The treatment of complex fractures and fracture dislocations of the hand

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Abstract

Most fractures of the phalanges or metacarpals are amenable to closed treatment, with favorable outcomes. However, two groups of complex fractures are difficult to diagnose and treat. The first group includes unicondylar and bicondylar fractures, fracture dislocations, and fracture-related instability of the proximal interphalangeal joint. Fracture dislocations can be treated with splinting or surgical intervention. Microscrews and condylar plates have added considerably to the ability to securely fix small articular fractures and fracture dislocations about the proximal interphalangeal joint. Some unstable fracture dislocations are characterized by loss of the volar aspect of the articular surface of the base of the middle phalanx; they can be treated using a sculpted osseous articular graft from the dorsal hamate. The second group includes displaced diaphyseal fractures associated with a soft-tissue injury, instability, or multiple fracturing. Articular fractures and fracture dislocations at the base of the metacarpal also can be difficult to diagnose and treat.

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Introduction

Intra-articular fractures and fracture dislocations of the proximal interphalangeal joint and metacarpal fractures and fracture dislocations are two groups of complex fractures that can be difficult to treat. The treatment options include splinting, surgery, and plate–screw fixation.

Intra-articular fractures and fracture dislocations of the proximal interphalangeal joint

Unicondylar fractures

Weiss and Hastings [1] identified four types of intra-articular unicondylar fractures of the distal aspect of the proximal phalanx [2] (Fig. 1). Type I, the most common, is an oblique palmar fracture caused by a rotatory and lateral deviation force to the proximal interphalangeal (PIP) joint, which creates a short oblique fracture in both the sagittal and frontal planes. Type II is a long fracture in the sagittal plane caused by an isolated, laterally applied force to the PIP joint. The mechanism of type I and type II unicondylar fractures is shown in Fig. 2. Type III, a dorsal osteochondral fracture, and type IV, a palmar osteochondral fracture, are much less common.

A nondisplaced fracture or a fracture that is displaced by less than 1 mm is treated with splint immobilization and close observation. These fractures are inherently unstable and can become significantly displaced; Hastings and Carroll [3] found that five of seven nondisplaced unicondylar fractures treated with immobilization became displaced and required surgical treatment. A type I fracture is particularly susceptible to displacement, and therefore percutaneous Kirschner wire fixation is recommended. The use of two small Kirschner wires is preferred to the use of a single larger wire. Active range-of-motion exercises are initiated by 3 weeks, with passive motion by 6 weeks.

An irreducible type I fracture should be treated with open reduction and internal fixation using 1.0-mm or 1.3-mm screws. Dorsolateral surgical exposure is used. The extensor mechanism should not be disrupted; instead, it should be retracted to facilitate a dorsal PIP capsulotomy for joint surface inspection. The optimal screw fixation is distal and deep to the appropriate collateral ligament. The screw is directed toward the opposite side of the phalanx so it will exit proximal to the opposite collateral ligament (Fig. 3). Additional screws are required for fixation of a large type I or long type II unicondylar fracture (Fig. 4).

A very small type III fracture fragment should be excised. A type IV fracture requires surgical fixation with a small Kirschner wire or screw. Weiss and Hastings [1] reviewed 38 unicondylar fractures treated surgically. At an average 3-year follow-up, the average joint extension was 14° and flexion was 86°. Patients with a type IV fracture had the poorest outcome.

Bicondylar fractures

Fractures involving both condyles of the head of the proximal phalanx are classified as T condylar, Y condylar, or lambda on the basis of their orientation. A nondisplaced fracture is treated nonsurgically. A displaced fracture requires open reduction and stable internal fixation with miniscrews, either alone or in combination with a small plate (Fig. 5). The fracture is best exposed

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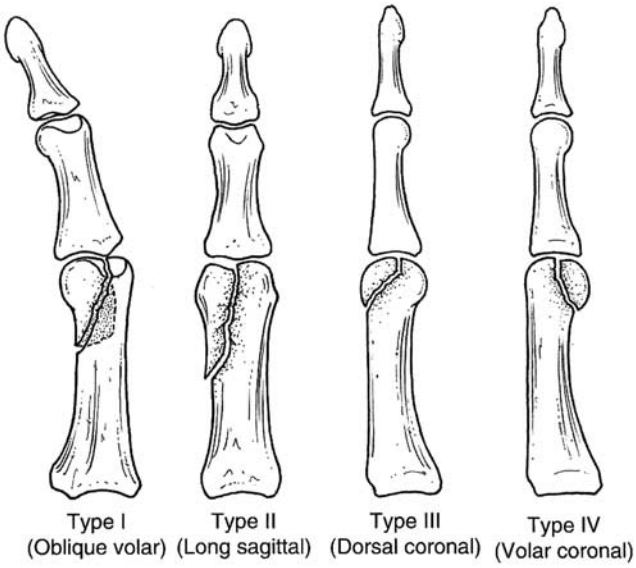
Figure 1



Schematic diagram of the Weiss and Hastings classification of unicondylar fractures of the proximal interphalangeal joint. Copyright Gary Schnitz, Indiana Hand Center.

using a central tendon-splitting approach. An open fracture with a larger, more unstable fracture fragment especially can benefit from the addition of plate fixation (Fig. 6).

A stable fixation permits active rehabilitation.

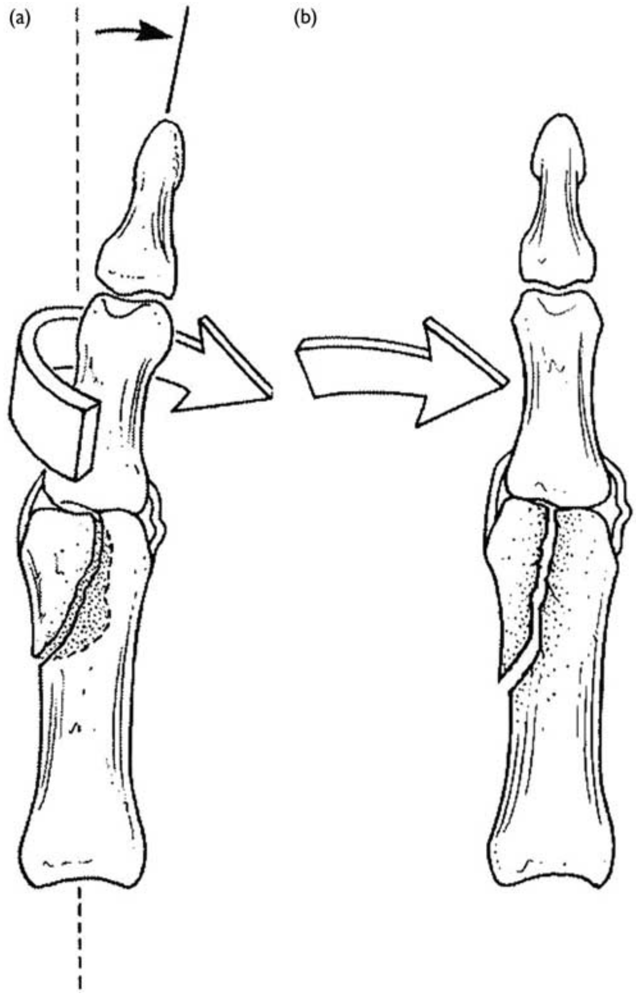
Fracture dislocations

PIP fracture dislocations were classified by Hastings [4] on the basis of the articular involvement of the volar base of the middle phalanx (Fig. 7). Injuries with less than 30% involvement are generally stable, with joint congruity through the full range of motion. If the fracture fragment involves 30–50% of the palmar articular base of the middle phalanx, the joint stability is less predictable and more tenuous, even if it is possible to manually reduce the joint with less than 30° of flexion. An unstable fracture dislocation involves more than 50% of the palmar articular surface, and more than 30° of flexion is required to maintain joint congruity.

As described by McElfresh *et al.* [5], the outcome of a PIP fracture dislocation treated with closed reduction and splint or cast immobilization depends on the accuracy of the joint reduction (Fig. 8). The concavity of the articular base of the middle phalanx, as seen on a lateral radiograph, must match the convexity of the head of the proximal phalanx. A relative widening of the dorsal aspect of the joint (the so-called V sign) suggests residual dorsal subluxation.

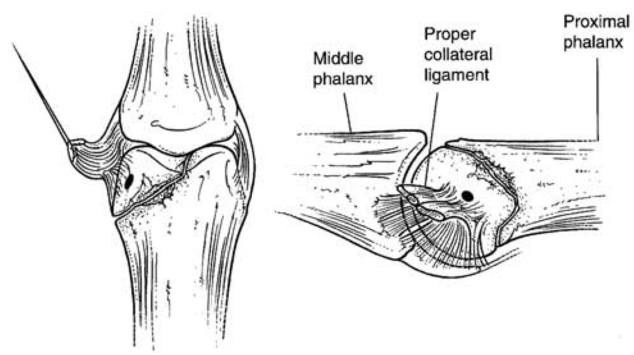
An unstable PIP fracture dislocation can be treated by closed reduction and percutaneous Kirschner wire fixation, static or dynamic traction (Fig. 9), open reduction and internal fixation (Fig. 10), palmar plate arthroplasty (Fig. 11), or, for late treatment, osteotomy. The least invasive method should be attempted. Palmar plate arthroplasty described by Eaton and Malerich [6] has

Figure 2



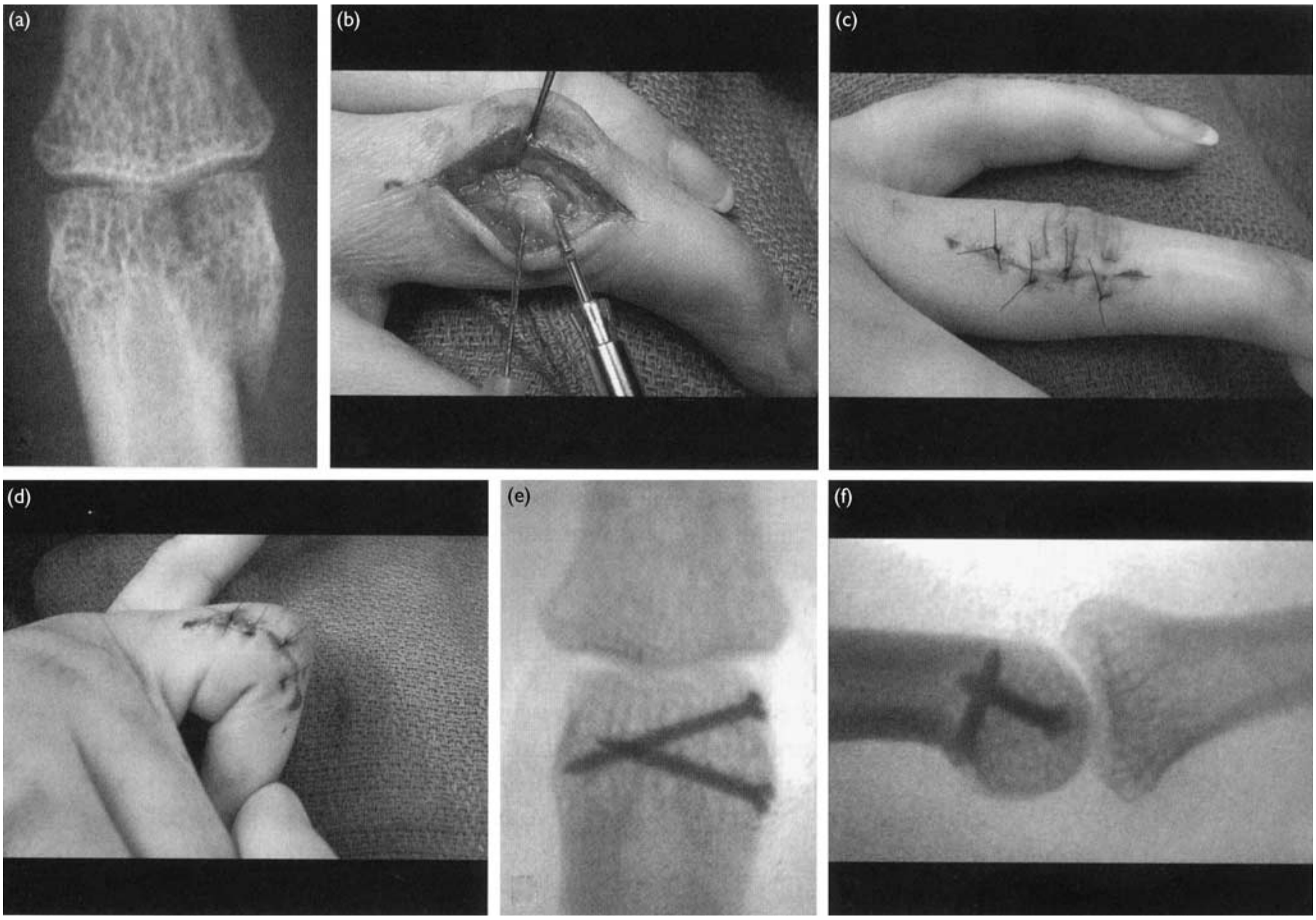
Schematic diagrams showing the mechanism of type I and type II unicondylar fractures. Lateral force is applied to the middle phalanx, with rotation in type I (a) and without rotation in type II (b). Copyright Gary Schnitz, Indiana Hand Center.

Figure 3



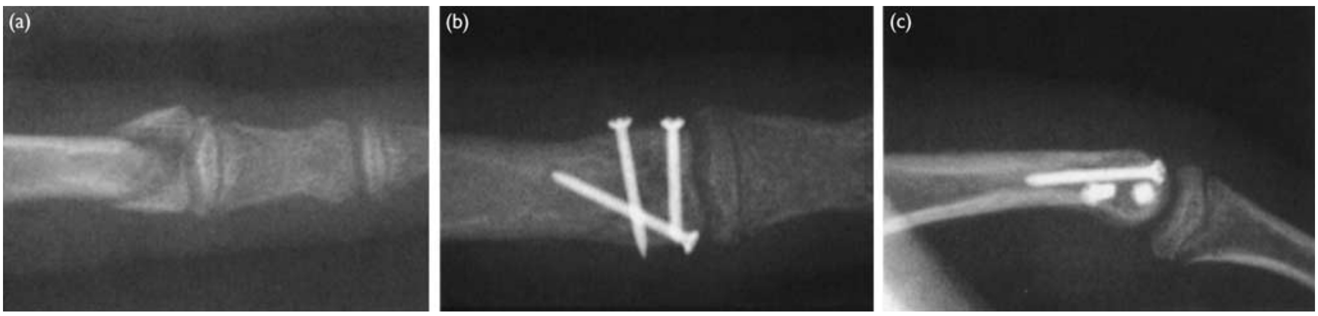
Schematic diagram showing proximal interphalangeal joint flexion, which allows drilling and subsequent screw placement proximal to the proper collateral ligament and through the more palmar aspect of the fracture fragment. Black oval = entry site for screw placement. Copyright Gary Schnitz, Indiana Hand Center.

Figure 4



(a) Anteroposterior radiograph showing a large type I unicondylar fracture. (b) Intraoperative photograph showing the placement of microscrews distal and proximal to the collateral ligament. (c) Photograph showing the incision and joint extension after fracture fixation. (d) Photograph showing joint flexion after internal fixation. Postoperative anteroposterior (e) and lateral (f) radiographs.

Figure 5



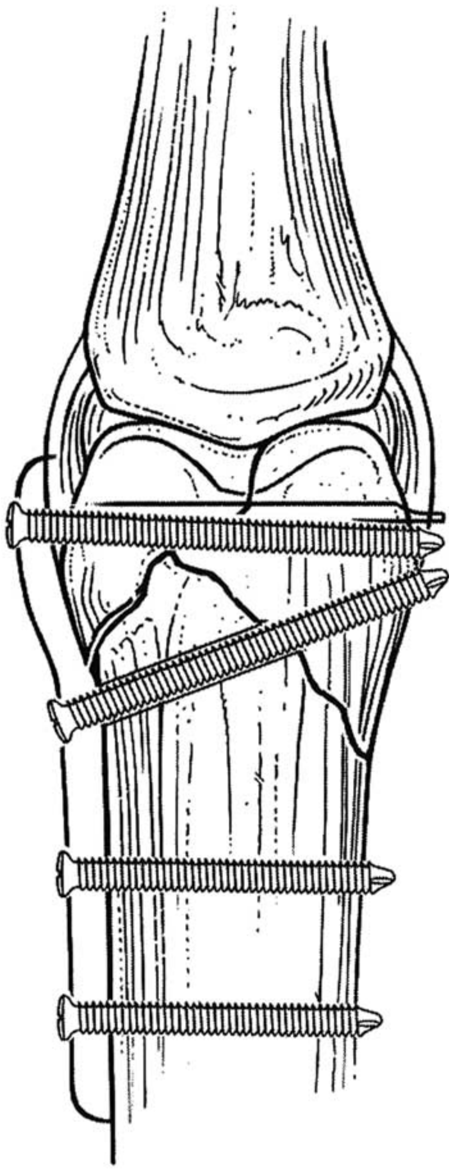
(a) Anteroposterior radiograph showing a T-condylar fracture. Anteroposterior (b) and lateral (c) radiographs showing fixation with 1.0-mm screws.

a predictable result if the fracture fragment is less than 30% of the articular surface of the base of the middle phalanx. Several investigators have reported that dynamic external fixation is a reliable, minimally invasive method of treating a very unstable PIP fracture dislocation [7,8]. Hastings and Ernst [7] noted that the PIP joint has a relatively unifocal axis of motion, which allows a dynamic hinged fixator to provide stability while permitting motion (Fig. 12). The application of a dynamic external fixator is especially useful in a pilon fracture dislocation, which is characterized by comminution of the dorsal, palmar, and central portions of the articular base of the middle phalanx (Fig. 13).

Several methods have been suggested for reconstructing the palmar aspect of the base of the middle phalanx.

If the articular impaction is less than 2 mm, the thickness of the palmar plate interposed into the joint may establish stability. For an established malunion of the palmar base of the middle phalanx, osteotomy and elevation of the depressed fragment along with a supporting bone graft has been successful [9].

Figure 6



Schematic diagram showing condylar plate fixation of a T-condylar fracture. Copyright Gary Schnitz, Indiana Hand Center.

A segment of the dorsal aspect of the ipsilateral hamate has been used to replace a deficient palmar articular buttress. Anatomic studies by Capo *et al.* [10] found that the hamate has a central ridge and a bicondylar facet with articular contours similar to those of the base of the middle phalanx (Fig. 14). Removing a central portion of the hamate was found not to induce dislocation or create carpometacarpal joint instability. This hemihamate resurfacing arthroplasty has been clinically studied by several researchers [4,10–12]. Capo *et al.* [10] found that the hemihamate graft had united in all 10 studied fractures at an average 33-month follow-up; the average PIP extension lag was 27°, and the average flexion was 91° (Fig. 15). Williams *et al.* [11] found an average arc of 85° of PIP motion in 13 patients.

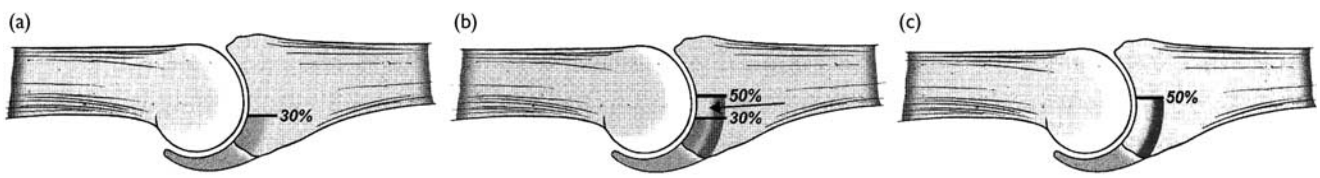
Metacarpal fractures and fracture dislocations

Most metacarpal fractures are amenable to treatment without surgery. However, surgical intervention is required if any of the following is present: unacceptable alignment after a closed reduction (defined as angulation of more than 10° of the deformity of the second or third metacarpal), causing an overlap of digits or shortening of more than 5 mm; a multiple metacarpal fracture; an open fracture; complex upper extremity trauma; or neurovascular or tendon injury [13,14].

Diaphyseal fractures

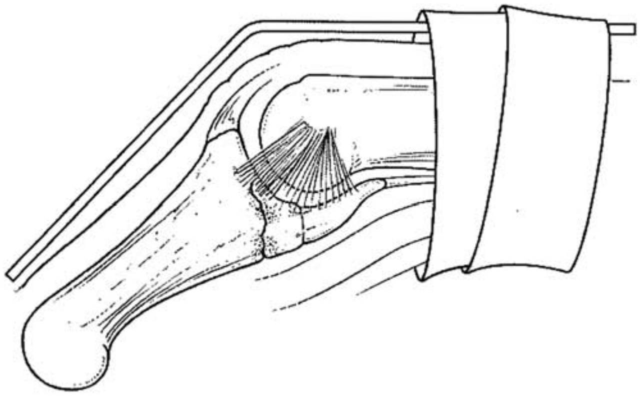
The treatment of a metacarpal shaft fracture depends on the fracture pattern. Percutaneous Kirschner wire fixation (intramedullary or into the adjacent metacarpals), open reduction and internal fixation, or external skeletal fixation can be used if surgical treatment is necessary [15–17]. Intramedullary percutaneous wire fixation is best used for a displaced transverse fracture. The wire can be introduced antegrade through the base or head of the involved metacarpal for a stable fixation. Supplemental splinting is required to achieve rotational control. To enhance rotational stability, the so-called bouquet technique is used, in which multiple pins are placed antegrade through the proximal flare and the pins diverge

Figure 7



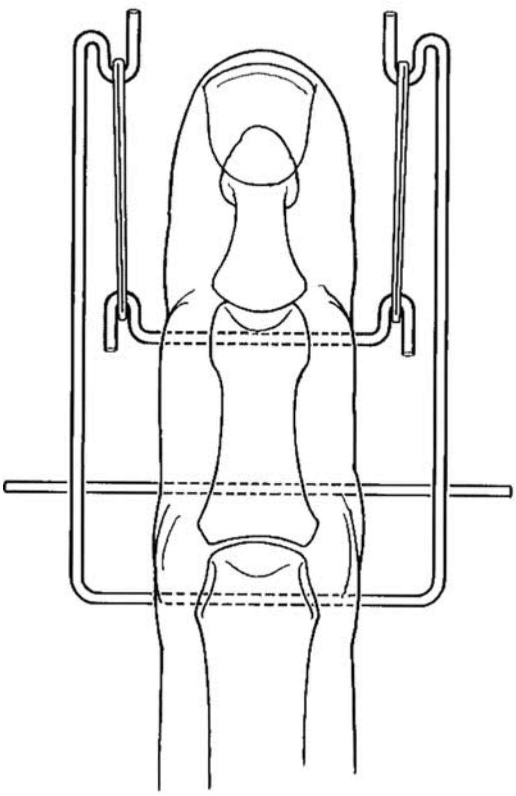
Schematic diagrams showing the Kiefhaber modification of the Hastings classification of proximal interphalangeal fracture dislocations. (a) A stable fracture dislocation involving less than 30% of the joint. (b) A tenuously stable fracture involving 30%–50% of the joint (arrow). (c) An unstable fracture involving more than 50% of the joint. Copyright Gary Schnitz, Indiana Hand Center.

Figure 8



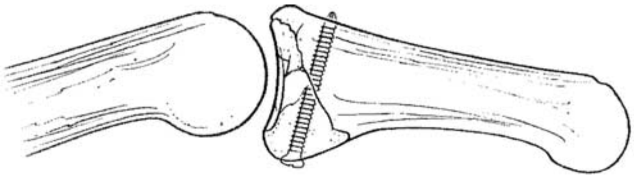
Schematic diagram showing dorsal block splinting of a stable or tenuously stable proximal interphalangeal fracture dislocation. The splint should include the metacarpophalangeal joint in slight flexion and the wrist in slight extension. Copyright Gary Schnitz, Indiana Hand Center.

Figure 9



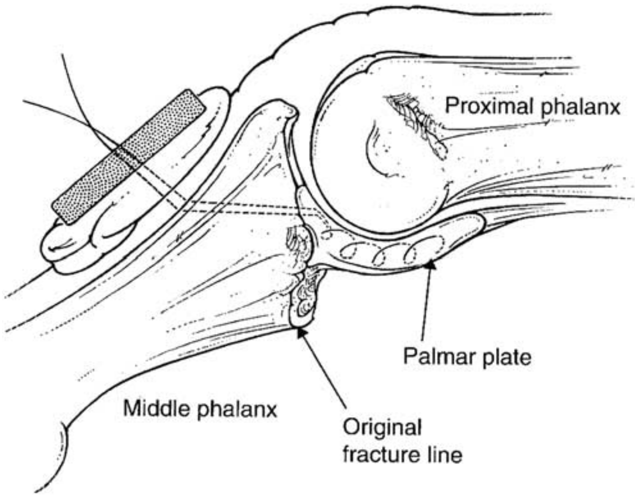
Schematic diagram showing dynamic traction for a fracture of the articular base of the middle phalanx using a Suzuki traction device. Copyright Gary Schnitz, Indiana Hand Center.

Figure 10



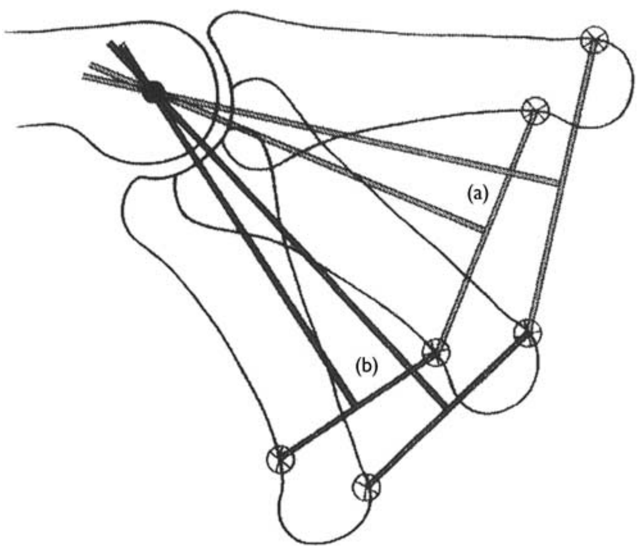
Schematic diagram showing screw fixation of a fracture dislocation of the articular base of the middle phalanx. Copyright Gary Schnitz, Indiana Hand Center.

Figure 11



Schematic diagram showing a palmar plate interposition arthroplasty with button-and-suture fixation. Copyright Gary Schnitz, Indiana Hand Center.

Figure 12



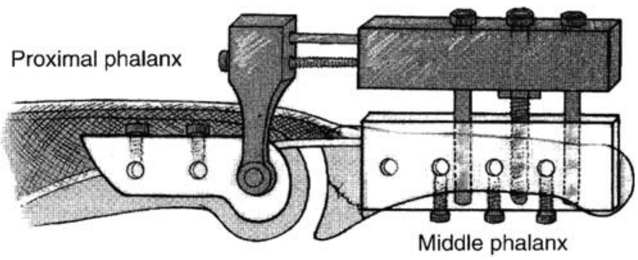
Schematic diagram showing an analysis of the instant center of motion of the proximal interphalangeal joint, which was found to have a relatively fixed axis in flexion (a) and extension (b). Copyright Gary Schnitz, Indiana Hand Center.

in the metacarpal head [18]. Transverse wire placement into an adjacent intact metacarpal is best used for a displaced fracture of the second or fifth metacarpal [19].

Interfragmentary screws can be used alone for stable internal fixation of a long oblique or spiral fracture. The ideal fracture length for achieving stability with interfragmentary screws alone is at least twice the diameter of the bone; the screws must lie perpendicular to the fracture plane to minimize instability from shear forces. The surgical exposure must disrupt as little of the soft-tissue attachment as possible to preserve the vascularity of the bone (Fig. 16).

Plate and screw fixation is best used for stable internal fixation of a transverse or short oblique fracture, especially if it is associated with soft-tissue trauma or multiple metacarpal fractures (Fig. 17). Straight linear incisions minimize the risk of venous and lymphatic injuries and provide extensile exposures. To expand the exposures, the extensor tendons are retracted or the juncturae tendineae are cut. At the completion of internal fixation, the surgeon must ensure that the digital cascade is normal and no rotatory deformity exists.

Figure 13



Schematic diagram showing dynamic external fixation of a pilon comminuted fracture dislocation involving the entire base of the middle phalanx. Copyright Gary Schnitz, Indiana Hand Center.

Metacarpal base fractures

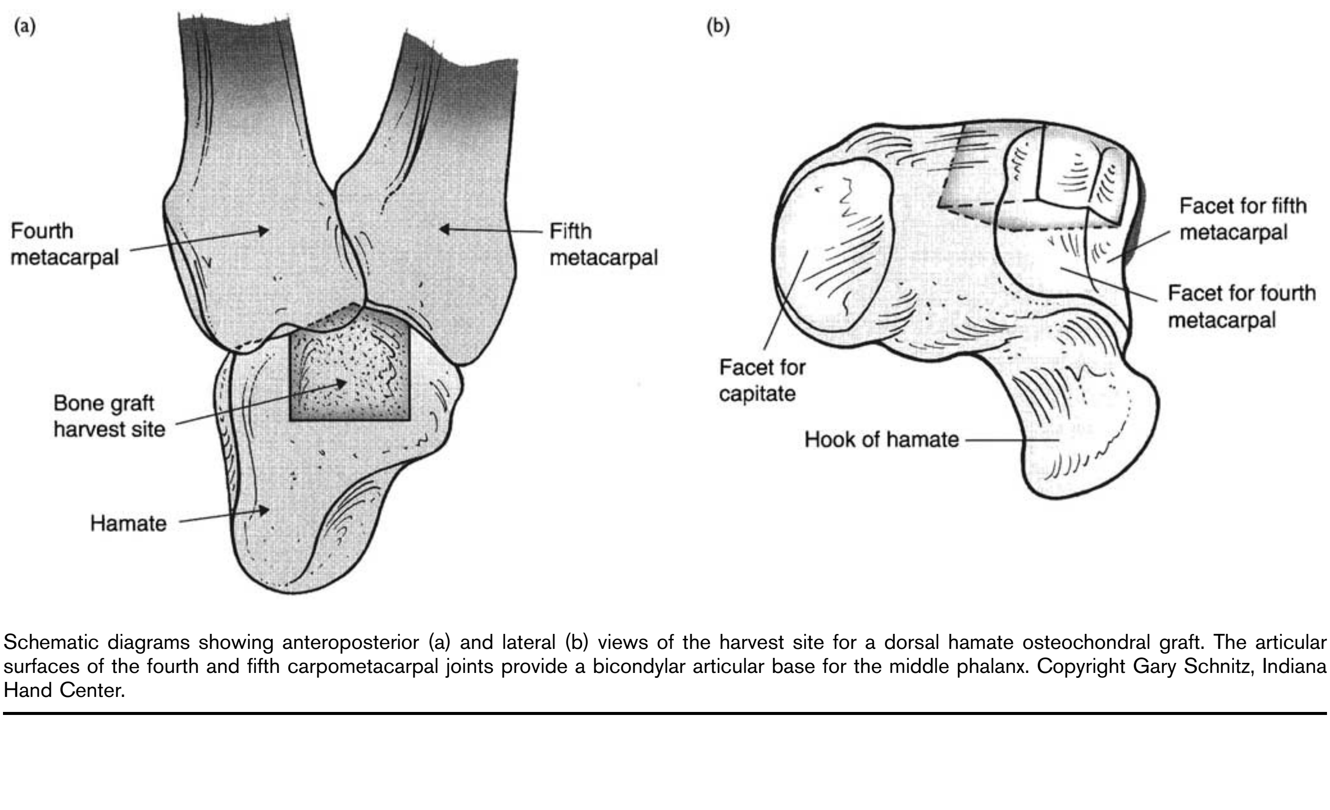
Fractures at the base of the metacarpal can be complicated by soft-tissue injury, intra-articular fracture dislocation, or limited cortical integrity. CT scans may be required to identify the injury. An intra-articular fracture at the base of the fifth metacarpal is especially difficult to treat; it sometimes is considered a reverse Bennett fracture (see chapter 29 for a description of the Bennett fracture). The fracture may be unstable because of the deforming force of the extensor carpi ulnaris, which inserts at the base of the metacarpal. A displaced, impacted, or comminuted fracture requires realignment and stabilization with percutaneous Kirschner wires or open reduction and direct realignment of the articular surface (Fig. 18).

A fracture dislocation extending beyond the fifth metacarpal base may be difficult to identify on standard anteroposterior and lateral radiographs. A pronated 30° lateral view may provide some evidence of displacement at the metacarpal base because in all views the dorsal cortex of the metacarpal base must be collinear with the distal carpal bones. CT scanning often is optimal for appreciating the displacement and any articular incongruity. The injury may be the result of a high-energy trauma with associated soft-tissue swelling, and cast immobilization after a closed reduction may not provide sufficient support. Stabilization with percutaneous Kirschner wires is preferable, in conjunction with cast immobilization.

Conclusion

Advances in the understanding of PIP fractures and fracture dislocations have led to improved outcomes after

Figure 14

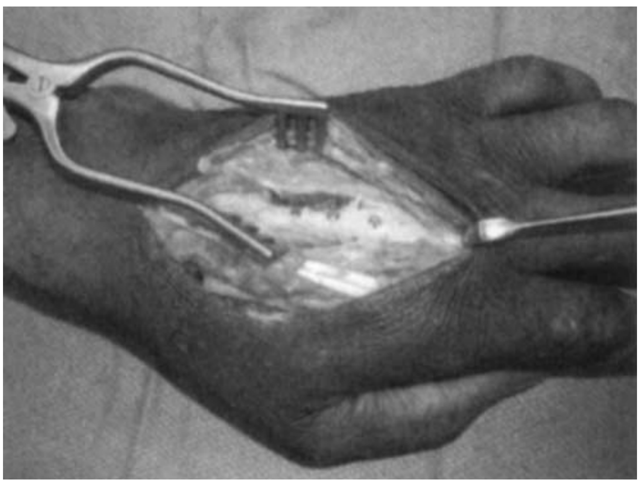


Schematic diagrams showing anteroposterior (a) and lateral (b) views of the harvest site for a dorsal hamate osteochondral graft. The articular surfaces of the fourth and fifth carpometacarpal joints provide a bicondylar articular base for the middle phalanx. Copyright Gary Schnitz, Indiana Hand Center.

Figure 15

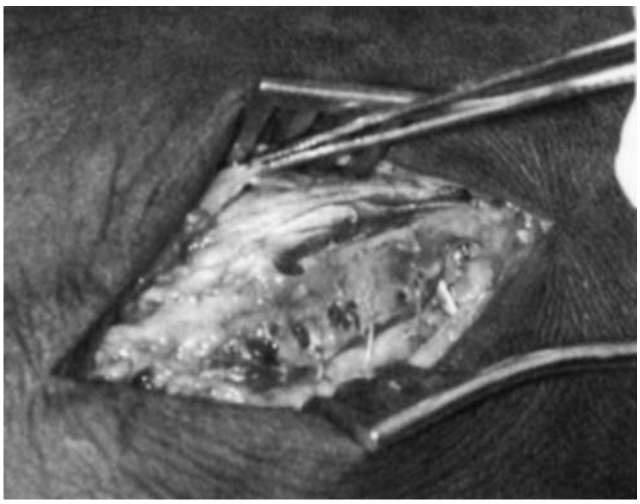
A hemihamate replacement 5 weeks after arthroplasty. Lateral radiographs show extension (a) and flexion (b). Clinical photographs show joint extension (c) and flexion (d).

Figure 16



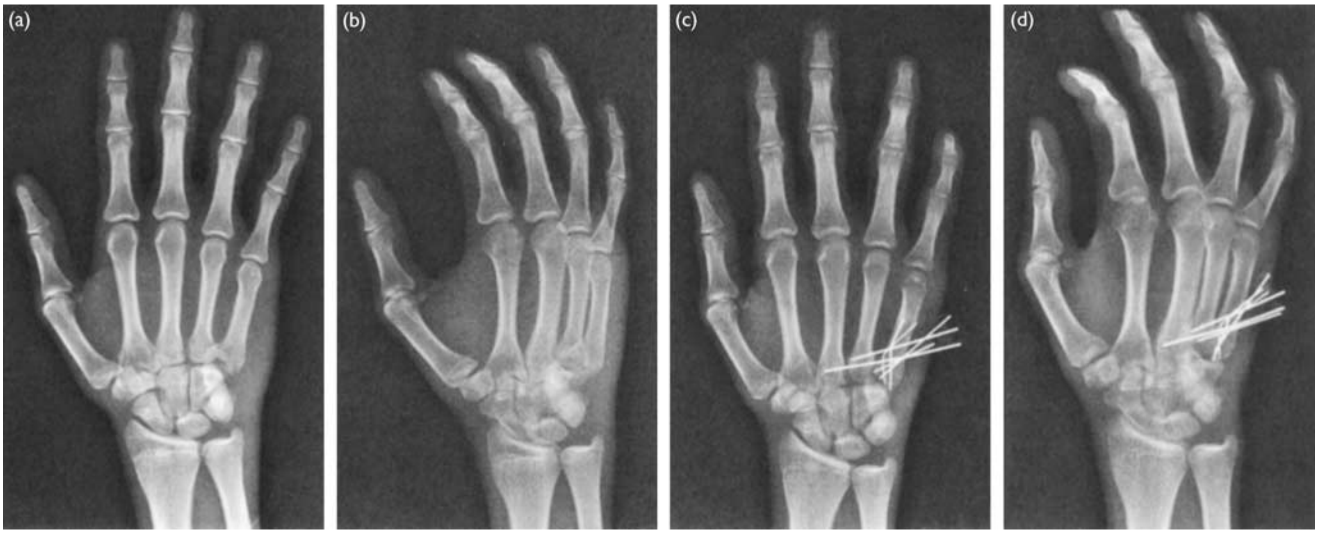
Clinical photograph showing a long oblique fracture of the third metacarpal. The fracture length is approximately three times the bone diameter. The fracture has been fixed with one 1.3-mm and two 1.5-mm screws.

Figure 17



Clinical photograph of a displaced transverse metacarpal fracture, showing the periosteum and interosseous muscle fascia closed over a titanium blade plate. Most of the plate was covered to provide a soft-tissue layer for optimal tendon gliding.

Figure 18



(a) Anteroposterior radiograph showing a comminuted intra-articular fracture of the base of the fifth metacarpal. (b) A 30° pronation-view radiograph showing subluxation of the metacarpal shaft. (c) Postsurgical anteroposterior radiograph showing an anatomic reduction of the articular fracture with Kirschner wires. (d) Oblique radiograph showing reduction of the metacarpal shaft, with the dorsal cortex of the fifth metacarpal aligned with the dorsal cortex of the hamate.

treatment. The PIP joint requires a palmar buttress for overall stability. Instability is common in a fracture of the palmar base of the middle phalanx that exceeds 40% of the articular surface; a percutaneous method, traction, or open reduction is used. Late treatment may require articular reconstruction using a graft from the hamate.

A displaced metacarpal fracture or fracture dislocation can result in a loss of digital motion, malalignment, or a complication related to surgical intervention. Whenever possible, a percutaneous method of stabilization should be used to avoid trauma to the soft tissue during open reduction or irritation of overlying extensor tendons during internal fixation.

Acknowledgements

Conflicts of interest

Dr Jupiter or an immediate family member serves as an unpaid consultant to Synthes; has received research or institutional support from Aircast-DJ Orthopaedics, Biomet, Hand Innovations, Linvatec, Mitek, SBI, Synthes, Wright Medical Technology, and Zimmer; and has received nonincome support (such as equipment or services), commercially derived honoraria, or other nonresearch-related funding (such as paid travel) from Saunders–Mosby–Elsevier and Wolters Kluwer Health–Lippincott Williams & Wilkins. Dr Hastings or an immediate family member serves as a board member, owner, officer, or committee member of the Indiana Hand Center and has received royalties from Biomet. Dr Capo or an immediate family member has received royalties from Wright Medical Technology; serves as a paid consultant to or is an employee of Wright Medical Technology; and has received research or institutional support from Synthes.

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