Iatrogenic Injuries in Percutaneous Pinning Techniques for Fifth Metacarpal Neck Fractures

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Abstract

Background: There is little information regarding anatomic structures at risk during closed percutaneous treatment of fifth metacarpal neck fractures. This study evaluates a variety of common percutaneous techniques with the hypothesis that each approach presents unique risks to tendons and neurovascular structures. **Methods:** Seven cadaveric hands were used for this study. The senior author, a board-certified hand surgeon with more than 20 years of experience, used a mini-C arm to pass 1.6-mm Kirschner wires (K-wires). The 4 percutaneous techniques employed were anterograde, retrograde, cross-pinning, and transverse fixations. Meticulous superficial dissection was carried out, with fixation from all 4 techniques left in place, to identify any tendons or neurovascular structures penetrated by the K-wires. **Results:** All techniques demonstrated penetration of at least 1 adjacent structure. The anterograde technique showed penetration of the extensor carpi ulnaris tendon in 5 out of 7 cadavers. In the retrograde approach, the K-wire impaled either the extensor digitorum communis or the extensor digitorum minimi tendons in 4 out of 7 cadavers. The transverse pinning technique exhibited injury to the dorsal cutaneous ulnar nerve in 2 of the specimens. In the retrograde cross-pin technique, there were 2 penetrations of the digital branch of the dorsal cutaneous ulnar nerve. **Conclusions:** None of the described percutaneous techniques for treating fifth metacarpal neck fractures eliminate the potential for damage to surrounding tendons or nerves. Each technique has at risk structures that the treating surgeon should be aware of in order to anticipate potential complications and counsel patients accordingly.

Keywords: boxer's fracture, percutaneous pinning, fifth metacarpal neck, closed reduction percutaneous pinning, K-wire, transverse pinning, retrograde pinning, anterograde pinning, cross-pinnings

Introduction

Fifth metacarpal neck fractures, also known as boxer's fractures, are among the most commonly observed injuries to the hand.¹ The vast majority of boxer's fractures are clinically stable and can be managed nonoperatively,^{5,11} although surgical management is indicated for patients with clinical malrotation, volar angulation greater than 40°, or >3 mm of shortening.^{1,11,12,14,16} Most hand surgeons prefer closed reduction percutaneous pinning, as it is the least invasive surgical option for stable fixation.^{1,3,5,6,8,20}

There are a variety of described methods for percutaneous pin placement; however, there is little information pertaining to the soft tissue structures at risk inherent to each approach. Due to the high prevalence of fifth metacarpal neck fractures, and the importance of hand function in activities of daily living, it is critical for sur-

geons to operate within a safe zone to mitigate any iatrogenic damage.^{1,6,12} Therefore, we undertook a cadaveric anatomical study to identify the tendons and neurovascular structures at risk during the following percutaneous pinning approaches for fifth metacarpal neck fractures: anterograde intramedullary pinning, retrograde intramedullary pinning, percutaneous transverse pinning, and the retrograde cross-pinning technique (Figure 1).

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Supplemental material is available in the online version of the article.

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Figure 1. Four operative techniques: (a) retrograde intramedullary pinning, (b) anterograde intramedullary pinning, (c) transverse pinning, and (d) retrograde cross-pinning.

Methods

Anatomic Assessment

Seven fresh-frozen cadaveric hands were used for this study, including 1 paired set. The senior author, a board-certified hand surgeon with more than 20 years of experience, used a mini-C arm to pass all 1.6-mm Kirschner wires (K-wires). The 4 percutaneous techniques were performed in each cadaver by the senior author in a randomized order (Supplemental Material). Meticulous superficial dissection was then carried out, with hardware from all 4 techniques left in situ, to identify any tendons or neurovascular structures penetrated by the K-wires. Although there was no fracture to reduce, the distal and proximal phalanges of the fifth digit were flexed $\sim 90^\circ$ (Figure 2) for all 4 operative techniques in each cadaver to simulate the position of the hand and its soft tissue structures when the “Jahss” maneuver is employed to close reduce the boxer’s fracture.

Figure 2. Flexed metacarpophalangeal and proximal phalanx during insertion of Kirschner wires.

Retrograde Intramedullary Pinning

The 1.6-mm K-wire is inserted midline at the distal articular surface of the metacarpal head and advanced proximally for intramedullary fixation. The extensor tendon slides radially when the metacarpophalangeal joint is flexed 90° , and thus should be safe from pin penetration¹³ (Figure 1a).

Anterograde Intramedullary Pinning

A modification of the technique first described by Foucher et al¹⁰ was utilized in this study, in that the approach is performed without a small incision. The base of the fifth metacarpal is the landmark for entry point of the 1.6-mm K-wire, which is pre-bent approximately 10° to 15° to facilitate entry into the intramedullary canal. The K-wire is inserted laterally at the fifth metacarpal base to avoid impingement of the extensor mechanism by the protruding K-wire^{3,9} (Figure 1b).

Transverse Pinning

The goal in this technique is to secure the center of the metacarpal, as all vulnerable structures lie dorsal or volar to the entry point.² The K-wire is advanced to the center of the fourth (and sometimes the third) metacarpal to increase stability. The senior author utilizes 2 distal pins and 1 proximal pin to optimize stability of fixation¹¹ (Figure 1c).

Retrograde Cross-Pinning

A technique guide for the cross-pinning of proximal phalanx fractures was modified for use in the metacarpal. The K-wires are placed just adjacent to the metacarpal head and sit in the collateral ligament fossa and are then advanced obliquely into the medullary canal. This technique avoids

Figure 3. One of the 5 specimens in which the extensor carpi ulnaris tendon is penetrated by an anterograde pin, as demonstrated by the arrow.

transfixion of the joint and minimizes the possibility of damage to articular cartilage⁴ (Figure 1d).

Results

All techniques demonstrated penetration of at least 1 adjacent structure. The anterograde technique exhibited penetration of the extensor carpi ulnaris (ECU) tendon in 5 out of 7 cadavers (Figure 3). In the retrograde approach, the K-wire impaled either the extensor digitorum communis (EDC) or the extensor digitorum minimi (EDM) tendons in 4 out of 7 cadavers (Figure 4). The transverse pinning technique exhibited injury to the dorsal cutaneous ulnar nerve (DCUN) in 2 of the specimens (Figure 5). In the retrograde cross-pin technique, there were 2 penetrations of the digital branch of the dorsal cutaneous ulnar nerve (Figure 6). Table 1 provides a summary of all of the soft tissue structures that were compromised by each approach. None of the pins inserted in our study were found to have penetrated multiple tendons or neurovascular structures; thus, each case of soft tissue compromise was isolated to one structure per pin.

Discussion

While closed reduction and percutaneous pinning of fifth metacarpal neck fractures is the mainstay for fixation, various operative techniques continue to be utilized with no definitive approach considered preferable.^{3,5,8,16} There are many problems that can occur irrespective of the approach, such as pin migration, tendon rupture/nerve irritation due to

protruding K-wires, and secondary displacement due to inadequate fixation.⁹ However, the aim of this study was to focus on those complications specific to the approach and the soft tissue structures at risk as the pin is inserted.

Foucher and Bouquet advocated the use of anterograde intramedullary “bouquet” osteosynthesis, reasoning that unlike the retrograde approach, this technique avoided fixation of mobile structures (such as the extensor tendons or extensor hood) that could lead to pin track infection, joint stiffness, and extensor lag.⁹ Calder et al expanded on this point, arguing that trauma to the extensor hood and collateral ligaments during retrograde wire insertion can potentially lead to both metacarpophalangeal joint stiffness and extensor lag; complications were not observed in their case series utilizing anterograde fixation.⁵ However, in comparison with the other techniques, the anterograde approach is often mini-open; thus, there is an accompanying dorsoular scar.¹⁷ Interestingly, the anterograde technique was the most traumatic approach in this cadaveric series, impaling the ECU tendon in 5 out of the 7 cadavers. Perhaps these results were due to the use of an all-percutaneous anterograde approach, a modification of the original “bouquet” technique proposed by Foucher, which utilized an arciform incision proximal to the base of the fifth metacarpal to avoid damaging the ECU tendon and neurovascular structures. Foucher and Bouquet presented an 82-patient series with one case of reflex sympathetic dystrophy (with no residual impairment) and one case of dorsal ulnar sensory neuritis (1.2% of neuritis) but without tendon impairment.⁹ Furthermore, there is no evidence that penetration of the ECU tendon has any clinical implications

Figure 4. Four cadavers in which the EDC/EDM tendons were penetrated by the retrograde pinning, as demonstrated by the arrows. Note. EDC = extensor digitorum communis; EDM = extensor digitorum minimi.

Figure 5. Two cadavers in which the transverse pins penetrated branches of dorsal cutaneous ulnar nerve, as demonstrated by the arrows.

as ECU tendinitis/irritation has not been reported in the literature as sequelae of the anterograde approach, whether mini-open or percutaneous. This can be due to the fact that the ECU inserts at the base of the fifth metacarpal at this

location, eliminating the potential for disruption of ECU tendon excursion or mobility, minimizing its clinical impact. The subsequent removal of the anterograde pins would also limit the potential for ECU tendinitis.

Figure 6. Two cadavers in which the retrograde cross-pins hit the digital branch of dorsal cutaneous ulnar nerve, as demonstrated by the arrows.

Table 1. Soft Tissue Structures Penetrated With Respect to Approach.

Approach	Involved structure	Pin penetration
Anterograde pin	ECU	5/7
Retrograde pin	EDM/EDC	4/7
Transverse pin	Dorsal cutaneous ulnar nerve	2/7
Retrograde cross-pin	Digital branch of dorsal cutaneous ulnar nerve	2/7

Note. ECU = extensor carpi ulnaris; EDM = extensor digitorum minimi; EDC = extensor digitorum communis.

With regard to the retrograde approach, Lord acknowledged metacarpophalangeal joint stiffness while the pin was in place but reported motion returned to normal shortly after pin removal.¹³ Rhee et al buried the pin in the subchondral metacarpal head, with protrusion of the wire proximally, to avoid this mechanical block to motion at the metacarpophalangeal joint.¹⁷ Although the pin is placed through the dorsal surface of the metacarpal head, there have not been any reports of metacarpal head arthritis or chronic metacarpophalangeal pain in the literature.^{6,17} Despite Lord's assertion that the extensor tendon slides radially when the metacarpophalangeal joint is flexed 90°, the retrograde K-wire hit the EDC tendon to the fifth digit in 3 out of the 7 cadavers and also penetrated the tendon of the EDM in a fourth cadaver. These findings support the notion that the retrograde intramedullary K-wire can inadvertently immobilize mobile structures, such as the extensor tendons. Sela et al reported a cadaveric series in which pin placement associated with tethering of extensor tendons led to restricted finger motion.¹⁸

Interestingly, the transverse pinning technique demonstrated nerve trauma in this cadaveric study, as branches of the dorsal cutaneous ulnar nerve were violated in the more proximal of the 2 distal transverse pins in 2 of the specimens. A descriptive cadaveric study by Polat et al supports this finding, demonstrating that the dorsal cutaneous ulnar nerve and its branches demonstrated an average distance of 5.86 mm from the proximal transverse pin, while the distal transverse pins were only 3.33 mm from the nerve.¹⁵ This is noteworthy, as there is little mention of potential injury to the dorsal branch of the cutaneous ulnar nerve with transverse pinning. Conversely, isolated cases of injury to the dorsal cutaneous ulnar nerve have been reported with the anterograde technique.^{10,19} Although our study focused specifically on compromise of tendons and neurovascular structures, Winter et al mentioned that the distal K-wire has a potential to damage the articulation of the metacarpophalangeal joint. Winter et al further noted that advancing the K-wire to the fourth metacarpal presents potential damage to the interosseous

muscle within the intermetacarpal space.²⁰ Anecdotally, the transverse pinning technique was easiest to perform, as the intramedullary techniques often required multiple passes resulting in potentially deleterious consequences to the articular surface.

Contrary to the aforementioned techniques, there is a dearth of literature that advocates for the percutaneous retrograde cross-pinning procedure. In fact, to our knowledge, no study has provided a description of the technique; those that advocate for this approach omit a descriptive technical guide.⁷ Two of the specimens in our cadaveric study had the digital branch of the dorsal cutaneous ulnar nerve compromised by the retrograde pin. The clinical implications of this finding are marginal, as this approach is rarely utilized.

There are several limitations to this study. For one, as a cadaveric study, there are no subjective markers to match the objective findings of the damaged soft tissue structures. For instance, there is no method to determine the degree and/or presence of neurologic symptomatology assigned to the specimen that had branches of the dorsal cutaneous ulnar nerve lacerated. Second, despite randomizing the operative approach, the potential for altered trajectory of pin placement was higher for each subsequent pin as the intramedullary space progressively narrowed when employing all percutaneous approaches through the same cadaveric hand.

In summary, none of the described percutaneous pinning techniques for treating boxer's fractures are safe from iatrogenic injury. Each technique has structures that are at risk, specific to the approach. Furthermore, long-term studies have demonstrated no difference in terms of functional outcomes with respect to the different percutaneous pinning techniques.¹² Therefore, it is surgeon's choice for which percutaneous approach to use. However, hand surgeons should be aware of the at-risk structures specific to their approach to anticipate potential complications and properly advise their patients.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. This was a cadaveric study, in which the cadavers were obtained from a licensed tissue bank. There was no identifying information included in this article. There were no animal subjects in this study.

Statement of Informed Consent

Informed consent was not needed as this was a cadaveric study. The cadavers were obtained from a licensed tissue bank.

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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