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CASE REPORTS

Treatment of Symptomatic Distal Interphalangeal Joint Arthritis with Percutaneous Arthrodesis: a Novel Technique in Select Patients

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Abstract Arthrodesis of the distal interphalangeal (DIP) joint is a reliable means of achieving pain relief in a symptomatic DIP joint afflicted by a variety of degenerative, inflammatory, or posttraumatic conditions. Successful arthrodesis is more reproducible when rigid compression of the joint is achieved. The emergence of an increasing number of commercially available headless or variable pitch compression screws reflects the growing trend among hand surgeons to utilize rigid stabilization of the DIP joint so that motion at more proximal levels can be initiated immediately without affecting arthrodesis rates. Successful closed percutaneous DIP arthrodesis can be achieved in a patient with hypertrophic osteoarthropathy, passively correctable deformity, and patients at increased risk for perioperative soft tissue complications associated with open arthrodesis. We present a novel percutaneous DIP fusion technique utilizing a cannulated headless compression screw in a select group of patients. The sagittal plane diameters of the distal and middle phalanges are templated. Cannulated headless compression screws, 2.4 and 3.0 mm, with short or long terminal threads at the leading end of the screw are selected based upon patient-specific anatomic considerations. Pain-free status and radiographic fusion were achieved in both patients (gout arthropathy, $n=1$; posttraumatic arthritis, $n=1$) at an average of 6 weeks postoperatively. Our current indications, along with pearls and pitfalls with this technique, are reviewed. In select patients, this percutaneous DIP joint arthrodesis is advantageous in comparison with open fusion techniques.

Keywords Arthritis · Arthrodesis · Distal interphalangeal joint · Percutaneous hand surgery

Introduction

Solid arthrodesis of the distal interphalangeal joint (DIP) will reliably relieve pain at a DIP joint afflicted by a variety of degenerative and/or inflammatory conditions. Common indications include refractory, symptomatic primary or posttraumatic osteoarthritis, deformity and instability in the setting of rheumatoid and other inflammatory arthritides, sequelae of chronic mallet finger deformity, and salvage for flexor digitorum profundus ruptures/avulsions [12, 14]. Limitations associated with motion- and joint-preserving reconstructive options continue to make DIP arthrodesis an attractive choice in the appropriately selected patient.

A variety of arthrodesis stabilization techniques have been reported in the literature. Following articular surface preparation, fusion constructs may include

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crossed Kirschner (K) wires [20], interosseous wiring [20], tension-band wiring [18], plate and screw fixation [12], and most recently, headless or variable pitch compression screws [5, 6]. As increased rigidity and compression provided by the fusion construct minimizes time to fusion as well as nonunion rates [10, 11], fixation with various compression screws has become increasingly more common. Several groups [2, 6, 7, 17] have reported high rates of fusion (83–100%) with a mean time to clinical union of approximately 8 weeks following traditional open interphalangeal joint arthrodesis with headless compression screws.

Open DIP arthrodesis is not a benign procedure, and several complications have been reported. These include nonunion, superficial and deep infection, tuft tenderness, nail plate deformity, and dorsal skin necrosis [17]. Interest in percutaneous techniques applicable to the hand and wrist continues to increase [13] and is motivated by the desire to minimize surgical dissection around tendons and the potentially unforgiving periarticular soft tissues, especially at the level of the DIP joint. In an attempt to avoid potential complications, the senior author has introduced a novel percutaneous DIP fusion technique utilizing a cannulated headless compression screw in a select group of patients. Our current indications, along with pearls and pitfalls with this technique, are reviewed. In select patients, this technique may be a better option than formal open DIP joint arthrodesis.

Indications

We recommend percutaneous DIP arthrodesis in only select patients. Our indications include the presence of hypertrophic osteoarthropathy, passively correctable DIP deformity, and patients at increased risk for perioperative soft tissue complications associated with open arthrodesis, either due to fragility of the soft tissue envelope or due to general medical comorbidities.

The rationale for performing a closed percutaneous DIP arthrodesis in a patient with a symptomatic degenerative joint with a significant degree of hypertrophic bone formation and a minimal arc of motion is based upon the fact that the provision of rigid stability through mechanical compression to the DIP helps affect formal arthrodesis (i.e., much like promotion of union in a hypertrophic nonunion with the provision of rigid mechanical stability) [3, 13].

Preoperative Planning

The sagittal plane diameter of the distal phalanx is a key consideration when compression screw fixation is contemplated for DIP arthrodesis. This potentially limiting factor exists regardless of whether an open or percutaneous insertion technique is utilized. In a cadaveric study, Wyrsch and colleagues [18] have previously demonstrated that the mean dorsal–palmar diameter of the distal phalanx is 3.55 mm at 4 mm proximal to the distal end. These authors observed dorsal cortical fracture or thread penetration in 83% of specimens in this region. Further, van Zeeland (Van Zeeland, Distal interphalangeal joint fusion: a morphometric and biomechanical analysis. Presented at the 62nd Annual Meeting American Society for Surgery of the Hand, Seattle, WA September 27–29, 2007) documented significant gender-specific differences in the dimensions of the distal phalanx (males, 4.22 mm; females, 3.54 mm) with a greater than 50% incidence of trailing thread penetrance in all three subgroups of headless compressions screws. These morphometric data are significant considerations given the larger diameter trailing threads of the various commercially available compression screws.

Therefore, the importance of preoperative templating cannot be overemphasized with the percutaneous arthrodesis technique. Distal phalanx fracture, dorsal cortical thread penetration, and disruption of the overlying nail bed must be avoided. The dorsal–palmar diameter of the distal phalanx and the narrowest point of the middle phalanx isthmus are recorded. The latter is critical since it is within the isthmus of the middle phalanx that the leading threads of the screw achieve purchase. Final implant selection also accounts for patient gender and size, as well as the digit involved.

We have utilized both 2.4- and 3.0-mm cannulated headless compression screws (Synthes, Paoli, PA, USA) based on preoperative templating. Short or long terminal threads at the leading end of the screw can be selected in this system based upon patient-specific anatomic considerations.

Technique

The patient is positioned supine with the arm placed on a hand table. The entire procedure is carried out under intraoperative fluoroscopic monitoring. A well-padded pneumatic tourniquet is applied to the upper arm, but is inflated only if necessary. The procedure is usually performed under regional or local digital anesthesia. The DIP is examined under anesthesia to confirm that full passive correction of the preoperative coronal, sagittal, and axial plane deformities is obtainable.

Under fluoroscopic control, a 1.1-mm terminally threaded guide wire is inserted through the tuft of the distal phalanx and inserted into the central axis of the distal phalanx in both the coronal and sagittal planes. The guide wire used must be from

the implant tray selected as its diameters vary by system. Passive correction of the joint deformity is then performed and held by the surgical assistant as the guide wire is advanced into the isthmus of the middle phalanx. Placement within the central axis of the middle phalanx is then confirmed under orthogonal fluoroscopy.

Screw length can be determined by placing a screw over the digit and assessing length fluoroscopically, as well as with the use of the cannulated measuring guide. Leading thread length (i.e., short versus long) is selected based upon patient anatomy. Screw length is maximized to optimize compression and intramedullary stabilization. It is critical that there are no screw threads crossing the fusion site in this system.

Although the terminal end of the leading threads contains self-drilling, self-tapping flutes, we recommend opening the distal tuft cortex with the 2.0-mm cannulated drill to facilitate initial screw advancement. Mild transient DIP distraction resolves as the leading threads obtain purchase in the middle phalanx isthmus.

The compression screw is inserted over the guide wire and countersunk 1–2 mm. The compression sleeve construct may also be used to achieve additional compression, as the tip of the compression sleeve acts as a conventional lag screw head. As the screw is advanced, the tip of the compression sleeve engages the cortex of the distal phalanx and the DIP joint space is compressed. Following compression, the compression sleeve is held stationary and the terminal screw head is countersunk within the terminal distal phalanx with the screwdriver. Compression is confirmed on orthogonal fluoroscopic views. All of the leading threads must be seated within the isthmus of the middle phalanx to effect maximal DIP compression. The guide wire is removed. DIP stability and coronal, sagittal, and axial (i.e., rotation) alignment are confirmed. The wound is irrigated and a single suture is sufficient for skin closure. The involved DIP is placed in a small splint initially.

Postoperative Protocol

The DIP is protected with a tip protector splint for 6 weeks. During this interval, proximal interphalangeal (PIP) and metcarpophalangeal (MCP) joint range of motion exercises are initiated. Edema control is initiated within the first postoperative week.

Case 1

A 79-year-old right-hand dominant white male, retired physician, presented with acute tophaceous gout of the left ring finger distal interphalangeal joint (Fig. 1). The initial examination was significant for swelling and erythema involving the distal aspect of the ring finger with proximal

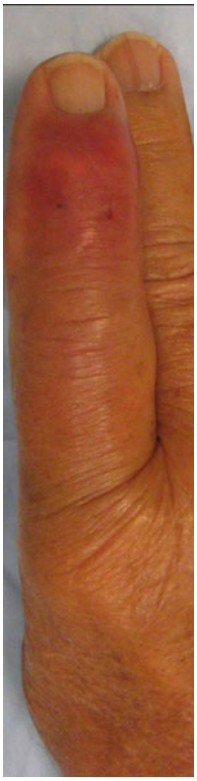

Figure 1 Dorsal distal interphalangeal joint subcutaneous tophus.

extension to the level of the proximal interphalangeal joint. White-colored, chalk-like material was obvious deep to the dorsal subcutaneous fluctuance overlying the DIP joint. Radiographs (Fig. 2) revealed advanced destruction of the DIP articulation with periarticular erosions and secondary hypertrophic osteoarthritic changes. These findings were consistent with gouty arthropathy [8]. The dorsal soft tissue swelling overlying the DIP joint of the ring finger represented the acute fluctuant mass of a gouty tophus. Following aspiration of the tophus, acute care of the fragile soft tissue envelope, and resolution of the acute attack [14, 15], examination demonstrated symptomatic gross instability of the DIP joint. Given the concern for the regional soft tissue envelope, the patient was considered suitable for a percutaneous DIP arthrodesis. Following closed reduction of the DIP subluxation under flouroscopy, a 3.0-mm cannulated headless compression screw (Synthes) with long threads was placed across the DIP joint. The patient was completely pain-free within a few days after surgery, and radiographic examination at 3 months demonstrated a well-aligned complete DIP arthrodesis (Fig. 3). The patient declined any further follow-up.

Case 2

A 27-year-old female previously underwent open reduction and internal fixation of a neglected left small finger mallet

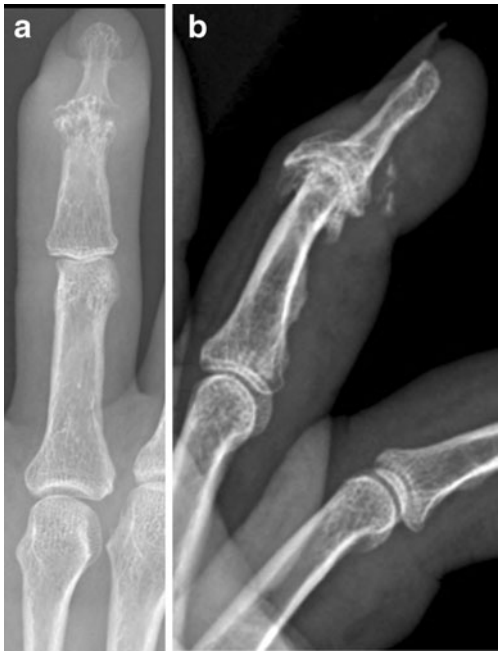

Figure 2 Preoperative radiographs, posteroanterior (**a**) and lateral (**b**), revealed advanced destruction of the left ring finger DIP articulation with periarticular erosions and secondary hypertrophic osteoarthritic changes. These findings are consistent with gouty arthropathy.

fracture dislocation (Fig. 4). She subsequently developed progressive, symptomatic posttraumatic osteoarthritis of the DIP joint (Fig. 5) following an initial excellent outcome. Serial radiographs demonstrated progressive hypertrophic changes with osteophyte formation and partial ankylosis.

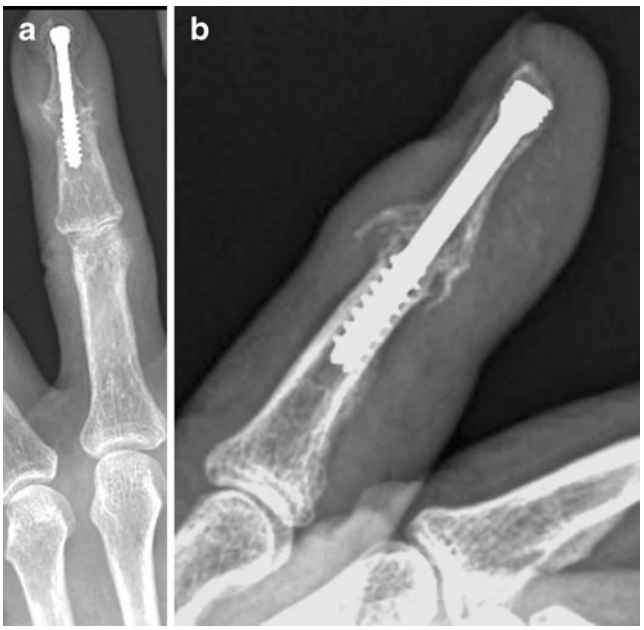

Figure 3 Postoperative radiographs, posteroanterior (**a**) and lateral (**b**), demonstrate a well-aligned, solid DIP arthrodesis.

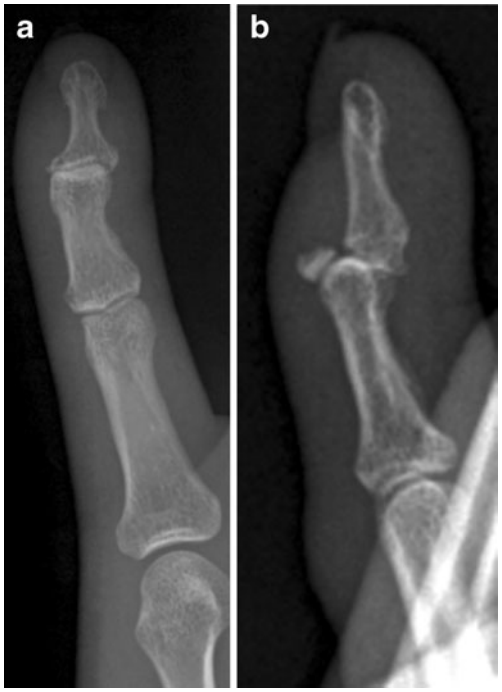

Figure 4 Presenting radiographs, posteroanterior (**a**) and lateral (**b**), of a previously neglected left small finger mallet fracture dislocation.

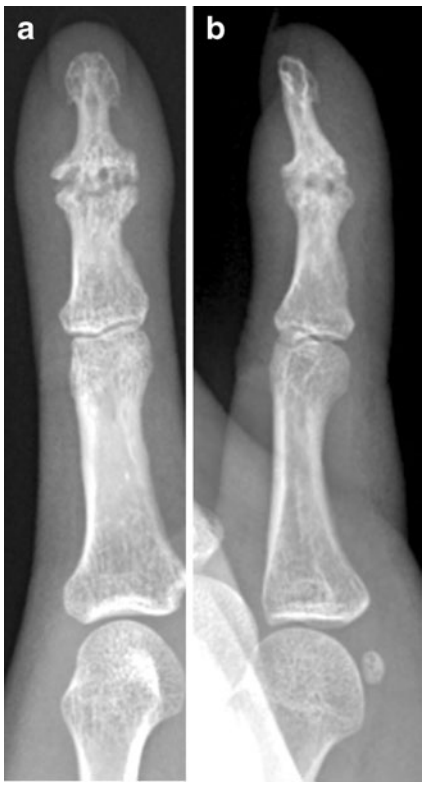

Figure 5 Preoperative radiographs, posteroanterior (**a**) and lateral (**b**), of posttraumatic osteoarthritis involving the left small finger DIP joint following operative fixation of the neglected mallet fracture dislocation. There are progressive hypertrophic changes with osteophyte formation and partial ankylosis.

Percutaneous arthrodesis of left small finger DIP joint was performed with a 2.4-mm cannulated headless compression screw (Synthes). Radiographic fusion was evident 6 weeks after the procedure with complete symptom resolution (Fig. 6).

Discussion

There have been several studies examining the outcomes of small joint arthrodesis utilizing compression screws. Ayers and colleagues achieved a 98% fusion rate using Herbert screws for PIP joint arthrodesis at a mean of 6 weeks postoperatively [1]. Katzman et al. reported similar results for interphalangeal fusions in patients with various underlying etiologies (i.e., rheumatoid arthritis, degenerative arthritis, posttraumatic arthritis, and chronic mallet finger) [9].

Leibovic and Strickland compared different PIP fixation methods and found that the Herbert screw had the lowest rate of nonunion when compared to K wires, tension band, and plates [11]. In contrast, Stern and Fulton [17] analyzed 139 patients who had underwent DIP arthrodesis with various constructs, including Kirschner wires, interfragmentary wire and longitudinal Kirschner wire, or Herbert screw fixation. The nonunion rate found was 11–12% independent of fixation used. Brutus and colleagues [2] reported an 85% union rate, which corresponds to the experience of Stern and Fulton [17]. In a cadaveric biomechanical model of DIP joint arthrodesis [18], Herbert screw fixation was found to have increased anteroposterior bending strength and superior axial plane torsional rigidity when compared to tension band wiring constructs. However, there were no significant differences in lateral bending strength between the groups. These authors concluded that the superior biomechanical properties of the Herbert screw are of clinical significance for small joint arthrodesis [18].

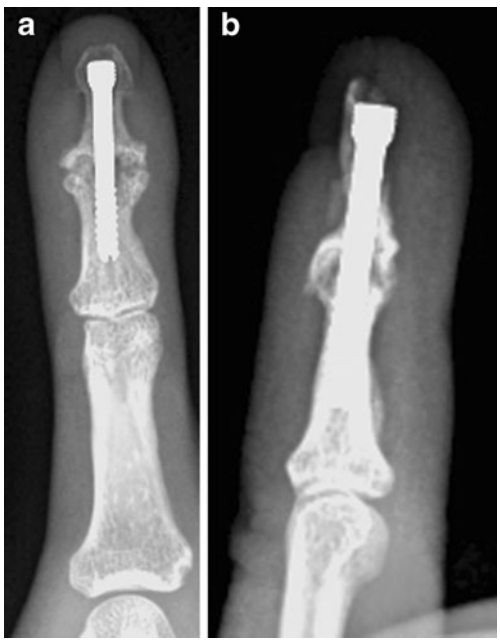

Figure 6 Postoperative radiographs, posteroanterior (**a**) and lateral (**b**), confirmed radiographic fusion at 6 weeks postoperatively. There is mild volar resorption around the terminal tuft and trailing threads of the headless screw. This radiographic finding was asymptomatic, had no impact on clinical or functional outcome, and did not necessitate screw removal.

Formal open DIP joint arthrodesis is most often performed through a Y- or H-shaped dorsal incision. Skin flap necrosis is an especially challenging complication and has been reported in 15% of patients fused with the Herbert screw [17]. The vascularity of the DIP region remains a concern. The dorsal skin of the hand is supplied by distal cutaneous branches of the dorsal metacarpal artery that perforate the fascia as they progress distally [4], as well as the dorsal cutaneous branch of the palmar digital artery [19]. Anatomical studies of the DIP joint utilizing MRI imaging have revealed minimal fat in the area of the DIP joint and a dorsal septum that adheres the skin to the extensor tendon at the level of DIP joint [16]. Laterally, the dorsal septum blends with the joint capsule and collateral ligament complex to form a dense fibrous network at the DIP joint which limits the mobility of the skin. Therefore, a major advantage of this percutaneous technique is its use in the patient with a compromised soft tissue envelope who is at increased risk of perioperative soft tissue complications (i.e., inflammatory arthritides such as rheumatoid arthritis and tophaceous gout arthropathy, the immunocompromised patient, and prior open DIP trauma).

We advocate percutaneous DIP arthrodesis only in select patients as outlined above. Percutaneous DIP arthrodesis should only be performed if the desired fusion angle is ≤10° of flexion. As the desired sagittal plane correction increases, it is technically difficult to achieve isthmal purchase in the middle phalanx with the leading threads of the compression screw. Other patient-specific contraindications include insufficient bone stock which may not allow adequate screw placement or purchase or both. Finally, correction of a rigid, multiplanar DIP deformity should not be addressed with this percutaneous technique.

Disclosure Statement The authors declare that they have no conflict of interest in connection to this study.

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