Rehabilitation Approaches for Distal and Middle Phalanx Fractures of the Hand

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One of the most common fractures treated in hand surgery and hand rehabilitation practices is the distal phalanx fracture; the least common is a fracture to the middle phalanx. Published statistics on the incidence of distal and middle phalanx fractures compared with all fractures of the hand are difficult to find.1-3 Among the few articles identified, the percentage varied.4-6 In one Canadian study, the author compared his findings with two other studies.5 Distal phalanx fractures accounted for 53%, 62%, and 26% of all hand fractures. Butt5 suggested the significantly lower 26% was likely due to patients not believing a distal phalanx fracture warranted going to a hospital, which was the location of the study. For middle phalanx fractures, the studies reported an incidence rate of 8.7%, 12.4%, and 17%. The largest percentage of fractures at this level were avulsion fractures at the proximal interphalangeal (PIP) joint.

In reviewing the literature, the number of articles published on middle phalanx and distal phalanx fractures are fairly representative of the frequency with which each fracture is treated in medical practice. Few articles have been published on the course of rehabilitation.

Key to establishing the optimal therapy program is obtaining detailed information regarding the fracture. Necessary information to obtain includes the type and location of the fracture, method of fracture reduction, type of internal fixation (where applicable), stability of the fracture, soft tissue structures involved, and problems the fracture may present during rehabilitation. This information and level of understanding, combined with access to the x-rays (before and after reduction) and the operative report, are invaluable for achieving the highest level of functional recovery.

DISTAL PHALANX FRACTURES

Distal phalanx fractures are common fractures seen in hand surgery and hand rehabilitation practices. The digit most vulnerable to fracture at this level is the middle finger simply because of its length compared with the adjacent digits. The most frequent cause of injury in small children is getting the finger caught between two objects, such as a door, whereas sports-related injuries are more common with children >9 years old.7 In adults, industrial accidents and activities in which the fingertip is compressed between objects are the primary cause of injury.8 Distal phalanx or P3 fractures, as they often are called, are easier to rehabilitate than other fractures of the hand. In large part, this is because the anatomic relationship of the soft tissue structures with bone is far less complex. The distal phalanx is surrounded by soft tissue, along with the nail bed. Sensory nerve endings surround the fingertip. The terminal tendon inserts on the dorsal and proximal most aspect of the distal phalanx. The flexor digitorum profundus inserts on the volar and proximal aspect of the distal phalanx (Figure 1).9 Because of the anatomic relationship of tendon to bone, there is little risk for the tendons to become adherent.

The chief complaint with these fractures is pain resulting from the abundance of sensory nerve endings along the distal phalanx. Limited range of motion is less of a problem and occasionally occurs when there is an articular fracture of the distal phalanx or there has been a severe crush injury with a comminuted fracture of the distal phalanx. A rehabilit-
itation program that focuses on eliminating the pain and hypersensitivity before starting active and, secondarily, passive range of motion typically yields excellent functional results.

Tuft fractures with concomitant nail bed injuries and proximally based distal phalanx fractures are seen commonly by a hand surgery practice and by hand therapists. Both areas are discussed, along with the course of rehabilitation.

Tuft Fractures with Concomitant Nail Bed Injury

In my clinical practice, the most common distal phalanx fracture managed is a tuft fracture, with concomitant nail bed injury. Typically the nail bed has been repaired, and the fracture has not required stabilization with internal fixation. The patient presents to therapy 1 to 3 days postoperatively to initiate rehabilitation.

Removal of the postoperative hand dressing is often a challenge for the patient and the therapist. Typically the dressing is adherent secondary to postoperative bleeding along the nail bed. Removing the adherent dressing over the highly sensitized nail bed is painful. An effective method for removing the final layers of the digital dressing is to soak the digit in saline with part hydrogen peroxide. The digit can be placed in a sterile container such as a specimen container (Figure 2), to allow the digit to soak for 5 to 10 minutes before attempting to remove the dressing. The dressing should be removed slowly. Removing the gauze parallel to the nail bed minimizes the pain.

When the dressing is removed, the initial evaluation includes an assessment of the wound, a pain rating (e.g., visual analog scale), edema measurement (circumferential measurement at the level of the middle phalanx [P2]), and range-of-motion measurements of the metacarpophalangeal (MCP) and PIP joints. Pain is the predominate factor during the initial evaluation.

A sterile dressing is applied to the distal and middle phalanx. The dressing includes petroleum jelly–impregnated gauze over the nail bed, followed by 1-inch sterile gauze. The final layer is 1-inch Coban for edema control (Figure 3). It is helpful to limit the dressing to one to two layers to allow unrestricted active range of motion of the digit. The dressing is changed every 24 to 48 hours to prevent it from becoming adherent again and to promote healing of the wound. If the initial wound was a “dirty” wound, with a risk of infection, a whirlpool with Chlorazine may be used to cleanse the wound and facilitate wound healing.

A small, hand-based, custom-made splint is fabricated to protect the highly sensitive distal phalanx. Thermoplastic splinting material, 3/32-inch, is recommended for splint fabrication. The thinner material minimizes bulk along the fingertip (Figure 4). The splint is worn continuously the initial 5 to 7 days after surgery to allow the inflammatory response and pain to decrease.

Active range-of-motion exercises are initiated within the first week to regain joint mobility unless the DIP joint is pinned. Exercises are performed four to six times a day. Typically, tuft fractures have satisfactory healing to allow active-assistive range of motion by 3 weeks and unrestricted passive range of motion by 4 weeks. An aggressive rehabilitation program to restore DIP joint motion rarely is needed.

Clinical experience has shown results following a carefully established rehabilitation program for tuft fractures and nail bed injuries are favorable. It is common for the sensitivity to resolve and the patient to achieve excellent range-of-motion within 8 to 10 weeks after injury. Assuming the nail bed was repaired, the new nail grows approximately 1 mm

FIGURE 1. Anatomic structures along the fingertip at risk for injury with distal phalanx fractures.

FIGURE 2. Nail bed injury with distal phalanx tuft fracture. Typically the postoperative dressing is adherent along the nail bed. Allowing the digit to soak in a sterile container filled with saline and part hydrogen peroxide can be an effective method for removing the dressing relatively pain-free.
each 10 days after the initial 30 days after injury and repair. Based on this, the patient can expect a new nail within 4 to 5 months. The initial nail may have ridges or have a dull appearance. As the new nail continues to grow, the appearance improves, unless there is permanent nail bed injury.

FIGURE 3. Tuft and shaft fracture and concomitant nail bed injury. A nail bed repair was performed with percutaneous pinning of the shaft fracture (A). Application of Vaseline gauze over the nail bed (B). One-inch sterile gauze applied along the distal and middle phalanx (C). One-inch Coban applied for edema control.

Distal Phalanx Fractures (Proximal P3)

Distal phalanx fractures proximal to the tuft may be immobilized or pinned for approximately 3 weeks to allow fracture consolidation before starting range-of-motion exercises. In either case, the splinting for these fractures is the same. The patient is fitted with a custom-fabricated splint to immobilize the distal interphalangeal (DIP) joint for continual wear. Range-of-motion exercises for the MCP and PIP joints are initiated while wearing the splint (Figure 5). When the fracture has healed adequately, commonly by 3 weeks, active range-of-motion exercises may be initiated for the DIP joint. Emphasis is placed on blocking exercises for the DIP joint. As passive range of motion is permitted, between 4 and 6 weeks, dynamic splinting, elastic bands, or taping may be initiated as needed.

From clinical experience, patients usually restore excellent, functional range of motion to the DIP joint. For the small percentage of patients who have limited motion, there are rarely complaints of functional limitation.

Distal Phalanx Avulsion Injuries

Bony Mallet Injuries. An avulsion injury to the terminal tendon of the distal phalanx results in a bony mallet (Figure 6). The insertion of the terminal tendon into the distal phalanx avulses a fragment of bone. With small fragments, <25% of the articulating surface of the bone, the DIP joint is splinted.9,12 Open reduction and internal fixation is reserved for fractures involving more than one third of the articular surface of the distal phalanx. Various techniques are described in the literature.13-15

For conservatively treated bony mallet injuries, a custom-made splint is fabricated. Splinting material,
3/32-inch, is used, positioning the DIP joint in approximately 10° of hyperextension (Figure 7). The splint is worn continuously for 6 to 8 weeks. When range-of-motion exercises are initiated, emphasis is placed on active range of motion, focusing on composite flexion and extension of the digit (Figure 8). Initially, exercises are performed three to four times a day. Blocking is not initiated as active motion is begun. The reason for waiting to perform blocking is that when the PIP joint is stabilized in extension and active flexion is performed at the DIP joint, this places tension on the oblique retinacular ligament (ORL). Because it can be difficult to restore DIP extension, it is important to have the terminal tendon, ORL, and posterior fibers of the collateral ligaments all assist in DIP extension. If the ORL is relatively lengthened, it becomes less effective in assisting with extension of the DIP joint. Passive range-of-motion exercises are initiated only if necessary. As for the mallet splint, the splint wearing time is decreased gradually and ultimately discontinued altogether between 12 and 14 weeks after injury. It is important to balance restoring active flexion and maintaining DIP joint extension.

One report in the literature on conservatively managed mallet fingers found the average active flexion at the DIP joint to be 40° and active extension to be 10°. There were 23 patients in the study with bony and soft tissue mallet injuries. The reported outcome for both types of injuries was the same. The average duration of splint immobilization was 9 weeks. Another report in the literature revealed a similar degree of extensor lag, yet full active flexion. Clinical experience has shown that patients managed conservatively for bony mallet injuries typically restore an average of 65° of flexion and have a residual extensor lag of approximately 5° to 10°.

_Flexor Digitorum Profundus Avulsions._ Flexor digitorum profundus avulsions are an uncommon injury. Either the profundus tendon ruptures at its tendinous insertion into the distal phalanx, or a bony fragment is avulsed. This type of injury occurs most frequently in sports such as football, rugby, and rock climbing. The ring finger most commonly is affected. Gunter believed the ring finger is injured most commonly because of the lack of independent extension of the ring finger. Manske and Lesker hypothesized that it is due to the profundus being the weakest in the ring finger.

Surgery often consists of reattaching the profundus to the distal phalanx with pullout suture. For larger avulsed fragments, open reduction and internal fixation may be required with Kirschner wire or screw.
fixation. Other techniques, such as bone suture anchors, have been suggested in the literature to provide a strong repair.

Therapy is initiated within 3 to 5 days postoperatively as the edema begins to subside. When the bulky dressing is removed, a light compressive dressing is applied to the hand, along with digital level edema control. The patient is fitted with a custom-fabricated dorsal blocking splint. The wrist is positioned in 20° of flexion, the MCP joints in 70° of flexion, and the PIP and DIP joints in full extension (Figure 9). The splint is worn continuously to protect the surgical repair. Passive range-of-motion exercises are initiated, performing the modified Duran exercises for flexor tendon repairs (25 repetitions, each 2 hours). At 3 weeks postoperatively, the dorsal blocking splint is removed for active range-of-motion exercises (Figure 10). The splint is continued between exercise sessions and at night. By 5 weeks, blocking exercises may be initiated. The splint is discontinued at 6 weeks, and the button is removed. Progressive strengthening may be added by 8 weeks postoperatively.

The most common problem is restoring motion at the DIP joint level. Active and passive flexion may be limited. Passive flexion often is limited when larger fragments of the distal phalanx are avulsed. One report in the literature by Moiemen and Elliot indicated a total active motion (TAM) of 67% for flexor digitorum profundus avulsions, based on Strickland’s criteria for flexor tendon results. Clinically, my experience is that patients achieve approximately 50% of normal DIP joint motion.

MIDDLE PHALANX FRACTURES

Middle phalanx fractures, or P2 fractures, as they often are called, are the least common fracture of the hand. Most of the fractures at this level are avulsion fractures of the PIP joint (i.e., volar plate avulsions and central slip avulsions). Other than avulsion fractures, transverse fractures are the most common type of middle phalanx fracture. They occur most commonly in sports-related injuries and in machinery accidents. These nonarticular fractures are uncom-

FIGURE 8. A 71-year-old man with bony mallet. (A) Radiograph of bony avulsion with proximal migration of fracture fragment. (B) Mallet splint. (C and D) Active extension and flexion at 11 weeks after splint immobilization. Range-of-motion exercises were initiated after eight weeks of splinting.
mon in part because the bone is short and broad, allowing the bone to be much stronger than the proximal phalanx or the metacarpal. In addition, injuries near the PIP joint typically result in disrupting the soft tissue structures surrounding the joint (i.e., dislocations, ligament injuries, and avulsion injuries) before independently fracturing the middle phalanx.

Middle phalanx fractures are far more challenging to restore range of motion and function than distal phalanx fractures because of the complex anatomy along the middle phalanx. The intimate relationship between the flexor and extensor tendons with the bone, along with the PIP and DIP joints, provide a challenge for maintaining tendon gliding and joint mobility (Figure 11). When this situation is compounded by bone shortening, an imbalance of the extensor mechanism can occur, resulting in PIP joint hyperextension and an extensor lag at the DIP joint.

An extensive literature search on the rehabilitation for middle phalanx fractures, separate from avulsion injuries, was not successful in identifying a single article specific to this topic. Therefore, emphasis is placed on my clinical experiences in managing these fractures. I have found the key to successful rehabilitation with middle phalanx fractures begins with excellent communication with the surgeon. It is important to understand the type of fracture and location, method of internal fixation, stability of the fracture after reduction, method of fixation, and other anatomic structures that have been repaired. In addition, it is essential to know when fracture consolidation is adequate to permit active and passive range of motion.

**Stable Middle Phalanx Fractures**

Some nondisplaced and closed reduced middle phalanx fractures are stable and require minimal immobilization. Incomplete or nondisplaced oblique and spiral fractures are in this category. These fractures simply can be secured with buddy tapes for approximately three weeks before resuming unrestricted motion (Figure 12). When the patient is fitted with buddy tapes, it is uncommon to follow these patients in therapy. The result is predictably favorable.

Other middle phalanx fractures may be stable or become stable with closed reduction and not require internal fixation. Although these fractures do not require internal fixation, they are immobilized for 3 to 4 weeks to allow early fracture consolidation before permitting active range of motion. The hand may be immobilized in a cast or splint positioning the wrist in slight extension, the MCP joints in approximately 75° of flexion, and the PIP and DIP joints in extension. As an alternative, it is common to immobilize the hand only with the involved digit and an...
adjacent digit in a hand-based static splint. This splint can be less cumbersome and provide adequate protection of the fracture (Figure 13). The purpose for immobilizing the PIP and DIP joints in extension is to minimize the risk of developing an extensor lag or a PIP joint flexion contracture. As active range-of-motion exercises are initiated, it is common to have limited active flexion. Emphasis is placed on composite active flexion exercises, including blocking to the PIP and DIP joints. Passive range of motion typically is allowed by 6 weeks, based on fracture healing. When unrestricted, passive motion is initiated, dynamic flexion splinting commonly is required.

Unstable Middle Phalanx Fractures

Stable Fixation Technique—Kirschner Wire Fixation. Unstable middle phalanx fractures that have been reduced and require percutaneous fixation or open reduction and internal fixation are more challenging to rehabilitate. Based on the location and severity of the fracture and method of internal fixation, some fractures that have been reduced and stabilized with internal fixation may not be stable enough to start early range of motion. This is particularly true when fractures such as transverse middle phalanx fractures are stabilized with Kirschner wire fixation. Depending on the location of the fracture, active contraction of the flexor digitorum superficialis can serve as a deforming force to the proximal or distal fracture fragment. Beginning active motion too early can risk a malunion or nonunion at the fracture site. This is one reason why these fractures require approximately 3 weeks of immobilization before beginning active range of motion. Midshaft fractures may require immobilization for 6 weeks before beginning motion because of the delayed healing in this area of the middle phalanx. Fractures such as this become a challenge in therapy because of the soft tissue structures becoming adherent along the middle phalanx. Most commonly, this affects the flexor digitorum superficialis and profundus and the terminal extensor tendon. When therapy is initiated, it is important to perform exercises to isolate the extensor and flexor tendons. A case example follows to provide an overview of the course of therapy.

**Case Example.** A 32-year-old woman suffered a severe crush injury when she was thrown from and trampled by a horse. Her hand injury included traumatic amputation of the long finger through the middle phalanx and an open, middle phalanx fracture of the ring finger. Surgery included revision of the long finger amputation and open reduction and internal fixation with Kirschner wire to the middle phalanx neck fracture. Surgery was performed the day of injury.
Therapy was initiated five days after surgery. The x-rays, operative report, and treatment orders for therapy were reviewed and discussed with the surgeon. The postoperative bulky dressing was removed and a light compressive dressing was applied to the hand and forearm to protect the wounds and facilitate reduction of edema. For digital level edema control, “finger socks” were used.

An initial evaluation was performed that revealed the following:

Pain rating: 3 out of 10 on a 10-cm visual analog scale
Wound: Sutures intact, no drainage
Edema: Long finger, 6.0 cm circumferential measurement P1, and ring finger, 5.9 cm circumferential measurement P1

Range of motion measurements are shown in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Index</th>
<th>Long</th>
<th>Ring</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP joint</td>
<td>0–60° (70°)</td>
<td>0–50° (80°)</td>
<td>0–70° (75°)</td>
<td>0–85° (90°)</td>
</tr>
<tr>
<td>PIP joint</td>
<td>0–70° (70°)</td>
<td>0–45° (45°)</td>
<td>5–75° (0/75°)</td>
<td>0–85° (95°)</td>
</tr>
<tr>
<td>DIP joint</td>
<td>0–30° (30°)</td>
<td>Amputation</td>
<td>Pinned</td>
<td>0–10° (70°)</td>
</tr>
</tbody>
</table>

*Numbers in parentheses = passive.

The pin was removed from the middle phalanx fracture at 7 weeks postoperatively. As expected, there was significant limitation in active and passive range of motion of the DIP joint. Active flexion was 15°, and passive flexion 20°. Dynamic flexion for the DIP joint was added to the therapy program. Emphasis was placed on blocking exercises to the DIP joint, along with active DIP joint extension. Putty was issued to begin strengthening and to provide resistance for the flexor tendons. As the patient’s passive flexion increased to 45° at the DIP joint of the ring finger, an elastic band was fitted to wear three to four times a day for 5- to 10-minute sessions to assist with restoring full passive flexion.

When the patient was discharged from therapy her range of motion was normal for the index, long and small fingers. The range of motion of the ring finger was as follows: MCP, 0° to 90°; PIP, 0° to 105°; and DIP, 0° to 45° (passive 75°). Pain along the stump of the long finger had resolved. Grip strength was 57 lb in the dominant right hand and 74 lb in the left hand. She stated her one functional limitation was with writing. It was difficult securing writing instruments because of the loss of the middle finger at the middle phalanx level. Because of her long finger amputation, she was considering a Pillet cosmetic prosthesis for social events. The patient expressed satisfaction with her functional recovery (Figure 14).

Rigid Fixation Techniques—Screws, Plates, Tension Band Wires. Unstable middle phalanx fractures that have been reduced and subsequently stabilized with rigid fixation usually can allow early motion. Commonly, rigid fixation is accomplished with screws, a plate with screws, or tension band wiring. In the limited number of fractures in which screws and plates can be used with middle phalanx fractures, the internal fixation usually provides adequate stability of the fracture to begin therapy within 3 to 5 days after surgery. Waiting 3 to 5 days allows the postoperative pain and edema to begin subsiding without compromising tendon excursion or joint mobility.

When therapy is initiated, emphasis is placed on reducing the edema. By focusing on edema reduction, the pain subsides more efficiently, less scar tissue is produced, and joint range of motion can be achieved more easily. Initially, edema is managed effectively with a light compressive dressing for the hand and forearm and digital level edema control with finger socks or 1-inch Coban. A custom-made
A splint is fitted positioning the MCP joints of the involved digit and an adjacent digit in flexion with the PIP and DIP joints in full extension. The splint is reduced to a digital extension splint to the PIP and DIP joint when the edema is resolved. Active range-of-motion exercises are initiated to the hand. Emphasis is placed on blocking exercises to the PIP and DIP joints, along with positioning the MCP joint in flexion and actively extending the PIP joint. This exercise helps facilitate extensor tendon excursion. To complement the active range-of-motion exercises, neuromuscular electrical stimulation may be initiated to facilitate tendon excursion, particularly for the flexor digitorum superficialis and flexor digitorum profundus. As passive range-of-motion exercises are initiated, it is important to emphasize composite flexion and extension of the digit. To assist in minimizing an extensor lag at the DIP joint, isolated passive flexion of the DIP joint with the PIP joint extended should be avoided. Because extensor lags are common at the DIP joint, it is beneficial to minimize passive tension on the terminal tendon and the oblique retinacular ligament, which could increase the likelihood of an extensor lag.

To review the course of rehabilitation, a case example is summarized in Figure 15. The patient had a

**FIGURE 14.** A patient with traumatic amputation of the long finger with open, middle phalanx fracture of the ring finger. Surgery included revision of the amputation and Kirschner-wire fixation of the middle phalanx fracture. (A) Radiograph of the original injury. (B) Middle phalanx fracture pinned. The pin was pulled, and active exercises were initiated at 7 weeks postoperatively. (C) Dynamic flexion splint custom fabricated to increase passive distal interphalanegal joint motion. (D and E) Active extension and flexion at discharge.
severe punch-press injury resulting in multiple fractures and soft tissue injuries.

The luxury of rigid fixation is that it permits aggressive range-of-motion exercises in the early postoperative days. Initially the challenges are postoperative edema and pain and secondarily adhesions limiting tendon excursion. To achieve a successful outcome, it is essential the patient achieve excellent range of motion in the initial 2 to 3 weeks after surgery, or significant tendon adherence and joint contracture can develop.

Results. Specific articles with objective results after middle phalanx fractures (separate from avulsion fractures at the PIP joint) were not found in a literature search. Clinically, I have treated middle phalanx fractures with varied outcomes. The magnitude of the initial injury (severity of the fracture, concomitant injuries) plays a significant role in the final range of motion. It is common for an extensor lag to be present at the DIP joint, along with a limitation in flexion. It is relatively uncommon for the patient to undergo an elective procedure to increase motion, unless there is a limitation in the PIP joint as well. Functional performance is usually satisfactory.

FIGURE 15. A 37-year-old man with punch-press injury. (A) Radiograph of middle phalanx fracture stabilized with plate and screw fixation. (B) Radiograph of internal fixation. Surgery consisted of: long finger proximal interphalangeal (PIP) joint fusion with a plate, ring finger extensor tendon repair (zone IV) and open reduction and internal fixation of proximal phalanx fracture with plate and screw fixation; and small finger extensor tendon repair (zone III) and open reduction and internal fixation of middle phalanx fracture with plate and screw fixation. (C) Initial therapy visit 11 days postoperatively required whirlpool therapy and dressing changes to facilitate wound healing. (D) A safe position splint was fitted to wear between exercise sessions and at night. (E) Early active range-of-motion exercises were initiated to the ring and small finger for digital level extensor tendon repairs. The gutter splint allowed 30° of active flexion, along with (F) active extension. At 3 weeks postoperatively, the gutter splint was adjusted to allow 45° of active flexion. (G) Unrestricted, active motion was initiated at 4 weeks postoperatively. This included blocking exercises to the PIP and distal interphalangeal (DIP) joints and (H) immobilizing the metacarpophalangeal joint in flexion to facilitate active PIP joint extension. (I) Passive flexion and dynamic flexion splinting was initiated at 5 weeks postoperatively. (J) At 8 weeks postoperatively, interphalangeal joint taping was added to achieve the end range of passive PIP and DIP joint flexion. (K) At 4 months after surgery, active extension was 35° in the ring finger and 25° in the small finger. (L) The patient restored excellent active flexion. Because of malunion of the long finger PIP joint fusion, a secondary procedure was performed at 5 months postoperatively, which required splint immobilization.
SUMMARY

Excellent communication between the surgeon and therapist is vital with all medical conditions and surgeries to the upper extremity. Hand fractures, in particular, require excellent communication between the surgeon and therapist to progress the patient through the course of therapy. Skilled hand therapists recognize the importance of this dialogue, have a comprehensive understanding of hand fractures, progress patients as fracture consolidation permits, and focus therapy on mobilizing the anatomic structures that may be affected adversely by the fracture. Clinical experience is invaluable to the rehabilitation for fractures of the middle and distal phalanx.

REFERENCES