

Open proximal phalangeal shaft fractures of the hand treated by theta fixation

Binu Prathap Thomas, Sreekanth R, Samuel C Raj Pallapati

ABSTRACT

Background: Many implants and techniques are used for the treatment of open phalangeal fractures with varying grades of stability. The ubiquitous and simple Kirschner (K) wiring does not provide adequate stability to allow early mobilization of fingers. Lister described a combination of coronal interosseous wire and oblique K-wire technique for phalangeal fracture fixation with a stable construct that allowed early mobilization. Due to the fancied resemblance of this construct to the Greek alphabet θ (theta), we have referred to this as the theta fixation.

Materials and Methods: Ten patients with open proximal phalangeal shaft (transverse) fractures were treated with theta fixation between January and June 2010. Outcome was analysed in terms of stability, early mobilization, fracture healing and function of hand. They were graded according to the Belsky score.

Results: 90% patients were graded excellent and 10% good, with none having fair or poor results. All fractures allowed the mobilization at a mean of 2.9 days and all healed at an average of 6.1 weeks. No loss of stability was seen on followup X-rays. All patients returned to their old profession.

Conclusion: The theta fixation technique is a safe, simple and effective method for open transverse phalangeal fractures with results comparable to other techniques. This method gives superior fracture stability to allow early mobilization of joints and thus early return of function. It is also a cost effective way of management for the developing world.

Key words: Hand fracture, interosseous wiring, Lister fixation, phalanx fracture, theta fixation

MeSH terms: Hand, finger, fracture, fracture fixation

INTRODUCTION

The most quoted statement regarding the management of hand fractures probably is the following comment by Swanson: “The treatment of hand fractures is complicated by deformity from no treatment, stiffness from overtreatment and both from poor treatment.”¹ This simple but eloquent statement points out the problems associated with phalangeal fracture treatment.

Various methods to treat phalangeal fractures include buddy strapping, percutaneous cross Kirschner (K) wiring, plate fixation and tension band wiring. Open transverse phalangeal fractures require internal fixation. Open fractures, however, must be fixed with a minimum of implants to reduce the possibility of infections, but with a stable construct to commence early mobilization to prevent stiffness. Lister described a technique of coronal interosseous wiring with oblique coronal K-wire supplementation for the treatment of phalangeal fractures.²

Early mobilization of phalangeal shaft fractures within the first 4 weeks after injury resulted in 75–80% return of hand function.³ However, when mobilization was initiated later than 4 weeks; the hand function was only 66% of preinjury levels. From this, the need for early mobilization is well-understood. Rigid fixation allows early mobilization of the injured digit. Various fixation techniques like single oblique K-wire fixation, crossed K-wire fixation, oblique screw fixation, plate and screw fixation etc., have been described for phalangeal shaft fractures. Fyfe and Mason⁴ produced experimental fractures of the proximal phalangeal shaft and tested different methods of fixation. They reported that the least rigid was the single K-wire fixation. Crossed K-wire

Dr. Paul Brand Centre for Hand Surgery, Christian Medical College and Hospital, Vellore, Tamil Nadu, India

Address for correspondence: Prof. Binu Prathap Thomas, Prof and Head, Dr. Paul Brand Centre for Hand Surgery, Christian Medical College and Hospital, Vellore - 632 004, Tamil Nadu, India.
E-mail: binu@cmcvellore.ac.in

Access this article online	
Quick Response Code:	Website: www.ijonline.com
	DOI: 10.4103/0019-5413.156204

fixation was more rigid and interosseous wiring supplemented with an oblique K-wire the most rigid. Since this configuration resembles the Greek letter theta (θ), we refer to it as “theta fixation.” The theta fixation, therefore, can be considered a rigid fixation allowing early mobilization of the fractured digit.

There is no specific literature available for the outcome of fixation of open phalangeal fractures. We report our experience in the management of open transverse phalangeal fractures of the hand using the theta fixation technique.

MATERIALS AND METHODS

Ten patients with open transverse fracture of the proximal phalanx from January to June 2010 who underwent fracture fixation using the theta technique after appropriate debridement and wound care were included in this study. The inclusion criteria were (a) single digit open transverse proximal phalanx fracture (b) no other injured structures in hand (c) no co-morbidities. The exclusion criteria were (a) comminution (b) extensive soft tissue injury (d) patients already with stiffness of any digit.

Operative procedure

Meticulous debridement and irrigation of wound was first done in the operating room. The fracture was classically approached by a dorsal curvilinear incision but required to be modified according to the position of the original wound [Figure 1a-d]. The extensor tendon was split longitudinally to expose the fracture. After trial reduction, two coronal transverse holes were drilled on each fragment parallel to fracture line using a 1.25 mm K-wire. Stainless steel wire (Ormed Surgicals, Chennai, India) (gauge 24–26) was threaded through the holes to complete a loop. The wire was tightened with a wire twister making sure that there was good apposition on the far cortex with a notch-notch fracture reduction. A K-wire was then drilled obliquely avoiding the drill holes for the steel wires. The K-wire was cut flush with the bone while the steel wire cut and twisted such that the extensor tendon was not impaled in any way [Figure 2a-c].

The free end of the wire loop may also be buried in the bone by a separate drill hole.

The extensor tendon was then repaired with Ethilon™ (Ethicon, Johnson and Johnson, Aurungabad, India) (4–0) followed by skin closure. The fingers were immobilized in volar plaster of Paris slab in the James position.

Postoperative care

Gentle mobilization of the fingers was done by the surgeon during wound inspection and patients were encouraged to move the fingers actively. After the 3rd day, the hand therapist was instructed to commence active and passive mobilization of the hand daily. In order to protect the fixation from unwanted unprotected activity, the splint was continued for 3 weeks. Patients attended the hand therapy clinic daily where the therapists would remove the splint to encourage active and passive range of motion exercises under supervision and then reapply the splint. The sutures were removed on the 10th day. The slab support to the hand was discontinued at the end of 3rd week. The K-wires

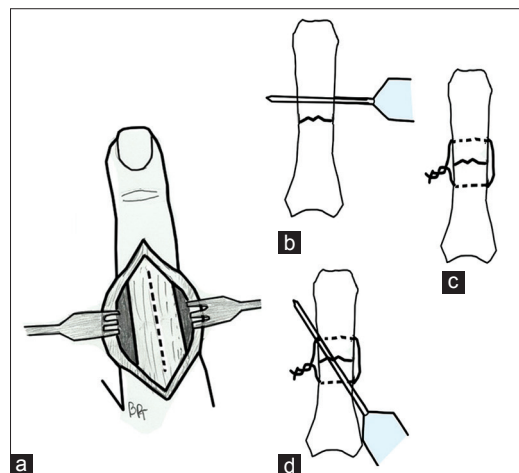


Figure 1: Diagrammatic representation of the theta fixation. (a) Dorsal extensor splitting approach. (b) Transverse drill hole for the cerclage wire. (c) Cerclage wire applied. (d) Oblique Kirschner-wire insertion

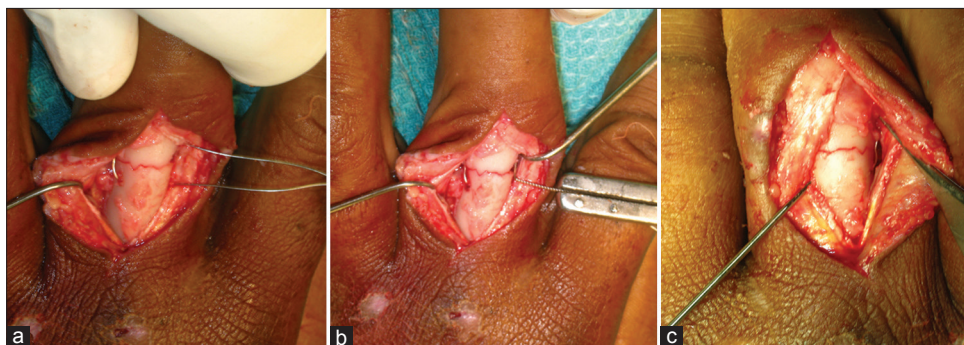


Figure 2: Intraoperative clinical photographs of theta fixation. (a) Fracture exposed through the dorsal extensor splitting approach, reduced and cerclage wire inserted. (b) Cerclage wire tightened. (c) Kirschner-wire inserted

were removed under local anesthesia in OPD after fracture union if required.

The radiographs were taken on 3rd day, at 6th week and 12th week and 24th week [Figures 3 and 4]. Patients were allowed to do light work at the end of 6 weeks to return to their profession with full unrestricted activity when radiological evidence of fracture union was confirmed. The outcome was measured by Belsky *et al.*⁵ score [Table 1] at end of 6th week, 3rd month, and 24th month.

RESULTS

Of the 10 patients, nine were male [Table 2]. The most common mechanism of injury was road traffic accident ($n = 6$). The average age was 33.6 years (range 19-53 years). Index, middle and ring finger were involved in three cases each and the thumb in one. Little finger was not involved in any patient in this series. The average followup was 28.8 months (range 25-33 months). The average hospital stay was 5.9 days (range 5-8 days). The average time for starting mobilization of joints was 2.9 days. The average time to return to unrestricted routine activities and work was 11.3 weeks.

The average duration for radiological healing was 6.1 weeks (range 6-7 weeks). The outcome measured by Belsky *et al.* scoring method revealed seven excellent and three good results at the end of 6 weeks which changed to nine excellent and one good at the end of 3 months. The digit to palm distance (DPD) of all patients at the end of 6 weeks was zero [Figure 5]. No patients had infection or resurgery. Implants were removed in three patients following irritation of the skin by the wire. In one, it was done on the patient's request.

DISCUSSION

Phalangeal fractures are not uncommon injuries. The extensor tendon over the phalangeal shaft may adhere to the fracture site during union causing stiffness of the proximal interphalangeal joint, as well as an extensor lag.⁶ Early mobilization helps in preventing the adhesion. A rigid fixation is a prerequisite for early mobilization. Open transverse phalangeal fractures require internal fixation. Open fractures, however, must be fixed with a minimum of

implants to reduce the possibility of infections, but with a stable construct to commence early mobilization to prevent



Figure 3: Preoperative X-ray of hand anteroposterior and oblique views showing a transverse fracture of the proximal phalanx of the middle finger



Figure 4: Postoperative X-rays of hand anteroposterior and oblique views showing the theta fixation with sound fracture union



Figure 5: Clinical photographs showing the range of movements following theta fixation at 3 months followup

Table 1: The Belsky *et al.*⁵ score

Belsky grade	Parameters
Excellent	No symptoms, pain-free union, no angular/rotational deformity, PIP>100°, TAM>250°
Good	Minimal angular/rotational deformity, PIP movement of >80°, TAM>180°
Fair	TAM<180°
Poor	Remaining unchanged

TAM=Total active range of motion, PIP=Proximal interphalangeal

Table 2: Clinical details of patients and followup

Sex	Age (years)	Side	Finger	Mechanism of injury	DPD (cm)	Fracture healing (weeks)	Followup (months)	Hospital stay (days)
Male	36	Right	Index	Cut injury	0	6	26	6
Male	42	Right	Ring	RTA	0	6	29	8
Male	52	Right	Index	RTA	0	6	32	5
Male	35	Right	Ring	RTA	0	6	31	5
Male	53	Right	Ring	Crush	0	7	29	7
Male	20	Left	Index	Crush	0	6	33	5
Male	26	Right	Middle	RTA	0	6	25	6
Male	19	Right	Thumb	RTA	0	6	28	6
Male	20	Right	Middle	RTA	0	6	28	5
Female	33	Right	Middle	Crush	0	6	27	6

RTA=Road traffic accident, DPD=Digit to palm distance

stiffness. Closed reduction and percutaneous cross K-wiring is the standard treatment for closed phalangeal fractures. However, cross K-wire fixation fails to provide compression at the fracture site especially for transverse shaft fractures⁷ and may also result in distraction of the fracture with subsequent delayed unions or gap nonunions.⁸ As the construct is not very rigid, early mobilization is not routinely done. Reports on phalangeal fracture fixations generally deal with closed fractures. Though extremely stable, plate, and screw fixation is best avoided in open fractures to minimize the chance of subsequent infection. In this context, the Lister fixation provides adequate stability but minimizes the chance of infection as there is a minimum implant used.

Lister² described fixation of transverse fractures and arthrodesis of digits with a cerclage wire and oblique K-wire which is type of tension band fixation, insisting on obtaining congruous reduction and maintaining fixation till the union. In his series, he had a 100% union rate in the case of transverse fractures. Overall, 83.2% of the maximum attainable total active range of motion (TAM) was achieved in the 100 cases. We have been utilizing this technique for the treatment of transverse phalangeal shaft fractures. The theta fixation technique is not as simple as crossed K-wire fixation, has a definite learning curve, but is our fixation of choice for open phalangeal fractures when the fracture line is transverse and there is no comminution.

Many studies have shown the efficacy of the tension band technique of fracture fixation. The strength of the K-wire and cerclage wire construct nears that of the plate and screw fixation. Rayhack *et al.*⁹ in their study concluded that single looped tension band wires were superior in strength to figure-of-eight constructs in experimental transverse osteotomies. Hung *et al.*¹⁰ following biomechanical testing of different fracture fixation techniques in the fifth metatarsal of porcine forelimbs concluded that an intra-medullary K-wire and a cerclage interosseous wire was more stable than crossed K-wires though not as rigid as a dorsal plate and screw fixation.

Pun *et al.*¹¹ reported 70% fair or poor results in 109 unstable digital fractures treated with K-wire fixation. Lag screw fixation for proximal phalangeal fractures can be done only if the length of the fracture exceeds 2 times the diameter of the bone.¹² Hence, screw fixation alone is not applicable to a transverse shaft fracture. Page and Stern^{13,14} reported total active digital motion was <180° in 62% of fractures after plate fixation of 39 phalangeal fractures. Green¹⁵⁻¹⁷ and Safoury¹⁸ have demonstrated that fracture stability is enhanced when the K-wires are supplemented with stainless steel wire, a technique termed composite (or tension band) wiring.

Massengill *et al.*¹⁹ noted that the only construct that is superior in stiffness and strength to any configuration of the wire loop or the K-wires is volar or lateral plate and screw fixation. Gould *et al.*²⁰ concluded that tension band stabilization provides superior strength, stiffness, and approximation when compared with K-wire fixation.

Our result is comparable to other studies.²¹ The percutaneous pinning alone was reported to give 83% excellent result in a study by Hornbach and Cohen.²² They reported the results of 12 unstable extraarticular fractures of the proximal phalanx treated with intra medullary K-wires.

To conclude, theta fixation technique is a safe and effective method for open transverse proximal phalangeal fractures. The technique gives good stability and compression at the fracture site which allows early mobilization of joints to prevent stiffness.

REFERENCES

1. Swanson AB. Fractures involving the digits of the hand. *Orthop Clin North Am* 1970;1:261-74.
2. Lister G. Intraosseous wiring of the digital skeleton. *J Hand Surg Am* 1978;3:427-35.
3. Strickland JW, Steichen JB, Klienman WB, Hastings H II, Flynn N. Phalangeal fractures. Factors influencing digital performance. *Orthop Rev* 1982;11:39-50.

4. Fyfe IS, Mason S. The mechanical stability of internal fixation of fractured phalanges. *Hand* 1979;11:50-4.
5. Belsky MR, Eaton RG, Lane LB. Closed reduction and internal fixation of proximal phalangeal fractures. *J Hand Surg Am* 1984;9:725-9.
6. Patankar H, Meman FW. Multiple intramedullary nailing of proximal phalangeal fractures of hand. *Indian J Orthop* 2008;42:342-6.
7. Freeland AE, Geissler WB, Weiss AP. Surgical treatment of common displaced and unstable fractures of the hand. *Instr Course Lect* 2002;51:185-201.
8. Ikuta Y, Tsuge K. Micro-bolts and micro-screws for fixation of small bones in the hand. *Hand* 1974;6:261-5.
9. Rayhack JM, Belsole RJ, Skelton WH Jr. A strain recording model: Analysis of transverse osteotomy fixation in small bones. *J Hand Surg Am* 1984;9:383-7.
10. Hung LK, So WS, Leung PC. Combined intramedullary Kirschner wire and intra-osseous wire loop for fixation of finger fractures. *J Hand Surg Br* 1989;14:171-6.
11. Pun WK, Chow SP, So YC, Luk KD, Ip FK, Chan KC, *et al.* A prospective study on 284 digital fractures of the hand. *J Hand Surg Am* 1989;14:474-81.
12. Steel WM. The A.O. small fragment set in hand fractures. *Hand* 1978;10:246-53.
13. Page SM, Stern PJ. Complications and range of motion following plate fixation of metacarpal and phalangeal fractures. *J Hand Surg Am* 1998;23:827-32.
14. Stern PJ, Wieser MJ, Reilly DG. Complications of plate fixation in the hand skeleton. *Clin Orthop Relat Res* 1987;59-65.
15. Greene T. Open pin fixation of the diaphysis for phalangeal fractures. In: Blair WF, editor. *Techniques in Hand Surgery*. Baltimore: Williams and Wilkins; 1996. p. 187-91.
16. Greene TL, Noellert RC, Belsole RJ. Treatment of unstable metacarpal and phalangeal fractures with tension band wiring techniques. *Clin Orthop Relat Res* 1987:78-84.
17. Greene TL, Noellert RC, Belsole RJ, Simpson LA. Composite wiring of metacarpal and phalangeal fractures. *J Hand Surg Am* 1989;14:665-9.
18. Safoury Y. Treatment of phalangeal fractures by tension band wiring. *J Hand Surg Br* 2001;26:50-2.
19. Massengill JB, Alexander H, Parson JR, Schecter MJ. Mechanical analysis of Kirschner wire fixation in a phalangeal model. *J Hand Surg Am* 1979;4:351-6.
20. Gould WL, Belsole RJ, Skelton WH Jr. Tension-band stabilization of transverse fractures: An experimental analysis. *Plast Reconstr Surg* 1984;73:111-6.
21. Al-Qattan MM. Closed reduction and percutaneous K-wires versus open reduction and interosseous loop wires for displaced unstable transverse fractures of the shaft of the proximal phalanx of the fingers in industrial workers. *J Hand Surg Eur Vol* 2008;33:552-6.
22. Hornbach EE, Cohen MS. Closed reduction and percutaneous pinning of fractures of the proximal phalanx. *J Hand Surg Br* 2001;26:45-9.

How to cite this article: Thomas BP, Sreekanth R, Raj Pallapati SC. Open proximal phalangeal shaft fractures of the hand treated by theta fixation. *Indian J Orthop* 2015;49:312-6.

Source of Support: Nil, **Conflict of Interest:** None.

Author Help: Reference checking facility

The manuscript system (www.journalonweb.com) allows the authors to check and verify the accuracy and style of references. The tool checks the references with PubMed as per a predefined style. Authors are encouraged to use this facility, before submitting articles to the journal.

- The style as well as bibliographic elements should be 100% accurate, to help get the references verified from the system. Even a single spelling error or addition of issue number/month of publication will lead to an error when verifying the reference.
- Example of a correct style
Sheahan P, O'leary G, Lee G, Fitzgibbon J. Cystic cervical metastases: Incidence and diagnosis using fine needle aspiration biopsy. *Otolaryngol Head Neck Surg* 2002;127:294-8.
- Only the references from journals indexed in PubMed will be checked.
- Enter each reference in new line, without a serial number.
- Add up to a maximum of 15 references at a time.
- If the reference is correct for its bibliographic elements and punctuations, it will be shown as CORRECT and a link to the correct article in PubMed will be given.
- If any of the bibliographic elements are missing, incorrect or extra (such as issue number), it will be shown as INCORRECT and link to possible articles in PubMed will be given.