Anatomic Assessment of K-Wire Trajectory for Transverse Percutaneous Fixation of Small Finger Metacarpal Fractures: A Cadaveric Study

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Abstract

Background: The purpose of this cadaveric study is to evaluate the trajectory of percutaneous transverse Kirschner wire (K-wire) placement for fifth metacarpal fractures relative to the sagittal profile of the fifth metacarpal in order to develop a targeting strategy for the treatment of fifth metacarpal fractures. **Methods:** Using 12 unmatched fresh human upper limbs, we evaluated the trajectory of percutaneous transverse K-wire placement relative to the sagittal profile of the fifth metacarpal in order to develop a targeting strategy for treatment of fifth metacarpal fractures. The midpoint of the small and ring finger metacarpals in the sagittal plane was identified at 3 points. At each point, a K-wire was inserted from the small finger metacarpal into the midpoint of the ring finger metacarpal (“center-center” position). **Results:** The angle of the transverse K-wire relative to the table needed to achieve a center-center position averaged 20.8°, 18.9°, and 16.7° for the proximal diaphysis, middiaphysis, and the collateral recess, respectively. Approximately 80% of transversely placed K-wires obtained purchase in the long finger metacarpal. **Conclusions:** These results can serve as a guide to help surgeons in the accurate placement of percutaneous K-wires for small finger metacarpal fractures and may aid in surgeon training.

Keywords: metacarpal fractures, transverse percutaneous K-wire fixation, trauma, cadaver

Background

Fractures of the small finger metacarpal are common injuries.^{1,11} When treatment is indicated, a variety of surgical techniques are available. Plate fixation, lag screws, external fixation, cerclage wiring, intramedullary Kirschner wires (K-wires), and transverse K-wires into the adjacent metacarpal have been described.^{2,4-6,8,12} The choice of procedure is often dictated by the integrity of the soft tissues, the geometry, and location of the fracture as well as surgeon preference.

Percutaneous transverse K-wire fixation for small finger metacarpal fractures has been described for neck, shaft, and base fractures.^{3,9,12} Results of this technique have demonstrated good functional outcomes with reliable fracture healing and limited complications.^{3,9,12} Although percutaneous fixation has advantages with respect to soft tissue preservation and ease of hardware removal, the technique can be challenging. Multiple K-wire passes through the soft tissues increase operative time and result in postoperative swelling, scar formation, and stiffness. Surgeons unfamiliar with the technique may struggle with efficient and accurate percutaneous K-wire placement.

The purpose of this cadaveric study is to evaluate the trajectory of percutaneous transverse K-wire placement for fifth metacarpal fractures relative to the sagittal profile of the fifth metacarpal in order to develop a targeting strategy for treatment of fifth metacarpal fractures. Three points of insertion are identified: proximal, midshaft, and distal. In addition, we aim to define whether K-wires placed in a “center-center” position transversely through the small and ring finger metacarpals can find purchase in the long finger metacarpal for injuries that require additional fixation.

Materials and Methods

Twelve unmatched fresh human upper limbs were obtained. Eight of the 12 fresh human cadaveric upper limbs were

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from women; 9 were right arms. There were 8 Caucasian and 4 African American specimens. The average age was 68 years (range, 52-78 years). All specimens were amputated above the elbow. A rectangular flap of skin and subcutaneous tissue was elevated from the dorsal aspect of each specimen to expose the entire length of the small, ring, and long finger metacarpals. The extensor tendons were left intact. Subperiosteal dissection along the ulnar aspects of the small, ring, and long finger metacarpals allowed for adequate exposure to guide K-wire placement. Care was taken to preserve the transverse metacarpal ligaments as well as the capsular structures of the carpometacarpal and metacarpophalangeal joints.

Calipers were used to measure the dorsal-volar thickness of the small and ring finger metacarpals at 3 locations: the proximal diaphysis just distal to the metaphyseal flare, the middiaphysis, and at the collateral recess distally. The location of the middiaphysis was determined by measuring the length of the small and ring finger metacarpals. The midpoint of the metacarpal in the sagittal plane was marked on the ulnar cortex of the small and ring finger metacarpals at each of the locations.

Our preferred surgical technique for transverse K-wire fixation of small finger metacarpal fractures involves positioning the patient supine with use of a hand table. A stack of 3 folded Sterile Disposable Surgical Towels (Medline Industries, Mundelein, Illinois) is positioned under the ulnar aspect of the hand. The use of a towel "bump" maintains the long axis of the small finger metacarpal parallel to, and elevated from, the hand table. This allows the surgeon to "drop their hand" while inserting the K-wire without the interference of the table. To standardize the position of the hand, we used an 8.5 × 11.5-cm rectangular wooden block under the small, ring, long, and index finger metacarpals. The height of the block (3.5 cm) was equivalent to the folded towel stack. The palm of the hand remained flat on the wooden block. The thumb was allowed to rest off of the block on the table.

Beginning at the sagittal midpoint of the proximal diaphysis, a 0.45-in K-wire was inserted across the small finger metacarpal perpendicular to the long axis of the bone. The wire was advanced into the sagittal midpoint previously marked on the ulnar cortex of the ring finger (Figure 1). Once this "center-center" position of the wire within the small and ring finger metacarpals was confirmed, the wire was advanced to assess contact with the long finger metacarpal.

Using a nondigital goniometer, the angle of the K-wire with respect to the table was recorded. If the K-wire contacted the long finger metacarpal, the penetration was categorized into three: dorsal, central, or volar. The K-wire was removed and the same steps performed for the remaining 2 points distally: the middiaphysis and the collateral recess.

Figure 1. Center-center position.

Note. K-wire advanced into sagittal midpoint at the middiaphysis of the ring finger metacarpal.

The hand remained positioned on the block during all measurements.

Descriptive statistics were utilized to determine the means and ranges for metacarpal thicknesses. The means and ranges for the angle of the K-wires with respect to the table were determined for each of the 3 locations on the metacarpal.

Results

The volar-dorsal thickness of the small and ring finger metacarpals at the proximal diaphysis, middiaphysis, and collateral recess are presented in Table 1. The angle of the transverse K-wire relative to the table needed to achieve a center-center position averaged 20.8° (range, 15-28°) at the proximal diaphysis, 18.9° (range, 10-26°) at the middiaphysis, and 16.7° (range 12-26°) at the collateral recess.

The contact of the K-wire with the ulnar cortex of the long finger metacarpal is presented in Table 2. Ten of 12 (83.3%) K-wires passed transversely through the ring and small finger metacarpals were able to penetrate the ulnar cortex of the long finger metacarpal at the proximal diaphysis and the collateral recess compared with 9 of 12 (75%) at the middiaphysis. All wires that failed to contact the long finger metacarpal missed dorsally.

Discussion

Percutaneous transverse K-wire fixation for small finger metacarpal fractures has been described for neck, shaft, and base fractures with good functional results.^{3,7,9,12} In comparing percutaneous transverse K-wire fixation to

Table 1. Volar-Dorsal Thickness of the Small and Ring Finger Metacarpal.

Location	Thickness in mm (average, range)
Small finger metacarpal	
Proximal diaphysis	9.75 (8-12)
Middiaphysis	9.46 (8-11)
Collateral recess	14.46 (13-18)
Ring finger metacarpal	
Proximal diaphysis	9.83 (9-12)
Middiaphysis	10.13 (9-12)
Collateral recess	13.88 (12-19)

Table 2. Location of K-Wire Penetration in the Long Finger Metacarpal With Center-Center Position in the Small and Ring Finger Metacarpals.

	Proximal diaphysis	Middiaphysis	Collateral recess
Volar 1/3 radial cortex	3	2	3
Central 1/3 radial cortex	7	6	6
Dorsal 1/3 radial cortex	0	1	1
Missed dorsally	2	3	2

intramedullary K-wires for small finger metacarpal neck fractures, Wong et al demonstrated equivalent results between the 2 groups with respect to union, functional outcome pain, and grip strength.¹² Paul et al analyzed 22 unstable metacarpal shaft fractures treated with transverse percutaneous K-wire fixation. Although all patients had good functional results, patients treated with 2 wires distal to the fracture had statistically significant improvement with respect to maintenance of reduction.⁹ Lamb et al noted excellent functional results with no cases of non-union or serious complications in their series of 66 patients with unstable metacarpal fractures treated with transverse percutaneous K-wire fixation.⁷

Pereira et al demonstrated that the mean diameter at the middiaphysis of the small and ring finger metacarpals is 7.48 mm and 6.32 mm, respectively, in 6 Asian cadaver hands.¹⁰ We found a slightly larger volar-dorsal thickness for both the small and ring fingers, which may be attributed to the small sample sizes in both series as well as anatomic differences with respect to race.

Having a reproducible guide to aid in accurately placing percutaneous K-wires may decrease operative time and limit the number of K-wire passes needed through the soft tissues. Although percutaneous techniques have the advantage of improved soft tissue preservation, multiple K-wire passes may increase postoperative swelling, pain, and stiffness. Stahl and Schwartz noted a 15.2% complication rate in their series of K-wire fixation for 590 hand and wrist fractures

and found that complications related to technical error, particularly resident involvement, were a major cause.¹¹

Limitations of our study include a small sample size and nonuniform race for our cadaveric specimens. The higher number of female specimens may account for disparities with respect to volar-dorsal metacarpal thickness measurements. In addition, our cadaveric specimens had no evidence of prior metacarpal fracture or malunion; thus, the clinical application of our model assumes an anatomic reduction of the fracture.

We found that the average angle for K-wire trajectory relative to the operating table for percutaneous transverse K-wire fixation of small finger metacarpal fractures was 20.8° at the proximal diaphysis, 18.9° at the middiaphysis, and 16.7° at the collateral recess. Approximately 80% of transversely placed K-wires across the small and ring finger metacarpals can obtain purchase in the long finger metacarpal. All wires that failed to contact the long finger metacarpal missed dorsally. The starting point on the small finger should be offset slightly volar if fixation into the long finger metacarpal is needed for additional stability. Our results can serve as a guide to help surgeons in the accurate placement of percutaneous K-wires for small finger metacarpal fractures and may aid in training residents with percutaneous fixation techniques.

Ethical Approval

This study was approved by the Geisinger Health System IRB (Reference No. 2015-103).

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

The informed consent is not required as it is a cadaveric study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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