phalangeal Fractures with Long Aluminium Splint Traction (LAST)

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ABSTRACT

BACKGROUND

Phalangeal fractures are common fractures of the hand. Various treatment protocols and options, ranging from splinting, percutaneous wires, external fixators, interfragmentary screw fixation to mini fragment plates exist in handling cases of proximal phalangeal fractures. The aim of the study is to find the outcome of fingernail traction with a digital aluminium splint in the management of closed phalangeal fractures of the hand.

METHODS

A prospective study was conducted among 24 patients between November 2017-October 2019 who were treated with Long Aluminium Splint Traction (LAST), a fingernail traction using a long aluminium splint in the management of closed fractures involving proximal and middle phalanx of the hand. The outcome measures included post reduction radiographic evaluation and total active motion (TAM) in the finger at the final follow-up.

RESULTS

On radiological assessment, 20 patients had good reduction, 2 had fair reduction and 2 patients had poor reduction. At final assessment with TAM score, 19 patients had good TAM score, 3 had fair and 2 had poor TAM. Complication was noted in two cases in the form of misalignment with poor reduction which required ORIF with K- wire fixation.

CONCLUSIONS

Long aluminium splint is readily available, cost effective and it is simple to apply traction. With traction splinting and early range of motion exercises, these patients were found to have an acceptable outcome with fewer complications when compared to ORIF with plates and screws.

KEYWORDS

Phalangeal Fractures, Aluminium Splint, Fingernail Traction, Hand Injury

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BACKGROUND

The goal of treating any hand fracture is to obtain acceptable alignment and bring back the pre-traumatic range of motion. Various treatment protocols and options, ranging from splinting, percutaneous wires, external fixators, interfragmentary screw fixation to mini fragment plates exist in handling cases of proximal phalangeal fractures. Open reduction with plate and screw fixation can cause further tissue trauma resulting in adherence of soft tissues and interference with tendon gliding.¹ On the other hand the conservative techniques such as splints and braces may not be able to maintain the reduced position. A balance between the pros and cons of surgical and non-surgical management paves the way in choosing the best option in a particular case. This study reports the results of 24 cases of closed phalangeal fractures which were managed by a Long aluminium splint traction (LAST) technique. Longitudinal traction was applied through the finger nail. The soft tissues around the proximal phalanx were made tense with traction to provide stability and maintain reduction. With splinting and early range of motion exercises, the patients will in general have an acceptable outcome with fewer complications when compared to ORIF with plates and screws.

We wanted to study the outcome of fingernail traction with a digital splint in the management of closed phalangeal fractures of the hand.

METHODS

A total of 24 patients were included in the study who presented between November 2017-October 2019. All the patients who came to emergency or to OPD with closed phalangeal fractures which were confirmed by x-ray were included in the study. Written informed consent was obtained from all the patients.

Inclusion Criteria

1. Closed phalangeal fractures (comminuted/intra articular)
2. With no fingertip injury.

Exclusion Criteria

1. Associated metacarpal fractures
2. Open wound with extensive tissue loss
3. Crush injury with doubtful vascularity to the finger.

Technique

Under aseptic conditions, a digital block was given with 2% plain lidocaine to the injured finger. Using a cutting needle suture of 3-0 Prolene a bite was then taken at the distal one third of the nail (non-germinal part) through the fingertip from distal to proximal with the needle passing through the nail and nail bed. A second bite was then taken in the reverse direction and the ends of the suture were left free at this stage. The aluminium splint was pre-bent before incorporating it in the below-elbow slab. The first bend

measuring 90° was at one inch from the distal end. The next bend was made measuring an angle 70-80° to accommodate the joint. The third bend was made measuring an angle of 45° to accommodate the wrist in dorsiflexion (Figure 1).



Figure 1

Then the aluminium splint was incorporated in the below elbow plaster of Paris (POP) slab by sandwiching it in between the two sets of POP slab (Figure 2A). After the POP hardens the surgeon reduces the fracture by traction with moulding and holds it firmly. The assistant ties the free ends of the Prolene to the distal bent part of the aluminium splint (Figure 2B). The knot is then firmly secured to the aluminium splint with adhesive tape to prevent it from slipping. The amount of force for traction was variable among the patients and was equivalent to the force just to maintain the fracture in reduced position without distraction. Folded Gauze is kept in between the splint and finger to nullify the deforming forces and bandage applied to secure the cast in place (Figure 2C). Fingertip viability checked by colour and capillary filling.

To prevent rotational deformity it was ascertained by the surgeon that the fingernail is parallel to horizontal before application of bandage while the MCP joint is flexed at 90°. In this position the bandage is applied after medial and lateral padding to minimize the risk of rotational deformity. At this point check radiographs were taken in AP and lateral views. Availability of 'C'- arm will make it more convenient. If reduction was not satisfactory slight manipulation was done by extending or bending the aluminum splint at its distal bend. Also altering the position of gauze under the finger might help with obtaining a desirable position.



Figure 2a, 2b, 2c and 2d

Figure 2. Steps in application of nail traction. 2A) After passing the suture through the nail. 2B). The aluminium splint is bent and incorporated in the plaster of paris (POP)

cast. 2C). Then the free ends of sutures are tied over the aluminium splint. 2D). The final bandage is applied over the POP slab to secure the slab with traction splint.



Figure 3 (Case 1). Proximal Phalangeal (PPx) Base Fracture- Figure 3A & B) Antero posterior view and Lateral view of (R) Hand showing fracture base of proximal phalanx. 3C) Immediate post op X-ray after reducing the fracture segment with finger splint in situ. 3D) Late post op x-ray at 3 months with good reduction. 3E and 3F) very late post op x-ray at 1 year with good reduction and union. 3G) Clinical photograph good TAM at all joints.

Immobilization and Rehabilitation

If the alignment was acceptable then the immobilization in the aluminium splint was continued for 3 weeks and the patient was advised to keep the hand elevated. Clinical and radiological assessment was done after 3 weeks by eliciting tenderness at fracture site and to confirm the alignment and position respectively. If there was no tenderness and good bony union achieved, then the splint was discarded and protected active mobilization was started by the physiotherapist which continued for one week. Later free active assisted mobilization was initiated until full recovery was achieved. Passive mobilization was taught to the patients. When the fracture site was tender at 3rd week, then the traction was released but the splint was continued

for a maximum of another week. The recovery times ranged from 6 to 10 weeks, but all the patients were followed up for one year.



Figure 4 (Case 2). Middle Phalangeal (MPx) Fracture- Figure 4A) Oblique view of (L) Hand showing fracture base of MPx. 4B) Immediate post op X-ray after reducing the fracture segment with finger splint in situ. 4C) Late post op x-ray with good reduction and union.

Outcome Measures

The outcome measures we used in this study included were post-reduction radiological evaluation and total active motion at final assessment.

For post-reduction radiological evaluation, the results were graded into 3 grades-

- 1) GOOD: Anatomical reduction or angulation less than 10 degrees in both planes,
- 2) FAIR: Angulation between 11 degrees and 20 degrees.
- 3) POOR: Angulation more than 20 degrees and any degree of rotation.

Based on the total active motion (TAM), the results were graded into three grades-

- 1) GOOD: TAM 210 or more.
- 2) FAIR: TAM between 180 and 210.
- 3) POOR: TAM less than 180.

RESULTS

Sl. No.	Age/Sex	Hand	Finger	Phalanx	Mode of Injury	Anatomical Reduction	TAM Score	Complication
1	23/M	Right	Middle	PPx	Assault	GOOD	230	NIL
2	25/M	Right	Ring	PPx	RTA	GOOD	220	NIL
3	31/M	Right	Index	PPx	Sports	GOOD	240	NIL
4	42/M	Right	Little	MPx	Assault	FAIR	200	NIL
5	26/M	Right	Middle	PPx	Workplace	GOOD	230	NIL
6	19/F	Right	Ring	MPx	Assault	GOOD	220	NIL
7	20/M	Right	Little	PPx	RTA	GOOD	220	NIL
8	50/M	Left	Middle	PPx	Workplace	GOOD	240	NIL
9	44/M	Right	Index	PPx	Assault	GOOD	230	NIL
10	35/F	Right	Middle	PPx	RTA	POOR	180	Malalignment (Managed by ORIF)
11	41/M	Right	Little	PPx	Sports	GOOD	260	NIL
12	37/M	Left	Thumb	PPx	Assault	GOOD	220	NIL
13	55/M	Right	Index	PPx	RTA	GOOD	240	NIL
14	52/M	Right	Thumb	PPx	Workplace	GOOD	220	NIL
15	29/M	Right	Little	MPx	RTA	GOOD	250	NIL
16	24/F	Left	Middle	PPx	Assault	GOOD	230	NIL
17	53/F	Right	Little	PPx	RTA	POOR	170	Malalignment (Managed by ORIF)
18	22/M	Right	Ring	PPx	Sports	GOOD	240	NIL
19	32/M	Right	Index	PPx	Assault	GOOD	220	NIL
20	39/M	Right	Middle	MPx	Workplace	GOOD	230	NIL
21	46/F	Right	Index	PPx	Sports	GOOD	220	NIL
22	21/M	Right	Middle	PPx	RTA	FAIR	190	NIL
23	44/M	Left	Middle	MPx	Assault	GOOD	230	NIL
24	45/M	Right	Ring	PPx	RTA	GOOD	240	NIL

Table 1. Patient's Information

Out of 24 patients, 19 were males, 5 females. The average age of the patient was 35 years (range 19-55). Twenty patients had involvement of right hand and 4 patients had involvement of left hand. Most commonly affecting Middle finger -8, ring -4, index-5, little-5, and thumb-2. Nineteen patients had proximal phalanx (PPx) fracture and 5 had middle phalanx (MPx) fracture. Various aetiology caused fractures like Assault-8, RTA- 8, Sports-4, workplace-4 (Table 1). Nine patients had involvement of transverse fracture, oblique-3, shaft comminuted-4, distal metaphysis-1, proximal metaphysis-3, and proximal metaphysis with intra articular extension-4 (Table 2).

On radiological assessment- Twenty (20) (83.5%) patients had good reduction, 2 (8.3%) patients had fair reduction and 2 had poor reduction. All the patients with poor reduction were taken up for ORIF with K wire. (Table 2). As for as the TAM score was concerned 19 patients (80%) had good ROM, 3(12%) had fair ROM and 2 (8%) had poor ROM. Out of the three fair results, 2 patients were having proximal phalangeal fracture and 1 had MPx fracture. Both the poor results were from PPx group. (Table 3).

Type of Fracture	PPx	MPx	Total	Results		
				Good	Fair	Poor
Shaft Transverse	8	1	9	9	-	-
shaft Oblique	3	-	3	2	-	1
Shaft Comminuted	3	1	4	2	1(PPx)	1(PPx)
Distal Metaphysis	1	-	1	1	-	-
Proximal Metaphysis	2	1	3	3	-	-
Proximal Metaphysis with Articular Extension	3	1	4	3	1(MPx)	-

Table 2. Post Reduction Radiological Assessment

Type of Fracture	PPx	MPx	Total	Results		
				Good	Fair	Poor
Shaft Transverse	8	1	9	8	1(PPx)	-
Shaft Oblique	3	-	3	2	-	1(PPx)
Shaft Comminuted	3	1	4	2	1(PPx)	1(PPx)
Distal Metaphysis	1	-	1	1	-	-
Proximal Metaphysis	2	1	3	3	-	-
Proximal Metaphysis with Articular Extension	3	1	4	3	1(MPx)	-

Table 3. TAM Score Assessment

DISCUSSION

Phalanges are more commonly involved in the fractures of the hand than the metacarpal fractures.²⁻⁴ The annual incidence of phalangeal fracture is 2.9%. Proximal phalangeal fractures constitute about 13% of all hand fractures. These apparently minor fractures may lead to long lasting deformity when there is reduction in the range of motion in the adjacent joints. The common causative mechanisms include road traffic accidents, industrial injuries, falls and sport related injuries.

Biomechanical studies have revealed that inter-segmental forces of up to 25 N are experienced at the proximal interphalangeal joint during day today activities.⁵ Insertion of interosseous muscles onto the base of proximal phalanx exerts flexion force at the proximal fracture fragment while the central slip hyper extends the distal fragment and causes apex volar angulation.⁶ The

longitudinal compression force imparted by the flexor and extensor tendons extends the distal fragment.

When the metacarpophalangeal (MCP) joint flexed, with traction force applied distally on the fingers, the extensor tendon shifts distally. As a result, two thirds of the proximal phalanx is embraced by the extensor expansion and the fracture is stabilized in terms of axis, length, and rotation. On the volar aspect long flexor tendons also provides stability and prevents further volar angulation. With the help of external device (long aluminium splint with finger nail traction) which acts like a splint by tightening and moving the extensor aponeurosis distally and keep the fracture segments in reduced position. Using the stabilizing effect of soft tissues (extensor hood dorsally and long flexor tendons volarly) and external device (LAST), the proximal phalanx fractures can be effectively reduced and splinted in the functional position.

When reduced properly, the fracture can be held by using a splint with traction and the stabilizing effect of tense soft tissues. The aim of the treating surgeon is not only to achieve timely union with good alignment but also to preserve the gliding mechanisms of these tendons.

Fitzgerald⁷ et al from Southampton firstly described 'Ligamentotaxis' with isometric traction splinting which is a simple, quick, inexpensive and non-invasive method. Fracture reduction, restoration of joint space and re-obtainment of functional motion are achieved by the distal traction force on the periarticular ligaments. Conservative management can result in delayed union or malunion. Any prolonged immobilization can result in stiffness of the joints and require long-term physiotherapy. With metacarpophalangeal (MCP) joint flexed at 90 degrees, the proximal phalangeal fractures are usually held in reduction. The collateral ligaments of the MCP joint in flexed position are taut with minimal chances of stiffness due to contracture. The extension of proximal interphalangeal (PIP) joints prevents volar plate contracture and contracture of collateral ligaments.⁸ The longitudinal traction applied in this position makes the extensor and flexor tendons tense, which provides dorsal and volar stability.

Closed reduction techniques frequently serve as a worthy alternative for stable surgical reduction in the management of closed phalanx fractures. Surgical fixation with K wire or plates and screws associated with soft tissue adhesion cause hindrance to the smooth tendon gliding. However, surgical management becomes necessary in unstable, irreducible and open fractures with soft tissue damage.^{8,9} In our study during the follow up, it was found that in 2 cases the alignment could not be maintained. These patients were taken up for open reduction and internal fixation with K- wire. Both the cases showed good result after internal fixation.

There have been previous studies on management of proximal phalangeal fractures with traction splints. Koul¹⁰ et al reported the results of 39 proximal phalangeal fractures treated with a custom made traction splint. They used adhesive glue to fix the traction to an over nail plate and reported excellent results in 72% of the patients, good

results in 22% and poor results in 6%. None of the patients in this group with transverse fractures were treated by traction splint; they suggested that internal fixation is more favourable for transverse fractures. In our series 9 cases had transverse fractures, which were treated by digital splint and nail traction, of which 8 patients had good results (89%). This shows that if good reduction is achieved and maintained with longitudinal traction and proper splinting, then transverse fractures can be treated successfully with traction splints.

Rajesh¹¹ et al used a thermoplastic MCP block splint for proximal phalangeal fractures in 32 cases. They did not apply traction on the finger. In their series they reported excellent results in 72%, good in 22% and fair to poor in 6% of the cases, similar to Koul et al. In our study 20 (83.5%) patients had good reduction, 2 (8.3%) patient had fair reduction and 2 (8.3%) had poor reduction which were comparable to the aforementioned studies. Strickland¹² et al. reported a decrease in function to 66% of normal total active range of motion after a 4-week immobilization period. The restricted movement has to be treated with physiotherapy after the consolidation of the fracture.

The most common complication after these fractures is malunion resulting in proximal interphalangeal joint (PIPJ) extensor lag, which is worsened by extensor tendon zone IV adherence and shortening at the fracture site.^{13,14} One millimetre of shortening leads to 12° of extensor lag at the PIPJ.⁴ In our series 2 patients could not maintain the alignment and were treated with ORIF. Non-union is common in middle phalangeal fractures because of the poor soft tissue sleeve around it and hence limited vascularity. For the same reason it is difficult to treat if it gets infected. So middle phalangeal fractures heal better with closed techniques with minimum surgical interference to its vascular supply. All the patients were followed up to one year and none of them were lost to follow-up. All the fractures were treated by the same single surgeon. The treating surgeon or his team followed up the patients. None of the patient developed nail plate avulsion or fingertip necrosis because of the nail traction with suturing.

When compared to other studies Chandraprakasam¹⁵ et al Koul et al used conservative management with traction splint only for fractures involving the proximal phalanges. In our series, we have used traction splint not only for closed fractures of proximal phalanx but also for middle phalangeal fractures which showed comparable results. Out of 4 middle phalangeal fractures 3 (75%) showed good result and 1 (25%) showed fair result. None of the middle phalangeal fractures had complications like malunion, rotational deformity or second surgery.

Disadvantages of Plate & Screw Fixation of Phalangeal Fractures

- Extensive soft tissue dissection for application of plate.
- Plate being a foreign body interferes with the biomechanical action of the tendon.
- Needs surgical removal at later dates.

Disadvantage of K-Wire Fixation of Phalangeal Fractures

- Soft tissue dissection to expose the fracture, distorts the soft tissue sleeve.
- In case of comminuted fractures needs open reduction. (In case of comminuted fractures it is difficult to apply K wire in a closed approach. Because, it is difficult to have purchase in all the fracture segments and chances of further fracturing of fragments while applying K wire. Hence it requires open approach). In this situation, our technique of LAST will help to reduce the fractures without distorting the soft tissue sleeve.

Advantages of LAST for Phalangeal Fractures

- No implant placed.
- Closed manipulation & splinting.
- Ligamentotaxis property is utilized for moulding & maintenance of reduction

Disadvantage of LAST

- Patient's compliance and cooperation is required to avoid displacement.

CONCLUSIONS

Aluminium splint application is very simple and easy to learn. Aluminium splint is easily available and cost effective. It involves a single stitch through the finger nail under local anesthetic and can be done as an office procedure in the sterile dressing room. Most of our cases were closed fractures but open fractures without significant soft tissue damage can be primarily closed and treated by nail traction. The results from our series show comparable results as that of other studies which were using conservative management for only proximal phalanx, but we have also managed middle phalanx fractures with the Long aluminium splint traction, which is an effective and safe technique producing long lasting results.

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