

Safe corridors for K-wiring in phalangeal fractures

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ABSTRACT

Background: Unstable phalangeal fractures are commonly treated with K-wire fixation. Operative fixation must be used judiciously and with the expectation that the ultimate outcome should be better than the outcome after nonoperative management. It is necessary to achieve a stable fracture fixation and early mobilization. In order to achieve this goal, one should closely understand the safe portals/corridors in hand for K-wire entry for fractures of the phalanges. Safe corridors were defined and tested using a pilot cadaveric and a clinical case study by assessing the outcome.

Materials and Methods: In our prospective case series, 50 patients with 64 phalangeal fractures were treated with closed reduction and K-wires were inserted through safe portals identified by a pilot cadaveric study. On table active finger movement test was done and the results were analyzed using radiology, disabilities of the arm, shoulder, and hand (DASH) score and total active motion (TAM). In our study, little finger ($n = 28$) was the most commonly involved digit. In fracture pattern, transverse ($n = 20$) and spiral ($n = 20$) types were common. Proximal phalanx ($n = 38$) was commonly involved and the common site being the base of the phalanx ($n = 28$).

Results: 47 (95%) patients had excellent TAM and the mean postoperative DASH score was 58.05. All patients achieved excellent and good scores proving the importance of the safe corridor concept.

Conclusion: K-wiring through the safe corridor has proved to yield the best clinical results because of least tethering of soft tissues as evidenced by performing “on-table active finger movement test” at the time of surgery. We strongly recommend K-wiring through safe portals in all phalangeal fractures.

Key words: K-wire, proximal interphalangeal joint, metacarpo-phalangeal joint, phalanges, fractures

MeSH terms: Phalanges of fingers, fracture fixation, hand injuries

INTRODUCTION

Fractures of metacarpals and phalanges are the most common fractures of the upper extremity.¹ The outer rays of the hand are most commonly injured.¹ Unfortunately, the metacarpal and phalangeal fractures are often neglected or regarded as trivial injuries.² The proximal phalanx of the fingers is fractured more frequently than the middle or even distal phalanges. The deformity with considerable displacement is typical when the proximal phalanx is fractured.^{3,4}

Most fractures are functionally stable either before or after closed reduction and do well with protective splintage and early mobilisation.^{1,2} The closed treatment has gained a poor reputation due to problems of malunion, stiffness and sometimes loss of skin or other soft tissues.^{1,2} Certain fractures (angulation $>20^\circ$ in anteroposterior view and $>15^\circ$ in lateral view, $<50\%$ bony contact, rotational deformity, collapse and multiple fractures) require operative fixation. Operative fixation must be used judiciously and with the expectation that the ultimate outcome should be better than the outcome after nonoperative management.¹ Selection of the optimum treatment depends on a number of factors including fracture location, fracture geometry, deformity, whether open or closed and fracture stability.³ Appropriate treatment is necessary for phalangeal fractures or else it will lead to stiffness. To prevent this disastrous complication, it is necessary to achieve a stable fracture fixation and early mobilization. In order to achieve this goal, one should closely understand the safe portals/corridors in hand for K-wire entry for fractures of the phalanges.

Safe corridor in a finger is an area where a K-wire can be passed with minimal soft tissue damage and without impaling major soft tissue structures such as the extensor expansion, neurovascular structures and flexor tendons,

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thus allowing relatively pain-free active range of movements and preventing stiffness.

MATERIALS AND METHODS

We did a pilot cadaveric study in hand and passed multiple K-wires in each phalanx [Figure 1— by visually identifying the extensor expansion and mapped the safe portal avoiding any tethering of the same. This is further tested by manual pulling of flexor and extensor tendons for full flexion and extension of fingers so that there was no restriction of movements. After a pilot study in cadavers by transfixing K-wires in phalanx [Figure 1] and checking the range of motion, we have defined a safe portal/corridor for K-wires [Figure 2a-c] by marking them in green. This has been implemented in clinical practice to assess the outcome.

Based on our pilot, cadaveric study on placement of K-wires the present clinical study was started. Mapping was done in each phalanx both in flexion and extension of the fingers and the safe corridor was identified.

Proximal phalanx

Safe corridor can be transcutaneously identified in proximal phalanx base by identifying the central tendon at metacarpo-phalangeal joint dorsally. On either side of this tendon, it is safe corridor for K-wire entry.

There is a triangular, wide area of a safe zone dorsolaterally and dorsomedially on either side of the extensor tendon in the base of the proximal phalanx. Shaft of proximal phalanx is a dangerous zone, it has ligaments all around (lumbrical and interossei tendon) and neurovascular structures on the volar side. In the head (in this study we call condyle of phalanx as head) of proximal

phalanx, dorsomedial and dorsolateral small triangular area is safe in flexion and this corridor gets obliterated in extension.

Middle phalanx

In middle phalanx base, there is a small triangular safe corridor in flexion of the PIP joint dorsomedially and dorsolaterally, between the central slip and the lateral band. Shaft of the middle phalanx is usually dangerous area to pass K-wires because lateral band and oblique retinacular ligament pass there. Head of the middle phalanx has a wide safe zone dorsomedially and dorsolaterally in both flexion and extension.

Distal phalanx

In distal phalanx, the tip is safe and the only dangerous zones are the dorsal and volar insertions of long extensor and flexor tendons respectively.

A prospective study was conducted on 50 patients with 64 phalanx fractures treated with closed reduction and K-wire fixation in the year 2011. They were followed up for a minimum period of 12 months and a maximum of 18 months.

There were 38 proximal phalanx fracture, 14 distal phalanx fracture and 12 middle phalanx fracture with absolute indications for closed reduction and percutaneous K-wire fixation. Little finger was most commonly involved (28), ring (16), middle (10), index (7), thumb (3) in order of frequency. Transverse and spiral pattern of fractures were common (20), oblique were the next common (10), followed by comminuted and avulsion fractures 8, 6, respectively. Base of the phalanx was most commonly involved (28) followed by shaft (22), then neck (10) and least involved was neck (4). Intraarticular



Figure 1: Clinical photograph of dissection on cadaveric finger showing multiple K-wire passed through safe corridors under direct vision

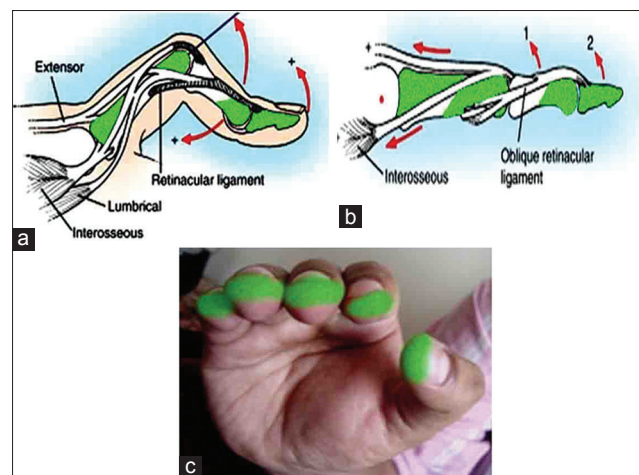


Figure 2: Safe corridors marked in each phalanx in flexion (green color). (b) Safe corridors marked in interphalangeal joint in extension (green). (c) Safe corridors in the distal phalanx

fractures and volar plate avulsion fractures were excluded in the study. Surgery was done by a single surgeon and late presentations were excluded. Easy surgical tip of finding the base of proximal phalanx is by flexing metacarpophalangeal joint and lifting the shaft of phalanx [Figure 3] Fracture needs perfect reduction and K-wires are placed parallel to each other [Figure 4A-C]. We need to know the safe zones before passing the K-wires in each phalanx [Figure 5]. After the procedure, all patients underwent testing range of motion in the operating room-“on-table active finger movement test,” as all of them had surgery under local anesthesia.

All patients had weekly followup for regular physiotherapy and pin tract care. Wires were removed at the end of 3–4 weeks except in avulsion fractures. These patients were followed regularly biweekly for 3 months and monthly thereafter for 1-year.

The functional outcome after fracture treatment was assessed by calculating disabilities of the arm, shoulder



Figure 3: Clinical photograph showing surgical tip to visualize by lifting the base of proximal phalanx as shown for easy introduction of K-wire

and hand (DASH)⁵ score and total active range of motion⁶ (TAM). TAM was calculated by adding the active flexion at metacarpo-phalangeal, PIP and distal interphalangeal joints, after subtracting the sum of extension deficit at these three joints. Recovery is calculated as percent regained motion compared to the normal range of digital motion (260°). According to this, patient with 85–100% of the movement are classified as excellent; 70–84% as good; 50–69% as fair and <50% as poor.

RESULTS

We had 86 patients with phalangeal fractures, and 50 patients underwent K-wire fixation due to various indications like unstable phalangeal fractures, fractures with rotations and angular deformity, multiple phalangeal fractures in the same hand and avulsion fractures (e.g. central slip avulsion, mallet finger). Rest of the patients (36) were treated either conservatively or eliminated due to the following reasons: Open fractures (5), stable fractures (5), extreme age groups (age <17 years and >70 years) (7), with comorbid conditions such as diabetes, peripheral vascular disease (7), polytrauma patients (6) ipsilateral arm fractures (4), intraarticular fractures and volar plate avulsion fractures (2). 37 patients were male, and 13 were female patients. 32 patients sustained fracture due to road traffic accident, 10 patients had an industrial accident, and 8 were sports injuries.

In our study, little finger is most commonly injured digit, more frequently proximal phalanx fracture was observed, transverse and spiral type of fracture was more frequent, base of the phalanx fracture were common in our study [Table 1, Figure 6]. At the end of 3 months, DASH score and objective hand score assessment (TAM) were excellent in 95% (47 patients) of cases, and 2 patient had a good result in spite of not attending physiotherapy, one patient



Figure 4A: (a) X-ray of hand oblique view showing displaced proximal phalanx fracture. (b and c) Clinical photograph showing introduction of two K-wires from the base of proximal phalanx and performance of full flexion and extension-“on-table active finger movement test.”

had pin tract infection leading to early removal of wire and poor compliance leading to mild residual stiffness in little finger resulting in fair score [Table 2].

DISCUSSION

The incidence of metacarpal and phalangeal fractures is the most common in males and peaks at young age as they are prone to road traffic accident, athletic injury, and industrial exposure as shown in our study. In our study, the most common age group is between 20 and 35 years (42 fractures). This age group is comparable Gupta et al.⁷ study which has 36 years as the mean age.

In our study, the male to female ratio was 7:3 while Ahmad et al.⁸ reported this ratio to be 6:1. Of the 64 fractures, 22% of the patients had multiple digital fractures. Adjacent finger fractures were seen most common in the middle and ring fingers and in the ring and little fingers. Almost equal percentage of right and left sided digits were involved in our study which is similar to Ahmad et al.⁸ study. Consistent with the study by Kar et al.⁹ we also found RTA as the most common mode of injury. In our study, the common site of fracture was base of the phalanx (42%) and transverse

and spiral fracture pattern (65%) was most common and Singh et al.¹⁰ had basal fractures as most common (41.7%) site and transverse pattern was (34.5%) common in his study. Our patients who had K-wire fixations had excellent scores (95%) compared to other studies, the reason being safe portal entry of K-wires and “on-table active finger movement test” was performed in all cases to assess tethering. The study by Hornbach and Cohen¹¹ showed 83% of the patients had excellent results. Our study had an average TAM of 270° and Hornbach et al. reported an average TAM of 265°.

Table 1: Clinical details of patients

	Frequency
Digits	
Little finger	28
Ring finger	16
Middle finger	10
Index finger	7
Thumb	3
Phalanx	
Proximal	38
Middle	12
Distal	14
Type of fracture	
Transverse	20
Spiral	20
Oblique	10
Comminuted	8
Avulsion	6
Site of fracture	
Head	4
Neck	10
Shaft	22
Base	28



Figure 4B: Postoperative X-ray anteroposterior (a) and oblique view (b) of hand showing phalanx fracture fixed with K-wire

Table 2: DASH and TAM scores in the study

Site of fracture	Total active motion				Mean DASH score
	Excellent	Good	Fair	poor	
Phalanx					
Proximal	32	6	0	-	34.46
Middle	8	4	-	-	10.88
Distal	7	6	1	-	12.69
Total	47	16	1		58.05

DASH=Disabilities of the arm, shoulder, and hand, TAM=Total active motion

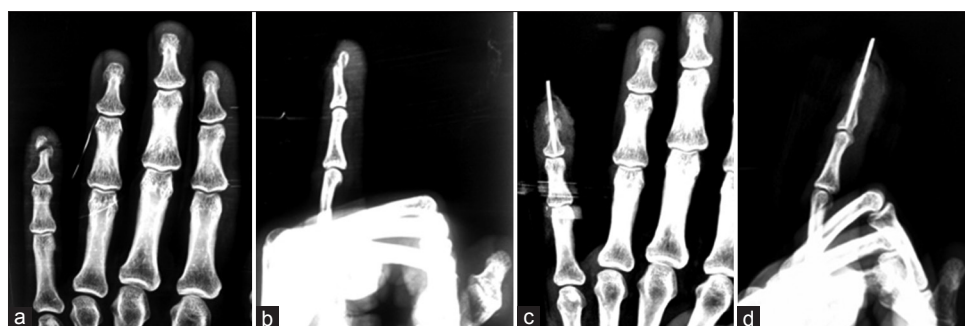


Figure 4C: (a) X-ray anteroposterior view of hand showing distal phalangeal fracture (b) X-ray of little finger lateral view showing distal phalangeal fracture (c) Postoperative x-ray showing K-wire in distal phalangeal fracture (d) Lateral view of postoperative showing K-wire in position

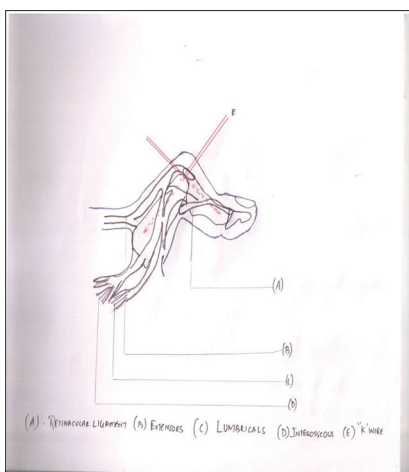


Figure 5: Line diagram depicting K-wires



Figure 6: X-rays of hand anteroposterior view (a) and lateral view (b) showing fracture of middle phalanx (c and d) Postoperative x-rays showing middle phalanx fixed with K-wire

To our best of knowledge, no study in the past has elaborated the importance of placement of K-wire, checking the active range of movement on-table for a better outcome which is directly proportional to the end result. Most of the papers do comparative results of conservative versus surgical treatment K-wire, external fixator, internal fixation with a plate, stainless steel wire SWG 216 for only the closed fractures of phalanges of the hand. Most of them considered all tubular bones of the hand together, both open and closed fractures together and all type of fixations together. This might be a confounding factor for the purpose of comparison of results with our study.

For most stable fractures, conservative treatment modalities are sufficient, but for most unstable fractures, surgical treatment gives the best results. Complication of malunion, stiffness and secondary loss of reduction can be reduced by focusing on the technique of K-wire fixation. This study highlights the importance of placement of K-wire in each phalanx through the safe zones. It is a simple, easy procedure and is well tolerated by patients. The main advantage is it does not need much expertise, understanding of proper anatomy is enough and is relatively very simple and safe technique. It has added advantages of early mobilization, lesser infection rate due to least tethering of soft tissues, decreased incidence of malunion and no implant *in situ* after healing. Strict adherence to safe portal K-wire pinning gives the best chance for full functional recovery.

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