SURGICAL TECHNIQUE

Reverse Instrumentation for Headless Compression Screw Fixation of Basal Proximal Phalangeal Fractures

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Intramedullary headless compression screw fixation of proximal phalangeal fractures permits semirigid stabilization through a minimally invasive approach with negligible tendon disturbance, allowing early mobilization and rehabilitation. Antegrade insertion is preferred for basal fractures, but various concerns and technical difficulties have been identified with both intra- and transarticular instrumentation. We describe a technical tip to facilitate easier guidewire insertion and instrumentation with a screw via an intra-articular approach. *(J Hand Surg Am. 2023;■(■):■−■. Copyright © 2023 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Proximal phalanx, intramedullary, screw, insertion.

Fractures of the proximal phalanx are among the most common in the upper extremity, with the mechanism of injury, patient characteristics, and fracture pattern determining the need for operative intervention.[1] The ideal therapeutic option should create a biomechanical environment capable of maintaining reduction and withstanding the gentle forces associated with early range of motion, while limiting soft tissue dissection (and resultant adhesions) and physical impediments to tendon glide. Intramedullary headless compression screw fixation permits semirigid stabilization through a minimally invasive approach with negligible tendon disturbance, allowing early mobilization and rehabilitation, and can be used in a range of fracture configurations.[2] Early results using this technique are promising, with improvements in patient-reported outcome measures, restoration of total active motion, and complication rates comparable to other modes of fixation.[3]

Intramedullary screws can be introduced either retrograde or antegrade, with the latter allowing transarticular (through the metacarpal head), intra-articular (with subluxation of the proximal phalanx dorsally at the MCP joint), or extra-articular (using an oblique trajectory without articular violation) insertion. Antegrade insertion is often preferred in basal phalangeal fractures and is thought to afford a greater degree of fixation in the smaller proximal fragment with limited bone stock. Concerns have been raised regarding the potential for adjacent lesions from corresponding metacarpal and phalangeal chondral defects and resultant future arthrosis via the transarticular method, although transarticular screw insertion in other areas of the hand undergoing loading has not been found to increase short- or medium-term incidence of

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arthritis.[4] The intra-articular method obviates the risk of adjacent lesions and is thus theoretically preferred. However, the “push up” technique to facilitate antegrade guidewire insertion (manipulation of the proximal phalanx dorsally at the MCP joint to allow entry) is often technically challenging, given that dorsal translation usually occurs at the fracture and not the joint, and may lead the surgeon to seek alternative routes of instrumentation.

We describe a technical tip to facilitate easier guidewire insertion and instrumentation with a screw via an intra-articular approach.

INDICATIONS/CONTRAINDICATIONS

This technique can be used in all patients with extra-articular basal proximal phalangeal fractures. We use this technique in the setting of open fractures following an adequate and thorough debridement. Although intramedullary screw fixation can be employed in intra-articular fractures in which the proximal epiphyseal articular surface can be stabilized into a single and stable fragment via percutaneous methods, it must be used with caution because of the risk of axial blowout.[2] Fracture configurations requiring open reduction of articular comminution may be best fixated using low-profile plating systems. Active infection and an open physis are absolute contraindications.

SURGICAL ANATOMY

Proximal phalangeal fractures tend to assume an apex volar deformity. The interossei tendons insert onto the base of the proximal phalanges (as well as the extensor hood), flexing the proximal fragment. Although there is no direct tendinous attachment to the distal fragment, the axial compression forces imparted by the extrinsic flexor and extensor tendons result in an extension moment to the distal fragment.

The MCP joints are diarthrodial condyloid articulations involving the convex metacarpal heads and the concave proximal phalangeal bases. Differences between the MCP joints of the thumb and lesser digits result in functional variations—the thumb MCP joint is a hinge joint that permits predominant flexion, whereas those of the fingers are of shallow ball-and-socket morphology, allowing some degree of motion in all 3 planes.[5] Extension at the MCP joints of the fingers is driven by the extensor tendon continuation to the extensor hood and middle phalanx, generating torque and possessing a moment arm—insertions of the extensor tendon to the base of the proximal phalanx have been proven to be inconsistent and functionally unimportant.[6]

The PIP articulations are uniaxial hinge joints that afford only sagittal plane motion. The condyles of the proximal phalanx are markedly trapezoidal in axial profile (with the volar surface approximately twice as wide as the dorsal surface), whereas the base of the middle phalanx is less so.[7] The central extensor tendon trifurcates at the midportion of the proximal phalanx, forming the central slip and the lateral bands; the central slip attaches to the base of the middle phalanx, where it delivers the extension load of the extrinsic extensor apparatus.

SURGICAL TECHNIQUE

The patient is positioned supine with an above-elbow tourniquet on a radiolucent hand table. The PIP joint is maximally flexed, and an appropriately sized guidewire for the desired headless compression screw is passed retrograde through a percutaneous approach, aiming for the dorsal third of the proximal fragment. Our preference is a 0.8 mm (0.031 in) k-wire for a 2.2 mm screw. Flexion of the PIP joint aids in reduction of the common volar apex deformity noted in proximal phalangeal fractures.

Once an appropriate reduction has been performed, the guidewire is driven retrograde until it engages in the proximal subchondral plate, with positioning confirmed via intraoperative fluoroscopy. Potential screw length is measured at this stage, using a depth gauge. Given that stabilization with antegrade screw insertion is dependent proximally on thread interdigitation with the subchondral plate and distally on isthmic fit, the authors prefer shorter screws to prevent screw penetration and the need for hardware removal; however, screw length should be based on individual fracture characteristics.

The stabilized proximal phalanx is then subluxated dorsally at the MCP joint via dorsal translation pressure applied on the volar surface of that phalanx (Figs.1, 2), and the guidewire is passed through the skin overlying the metacarpal head. The degree of subluxation permitted is a function of the patient’s inherent ligamentous elasticity; when limited subluxation is affordable, a combination of MCP joint flexion to 90° and advancement via oscillation can be used to direct the guidewire dorsal to the metacarpal head.

The guidewire is withdrawn proximally, with a length left proud distally so that it can be easily accessed at either end. A percutaneous incision is made around the guidewire in the skin, and the self-drilling and self-tapping screw is inserted antegrade via an intra-articular

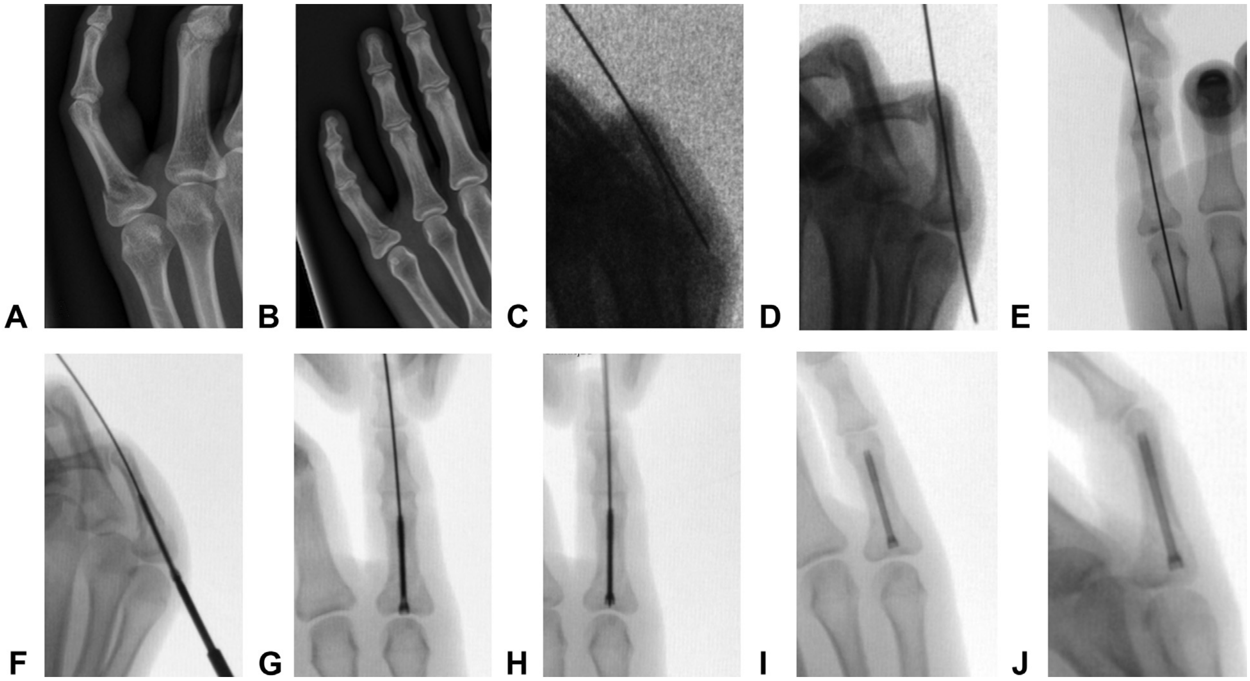

FIGURE 1: Clinical example demonstrating a technique for basal fracture of proximal phalanx. **A** and **B** Preoperative radiographs of fracture, **C** fracture reduction is obtained and guidewire driven in a retrograde fashion through PIP joint into subchondral plate at the base of phalanx, **D** and **E** MCP joint is subluxated and wire is passed and withdrawn proximally, **F** screw is inserted in antegrade fashion, **G** and **H** guidewire withdrawn through PIP joint to allow unobstructed motion of MCP joint and serial radiographs to check insertion, **I** and **J** final intraoperative radiographs.

method, with care taken to maintain fracture reduction. In particular, malrotation is prevented via flexion and alignment of all digits in unison. We use reaming prior to insertion if there is a tight canal on preoperative radiography, or any difficulty in introducing the guidewire or definitive screw past the isthmus.

Repeat orthogonal intraoperative radiographs are taken to ensure adequate screw positioning—the screw should be inserted until just distal to the subchondral plate, with further insertion potentially destabilizing the construct owing to lack of hold in limited and often porotic proximal bone. To easily obtain these radiographs, the guidewire is withdrawn distally until it sits within the cannulated screw, allowing unobstructed manipulation of the MCP joint. The guidewire can then be driven proximal to facilitate adjustment of screw position (Figs.1, 3). The tenodesis mechanism is used to check appropriate rotation and alignment following guidewire removal and prior to skin closure.

POSTOPERATIVE MANAGEMENT

After surgery, the patient is placed in a below-elbow splint in an intrinsic plus position. This is converted to a hand-based thermoplastic splint in the same position within a week, and the patient commences active and gentle passive range of motion with buddy strapping to an adjacent digit under the direction of hand therapists. Following repeat radiographs at the 4-week postoperative mark, the splint can be weaned, with return to full activities in a graded fashion.

ADVANTAGES, PEARLS, AND PITFALLS

Stabilization of proximal phalangeal fractures via intramedullary screw fixation through a minimally invasive approach has demonstrated promising early clinical and radiographic results, although long-term follow-up is needed. A systematic review of the literature found a near-normal pooled total active motion of 248°, and a major complication rate between 3.6% and 6% compared favorably with plating and other techniques.[3] Biomechanical analysis using polyurethane models has also demonstrated greater rigidity and load to failure in intramedullary screw fixation as compared to plating.[8]

The described technique affords a number of advantages when compared with conventional antegrade guidewire insertion. It is technically easier to dorsally subluxate the MCP joint while fracture reduction is held via 2 points of fixation (the guidewire articulating with the proximal and distal subchondral plates), eliminating translation at the

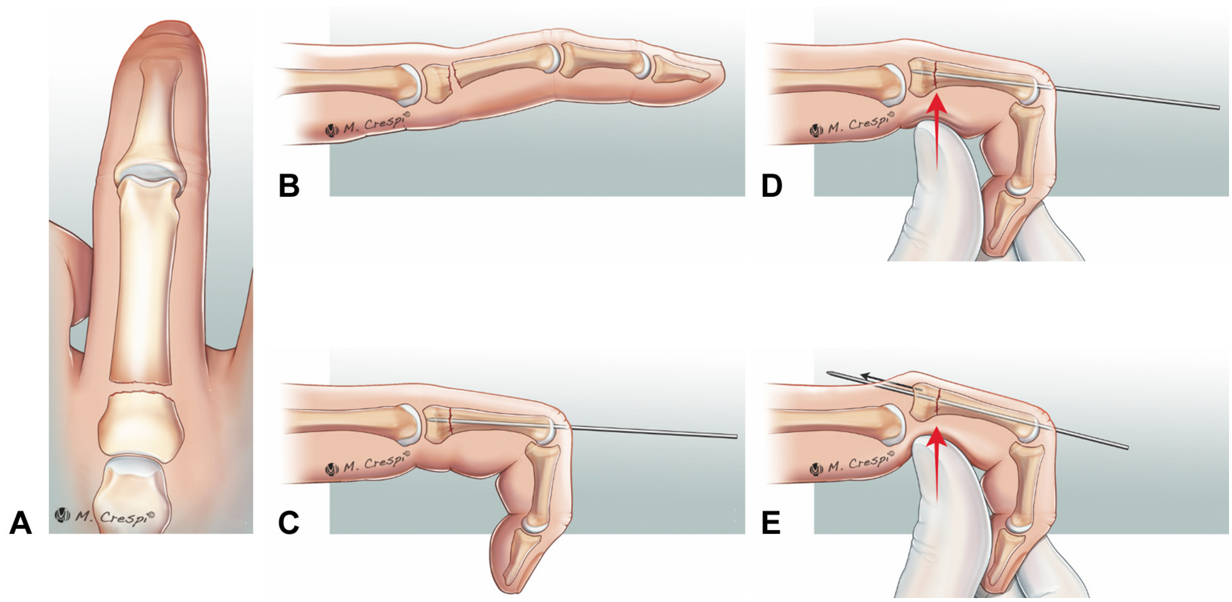

FIGURE 2: Illustrations demonstrating technique. **A** and **B** Preoperative fracture position, **C** guidewire driven retrograde into proximal subchondral plate of proximal phalanx, **D** proximal phalanx dorsally subluxated at MCP joint, **E** guidewire withdrawn proximally.

fracture site. Intra-articular screw insertion obviates the possibility of "kissing lesions" and theoretically reduces the risk of future arthrosis when compared with transarticular screw insertion. Intra-articular insertion with a mobile MCP joint also facilitates easier intraoperative imaging to judge depth of screw insertion. This is of particular relevance when assessing AP radiographs of the phalanx, which can be difficult during transarticular screw insertion owing to the overlapping profile of the metacarpal. Withdrawal of the guidewire through the PIP joint in the described technique allows unobstructed motion at the MCP joint and procurement of satisfactory AP radiographs. This technique can also be used for more distal fractures—antegrade screw insertion in this setting diminishes the relative proportion of articular cartilage affected by instrumenting the comparatively larger proximal articular surface of the phalanx.

Subluxation of the proximal phalanx should only be attempted once the guidewire has breached the proximal subchondral plate of the phalanx, as evidenced on a lateral intraoperative radiograph. Insufficient capture of the proximal fragment prior to subluxation will result in loss of fracture reduction during the maneuver. Although not always possible because of a tight isthmus, a secondary wire can be inserted in a retrograde fashion (aiming volar and lateral to avoid impeding screw insertion) to help maintain reduction during subluxation and instrumentation (Fig. 4).

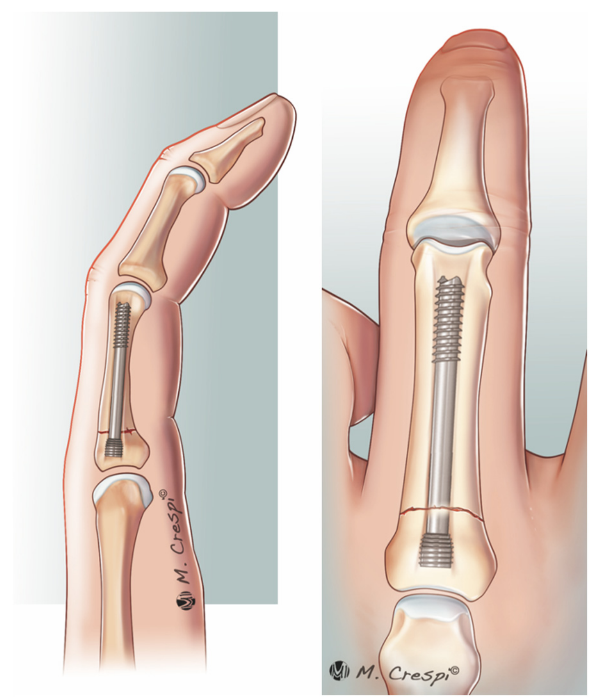

FIGURE 3: Illustration demonstrating final screw position with reduction of proximal phalanx fracture.

COMPLICATIONS

An often raised concern with intramedullary screw fixation of phalanges is that of articular damage. Borbas et al[9] quantified the size of the chondral lesions on cadavers and found a mean defect of 4.6% of the proximal articular surface of the proximal phalanx

FIGURE 4: Secondary wire directed volar and lateral aids in maintenance of reduction during MCP joint subluxation and primary guidewire insertion.

using a 2.2 mm compression screw, rising to 8.5% with the use of a 3.0 mm screw. The authors prefer the use of 2.2 mm headless compression screws at all times. It is envisioned that these defects will reconstitute with fibrocartilage, as seen with chondral loss in other parts of the body.

A lesser concern is osteochondral and extensor apparatus damage during retrograde guidewire insertion. Although not directly assessing the effect of a guidewire, Vegas et al[10] found that retrograde insertion of a 2.8 mm screw resulted in damage to 6.2% of the articular surface on cadaveric digits and that the central slip attachment was not affected, with the lesion in the tendon an average of 2.7 mm in width and 4.9 mm proximal to the insertion onto the middle phalanx. Thus, it is unlikely that a 0.8 mm guidewire will cause considerable damage during instrumentation.

Dependent on the design of the headless compression screw, the conical shape of either part or all of the construct can lead to considerable hoop stresses during insertion, particularly if predrilling is omitted. This may lead to cortical blowout of the proximal articular surface or disruption of previously unrecognized intra-articular fracture extension. Salvage in this setting should include removal of the screw (either by reversing the insertion or, if this proves difficult, disengaging it "through" the fracture via a dorsal approach) and careful radiographic assessment prior to stabilization via repeat percutaneous methods or open plating.

As fracture subsidence and union occur, the screw may become prominent, particularly in juxta-articular fractures, and may require removal.

CASE ILLUSTRATION

Figure 1 demonstrates the technique used in a proximal phalangeal fracture in the little finger of a 24-year-old woman. The patient had a full range of motion at the 6-week postoperative follow-up appointment, with no complications, and had returned to full manual professional and social activities at that point.

CONCLUSION

The technical tip described facilitates easier maintenance of fracture reduction and guidewire insertion when compared with the conventional antegrade method of instrumentation, while avoiding damage to the metacarpal head. It is of greatest use in basal fractures of the proximal phalanx, particularly in marginal or subchondral fractures with limited bone stock for purchase.

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