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Simple Hand Fractures That Aren't

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Growing up, a favorite television show was *My Favorite Martian*. Ray Walston was a marooned Martian whose antennae would emerge from his skull when he was faced with a difficult situation. Fracture care is similar. Most of what we treat is commonplace and is managed easily; however, there are subsets of common fractures that behave badly. For these injuries, we need to raise our antennae and explain to our patients that the care may be more involved and the outcome less predictable. In this article, the authors consider four injuries: the mallet fracture with a compensatory swan neck deformity, pilon fractures at the base of the middle phalanx, oblique shaft fractures of the proximal phalanx, and transverse midshaft fractures of the metacarpal.

Mallet fracture with compensatory swan neck deformity

An axial load to the tip of the finger that drives the distal phalanx into flexion may result in an avulsion of the extensor tendon along with the dorsal lip of the distal phalanx. The tendon retracts proximally, creating an increased extension moment at the proximal interphalangeal joint (PIP). A person who has a normally lax PIP joint is more prone to develop hyperextension at the PIP joint in concert with the flexed distal interphalangeal (DIP) joint (Figs. 1 and 2). This is described as a "compensatory" swan neck deformity.

Splinting the DIP joint in extension will typically be inadequate to treat the combined mallet injury with compensatory swan neck deformity. It is important to address the PIP hyperextension at the same time, whether operatively or nonoperatively. The authors have had success using a splint that blocks PIP extension beyond 30° while holding the DIP joint extended (Figs. 3 and 4). The splint is worn full-time for 6 weeks. Over the ensuing 6 weeks, the splint is worn during heavy use of the hand and at night.

It is rare that this treatment results in a normal posture of the finger. Patients will be disappointed unless they have been forewarned [1]. Fortunately, a mild residual swan neck deformity usually does not interfere with use of the hand [1,2]; however, a persistent swan neck deformity will affect hand function if the hyperextension deformity is severe enough to force the lateral bands to snap over the condyles of the head of the proximal phalanx during PIP flexion.

Tenotomy of the central slip has been used to treat chronic mallet injuries with and without compensatory swan neck deformity. Grundberg and Reagan [3] reported an average DIP lag of 9° at greater than 2 years, but had 6 of 20 patients who had a residual DIP lag of 20° or more. The authors have no personal experience with the central tenotomy technique for mallet deformities with combined swan neck deformity.

The authors prefer correction of the swan neck deformity using the technique of spiral oblique retinacular ligament (SORL) reconstruction [4]. The spiral oblique ligament is an inconsistent structure that runs from the flexor sheath obliquely, crossing the PIP joint to join the fibers of the lateral bands at the terminal extensor tendon (Fig. 5). This structure is most consistently found on the ulnar side of the ring finger [5]. With PIP joint extension, the SORL tightens and helps effect extension of the DIP joint. Suturing a free palmaris longus graft to the terminal tendon and then passing the graft between the flexor

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Fig. 1. Side view of finger with swan neck deformity.

Fig. 3. Side view of finger with splint holding DIP joint in extension. The splint blocks extension of the PIP joint beyond 30°, but allows PIP flexion.

tendon and the palmar plate of the PIP joint accomplishes reconstruction of the SORL. If the native terminal tendon is intact or has healed to the distal phalanx, one of the lateral bands can be harvested, transected just distal to the MP joint, and then transferred beneath the PIP joint and fixed to the opposite side of the proximal phalanx.

The graft is tensioned with the PIP joint in 20° of flexion and the DIP joint extended. The proximal end of the tendon graft is fixed to the diaphysis of the proximal phalanx with either two suture-anchors or into a bone tunnel. When using a bone tunnel, the graft is secured with a pull-out suture that exits the opposite side of the finger and is tied over a button (Figs. 6–10).

The finger is splinted for 2 weeks with the PIP joint in 20° of flexion and the DIP joint extended. A splint is then created that holds the DIP joint extended and blocks PIP extension beyond 20°, but allows PIP flexion. This is worn for 4 weeks. The DIP joint is splinted in extension for an additional 6 weeks at night and during vigorous daytime activities. The procedure typically corrects the hyperextension of the PIP joint; however, there is often a residual lag at the DIP joint, and DIP flexion may be compromised [4,6].

Pilon fractures involving the base of the middle phalanx

An axial load to the end of the finger can create a comminuted fracture of the base of the middle phalanx. When the fracture extends to both the dorsal and palmar cortices, it is referred to as a ''pilon'' injury. The fracture planes separate the middle phalanx from the stabilizing ligaments, creating a highly unstable situation. Treatment should be designed to permit motion at the PIP joint within several days of surgery.

Open reduction and fixation is possible in those instances in which the fracture fragments are large enough to secure with a pin, screw, or wire. Often the fracture fragments are small. In these instances, external fixation or traction with or without percutaneous pins can restore some semblance of articular congruity and joint stability [7–11].

Dynamic traction, popularized by Schenck [8], involves attachment of a rubber band from a pin placed in the middle phalanx to an external splint that is fabricated to allow controlled finger motion. Schenck reported an average arc of 87° of PIP motion [8]. This technique has been modified to include smaller traction devices, as well as to

Fig. 2. Lateral radiograph showing swan neck deformity in finger with small mallet fracture.

Fig. 4. Lateral radiograph of finger in splint with correction of swan neck deformity.

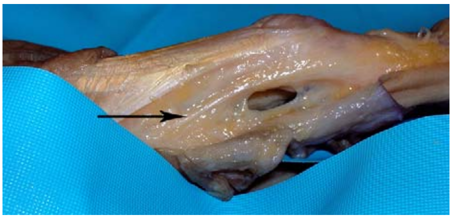

Fig. 5. Side view of digit. Arrow points to spiral oblique retinacular ligament.

take advantage of limited internal fixation in an effort to decrease the total time in traction [12,13]. The authors favor external fixation using 0.045-in pins inserted through the heads of the proximal and middle phalanges. The proximal wire is bent distally, and the distal is bent proximally. By bending a loop in the end of the wires, rubber bands can be attached and used to distract the PIP joint. An additional transverse wire can be added, if necessary, to control dorsal translation of the middle phalanx. Percutaneous pins can be inserted to help stabilize major fracture fragments (Figs. 11–15).

Stern and colleagues [14] compared immobilization, open-reduction internal fixation (ORIF), and traction for the treatment of pilon digital fractures. Extension-block splinting was associated with a high rate of symptomatic arthritis and stiffness. ORIF was associated with a high rate of complications. The study authors concluded that skeletal traction was safer and provided similar results to ORIF for pilon fractures. It was also noted that although no patient had anatomic restoration or regained full motion, there was significant articular remodeling over time [14].

Fig. 6. Dorsal view of digit where the lateral band has been mobilized. The distal end remains attached to the distal phalanx. The proximal end has been transected just distal to the MP joint.

Fig. 7. Dorsal view of digit with hemostat passed from radial to ulnar beneath the PIP joint, between the palmar plate and flexor tendons.

Oblique shaft fractures of the proximal phalanx

Fractures involving the shaft of the proximal phalanx can impair finger function in three ways:

1. Crossover caused by malrotation
2. Loss of extension at the PIP joint caused by loss of extensor tone from an apex-palmar malunion of the proximal phalanx
3. Stiffness from tendon adhesions or joint contractures

Optimum function following fracture of a digit hinges on finger alignment and PIP joint motion. Parameters of acceptable alignment vary, but have been extensively documented, and include less than 2 to 6 mm shortening, less than 10° to 15°of angulation, and no rotational deformity [15,16].

Acceptable rotational alignment is best defined by the absence of finger crossover when making a fist, an assessment that can be difficult in a painful, swollen digit. Inspecting the orientation

Fig. 8. Dorso-radial view of digit with lateral band passed beneath PIP joint.

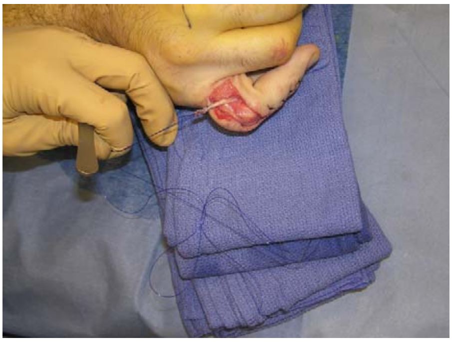

Fig. 9. Dorso-radial view of digit with 2-0 PROLENE woven through graft.

Fig. 11. Posteroanterior view of digit with comminuted fracture at the base of the middle phalanx.

of the nail plate, flexing the finger within the limits of comfort, and comparing the finger to the normal contralateral finger facilitate this assessment.

Alignment of the phalanx in the sagittal plane facilitates normal tendon function in two ways: restoring a flat surface to the phalanx allows the tendons to glide across the dorsal and palmar surfaces, and restoration of phalangeal length by angular correction allows the extensor tendon to function at its normal length.

Fixation of the injured phalanx should restore alignment and the gliding surface for the tendons, and permit PIP motion within several days of the surgery. Stabilization of the fracture should be performed in such a way as to minimize soft tissue stripping, in an effort to avoid postoperative stiffness [7,15]. A balance must be sought between minimizing operative soft tissue trauma and obtaining "rigid" fixation to allow early motion.

Transverse and short oblique fractures are best managed with an intramedullary, percutaneous pin [7,17]. Reduction is not challenging because it involves correcting only the apex palmar deformity. Reduction of spiral fractures, on the other hand, involves correction of malrotation. Holding the bone reduced with reduction forceps is typically not difficult. Spiral fractures can be treated with percutaneous pins, with percutaneous screws using a reduction forceps that acts as a targeting device, or with open reduction and lag screws. A recent comparative study [18] found a similar incidence of malunion when comparing open lag-screw fixation to percutaneous pin fixation. Plates are rarely necessary for stabilization of phalangeal fractures. A plate can be helpful for comminuted shaft fractures and for nonunions and malunions. Page and Stern [19] reported on 100 metacarpal and phalangeal fractures treated by plate fixation,

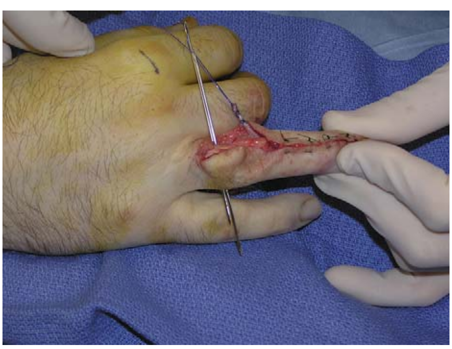

Fig. 10. Dorsal view of finger with graft tensioned. The DIP joint is extended and the PIP joint flexed approximately 20°.

Fig. 12. Dorsal view of digit with wire traction apparatus.

Fig. 13. Side view of digit with wire traction apparatus.

Fig. 15. Lateral view of digit with traction and percutaneous pin.

and noted poor postoperative motion and a 36% complication rate.

Long oblique fractures can be a challenge. The fracture is difficult to hold with reduction forceps, because the fracture tends to slip. Holding the reduction can be particularly difficult when there is comminution. Screw placement can be challenging, especially near the apices of the fracture. The diaphyseal bone of the phalanx is brittle and prone to fracture as compression is applied [7,15]. Splitting of the bone may lead to poor fixation or extension of existing fracture lines. Recent research indicates that bicortical fixation, rather than lag-screw fixation, may be adequate, and has the advantage of minimizing steps in the operative process while trying to hold the reduction [20]. The authors prefer open reduction and internal fixation with lag or bicortical screws. The fracture is approached via a midaxial incision that tails dorsally on either end in order to permit access to both the radial and ulnar cortices. The lateral bands are resected, and the fracture is exposed by working on either side of the extensor tendon. In the rare instances in which visibility is limited, the extensor tendon can be split down the center. The oblique fracture often behaves like a sliding board. This can make it very difficult to hold the reduction. Reduction is facilitated by using a tenaculum or sharp towel clip. Provisional fixation with a 0.045-in pin may be used to help hold the reduction while lag screws are placed (Figs. 16–18).

Fig. 14. Posteroanterior view of digit with traction and percutaneous pin.

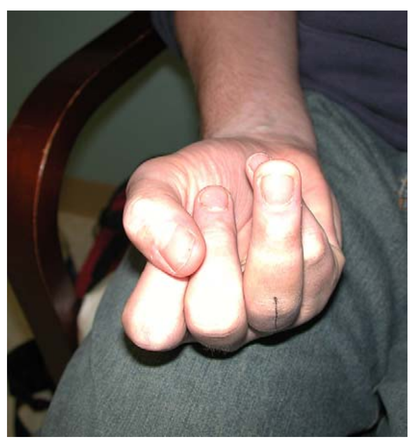

Fig. 16. Palmer view of hand with malrotated ring finger.

Fig. 17. Posteroanterior view of digit with displaced oblique fracture of the ring finger proximal phalanx.

Fig. 19. Posteroanterior view of displaced and angulated fracture of the ring finger metacarpal.

The authors offer the following tips for phalangeal fixation [7]:

- Be sure the drill bits are sharp and properly centered in the drill chuck in order to avoid splitting the fracture.
- Ensure proper distance from the fracture apex, usually two screw diameters. The phalangeal cortex is hard, brittle, and unforgiving.
- Use a countersink to place the screw head flush with the bone.
- Pay attention to screw length and exit points of the screws in order to avoid flexor tendon impingement. Remember that the phalanx is kidney–bean-shaped in cross-section.
- If your best intentions fail and you end up with a fracture pattern that is worse than the one you started with, stop, take a breath, and fix the major fragments. If you align the fracture and splint the hand, the fracture will heal. Not every fracture is amenable to rigid fixation and early motion.

Fig. 18. Posteroanterior view of digit following lag-screw fixation of fracture of the ring finger proximal phalanx.

Fig. 20. Oblique view of ring finger displaced and angulated fracture of the ring finger metacarpal.

Fig. 21. Prebent 0.062-in pin placed over ring finger metacarpal to estimate appropriate pin length.

Fig. 23. Dorsal view of hand with pin being introduced into the entrance hole in the base of the ring finger metacarpal.

Transverse diaphyseal fractures of the metacarpal

Neck fractures are the most common fracture of the metacarpal. Most of these can be managed nonoperatively. Nonunion is rare [21]. Malunion is common, but rarely leads to functional impairment. Long oblique and spiral fractures are similarly benign, and can be treated nonoperatively or surgically with lag-screw fixation when there is a rotational malalignment.

Transverse diaphyseal fractures, on the other hand, are prone to delayed union and nonunion. Following a transverse metacarpal fracture, the pull of the interossei flexes the distal fragment of the fractured metacarpal, creating an apex dorsal deformity. Muscle is often interposed between the fracture ends. The diaphysis of the metacarpal is thin and has relatively poor circulation. Although not reported in the basic science literature, the authors feel that these factors conspire to create an unacceptably high rate of nonunion and malunion, even in nondisplaced fractures. Fusetti and

Fig. 22. Dorsal view of hand with curette used to create an entrance hole in the base of the ring finger metacarpal.

Fig. 24. Posteroanterior view of intramedullary pin stabilizing the ring finger metacarpal.

Fig. 25. Lateral view of intramedullary pin stabilizing the ring finger metacarpal.

Della Santa [22] retrospectively reviewed 104 extra-articular metacarpal fractures, and reported a significantly higher nonunion rate with transverse fractures compared with nontransverse fractures. The authors' clinical experience has paralleled these findings.

The upper limit of acceptable angulation following metacarpal fracture ranges from 10° at the index to 50° at the small metacarpal, based upon the available motion in the corresponding carpometacarpal joint [15]. Although the primary deformity in transverse fractures is an apex dorsal deformity, the importance of small rotational deformities this far proximally cannot be ignored, because slight rotational changes at the metacarpal level can significantly affect the position of the digital tip. In fact, a mere 5° of metacarpal shaft rotation can result in 1.5 cm of digital overlap [16].

Transverse diaphyseal metacarpal fractures can be stabilized with plates, with pins placed transversely from the injured metacarpal into an adjacent metacarpal proximal and distal to the fracture, or with intramedullary pins [23]. Percutaneous fixation may avoid some of the complications associated with open plating techniques [24,25]. Page and Stern [19] cited a 36% complication rate in a large series of metacarpal and phalangeal fractures that were plated.

Intramedullary pins can be introduced through the metacarpal head or through the base [26–28]. Although prefabricated intramedullary systems exist, a quick and inexpensive approach is to place a prebent 0.062-in pin across the fracture by introducing it through an opening in the base of the metacarpal (Figs. 19–25). The pin should be cut so that it can be completely contained within the bone. This is facilitated by taking an intraoperative radiograph with the pin held against the metacarpal. An opening in the base of the metacarpal is created with an awl followed by a small, curved curette. The pin is inserted with a needle holder. If the fracture is difficult to reduce, the incision can be extended distally to clear interposed tissue and line up the fracture ends.

There are several caveats:

- This technique does not work well for oblique or spiral fractures.
- This technique does not work as well for fractures at the metaphyseal/diaphyseal junction.
- Assess the diameter of the medullary canal on preoperative radiographs. Small canals may be too narrow to accept a 0.062-in pin, and the small gauge pins do not work as well. Similarly, a 0.062-in pin in a large canal may not provide adequate stability.
- Multiple small pins do not stabilize the fracture as well as a single 0.062-in pin.

If the fixation feels solid, the hand is placed in a short arm splint for 2 weeks. This is converted to a hand-based splint that leaves the wrist and fingers free.

Summary

Patients expect physicians to predict the future. Recognizing injuries that behave badly improves care and modulates expectations. Your antennae should deploy when you are presented with a simple fracture that isn't.

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