

Phalangeal and Metacarpal Fractures of the Hand: Preventing Stiffness

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Summary: Fractures of the phalangeal or metacarpal bones of the hand are common. Many of these fractures are treated without surgery. However, both conservative and operative management of fractures of the hand can result in stiffness. Stiffness is the most common complication in the management of hand fractures. The key to preventing stiffness is early range of motion exercises. This article challenges many of the current treatment regimens offered to patients with the so-called unstable fractures. The evaluation of the patients' function is the primary factor that should determine the course of conservation versus operative management. X-rays do not demonstrate function and therefore act as an adjunct only to the care of the patient. The goal of treating hand fractures is to restore function. Early motion may not only improve healing but may also hasten the return to normal hand function. The tenets of how to prevent stiffness are described in this review. (*Plast Reconstr Surg Glob Open* 2021;9:e3871; doi: [10.1097/GOX.0000000000003871](https://doi.org/10.1097/GOX.0000000000003871); Published online 28 October 2021.)

There are two truisms about hand fractures that should be stated. The first is that most nonarticular hand fractures do not require surgery.¹⁻¹³ This is a finding that has transcended generations of hand surgeons believing that stable isolated fractures can be treated with conservative measures, such as splinting, followed by therapy. The second truism is that there is no consensus on the optimal way to treat most fractures of the hand.

As a foundation of nonarticular hand fracture management, surgeons often refer to their understanding of fracture stability.⁵⁻¹² It is often stated that stable fractures can be treated nonoperatively, whereas unstable fractures should be managed operatively.⁴ Stable fractures may be broadly defined as those where the fracture ends are appropriately juxtaposed in relative anatomic position to foster healing and that the bone segments maintain that position at rest and in motion (Fig. 1). Unstable fractures, by contrast, lack bony support due to comminution, angulation, or translational deformity (Fig. 2). Some authors have opined that unstable fractures, if not treated operatively, will lead to

complications such as stiffness, weak grip, pain, malrotation, or nonunion and ultimately poor function due to angulation or shortening.⁵⁻¹⁵ But stiffness is undoubtedly the most common untoward sequelae of fracture management, and this outcome is true for both conservative and operative treatment regimens.¹⁻¹⁶ Perhaps, therefore, labeling fractures as “stable” or “unstable” should not define our management but rather the function of the hand. The management of metacarpal and phalangeal fractures in the hand is intended to culminate in the restoration of normal function.¹⁻⁴ Conservative management when splinted for too long can lead to stiffness, joint contractures, and potential prolonged healing leading to malunion or nonunion. Operative intervention also has its potential complications. The patient is at risk for infection, bleeding, hematoma, soft tissue necrosis, osteomyelitis, and adhesions as well as the risks noted in conservative management, including malalignment, malunion, nonunion, avascular necrosis of bony fragments, pain, and stiffness.^{17,18}

Ultimately, each surgeon must define the goals of management for any given hand fracture patient. We define the goals rather broadly, such as patients obtaining normal digital alignment, a pain-free status, and normal range of motion to essentially achieve normal function that allows the patient to return to the activities that they were doing. Defining these goals should direct surgeons to the appropriate management of their patient who has

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Fig. 1. AP view of the right hand: a 32-year-old woman with a minimally displaced fracture of the long finger metacarpal. Significant bony contact of the fracture ending with normal alignment is demonstrated in this stable fracture.

a fracture or phalanx or metacarpal. Then, the surgeon must answer the question, “are the goals comprised by either conservative or surgical treatment?” The mode of management should foster the return of normal motion and functional finger biomechanics. Observing patient function should be the primary source of information for a surgeon to decide upon treatment. X-rays do not show us function but often sway the decision to operate presumably because of our thoughts about “stability” and healing of nonanatomic alignment of fracture ends. But anatomical alignment is not required for bony healing and subsequent stability. Fractures will heal by secondary healing even though there is malalignment or shortening. Fracture healing relies on pluripotent cells to regenerate bone vascularity at the defect site. Pluripotent mesenchymal stem cells arise from multiple sites: bone marrow, periosteum, endosteum, Haversian canals, surrounding soft tissue, and from systemic recruitment.^{19–22} Complex signaling cascades direct mesenchymal stem cells to differentiate into chondrocytes, endothelial cells, osteoblasts, and osteoclasts to regulate bone healing.^{23,24} The amount of mechanical stability and strain about the fracture site will determine the method of bone healing intramembranous ossification, endochondral ossification, or a combination of both.²⁵ Micromotion in secondary bone healing is important. Indirect (secondary) healing



Fig. 2. Oblique view of the right hand: a 53-year-old man with an unstable proximal phalanx fracture of the right long finger. Minimal bony contact and obvious finger deformity are observed.

occurs through endochondral ossification in which a cartilage callus bridges the fracture site before bony deposition. Secondary healing does not require anatomic reduction or rigid stability. Micromotion and controlled weight bearing at the fracture site promote indirect healing, explaining the success of the following treatments: splinting, intramedullary nails, external fixation, or ORIF of comminuted fractures.^{23–28} Axial loading stress results in electrical polarity across the bone and increased bone formation via osteoblasts in areas of high stress, while resorption occurs via osteoclasts in areas of low stress.^{28,29} Replacement of the hard callus with lamellar bone and development of a central medullary canal completes the fracture healing process.^{23–29} Some element of motion may actually be beneficial to bone healing while reducing stiffness because soft tissues are allowed to glide. Fractures are associated with a varying degree of soft tissue damage. Contusion, hematomas, direct bone spicule damage, or penetrating injuries are all intimate with the fracture. This means that the soft tissue must heal as well as the fracture if one is to return to normal function. However, soft tissue heals through a sequence of physiologic events, ultimately ending in fibrosis and scarring, whereas the bone heals

through a different sequence of physiologic events by either intramembranous or endochondral ossification.^{30,31} Unfortunately, the direct approximation of the soft tissue to the bone means that any process of healing may affect the reparative process of the adjacent tissue. Earl Peacock once stated, “One wound, one scar” in his summary of composite tissue injuries.³² Herein lies a concern that the gliding properties of the surrounding soft tissue require appreciable movement to restore normal function, whereas the bone requires relative immobilization to foster stability and healing. This seems like opposing requirements, making the hand that is subject to a fracture either prone to stiffness or prone to nonunion depending on the option taken to start movement or to restrict movement, respectively. Clinically, however, we know this is not true, and optimal outcomes can occur where the bone heals well and the soft tissues glide normally after fractures. The key to preventing stiffness is not necessarily how we treat a fracture but in allowing the fingers to move as soon as possible.

As late as the 1970s many hand fractures were treated with delayed motion for up to 6–8 weeks, with some surgeons believing that absolute rest fostered maximum healing.³³ Hand therapists were subsequently challenged with trying to regain motion in fingers that had developed severe stiffness and contractures. Patients often required secondary tenolysis and capsulectomy procedures to release scars that had hindered the normal function of tendons and joints. The secondary procedures were often fraught with poor outcomes.^{34–36}

The concept of early motion over fracture immobilization is not new. The French physician Nicolas Andry (1658–1742) published the first textbook on orthopedics in 1741.^{37,38} He believed in family education, habit change, medication, splinting, and exercise. He advocated exercise and early range of motion in all tissues damaged from injury, including bone and surrounding structures. The sequela of rest was stiffness and contractures. Over 150 years later, a French surgeon (Just Lucas-Championniere) published his work on the benefits of early motion of fractures to prevent stiffness and dysfunction.³⁹ Even the founder of hand surgery in the United States, Sterling Bunnell, stated, “An ever-present menace in hand surgery is the decided tendency for the hand to stiffen and to stiffen in the position of nonfunction.”⁴⁰ Hands swell from trauma, infection, operative procedures, or vasomotor disturbances. If patients continue moving the hand and digits, then this swelling is pumped away. In the setting of swelling, immobilization allows fibrin from protein-rich edema fluid to settle between and within all movable digits, including the tendons and joints until all is sealed. Tendons cease to glide, joint folds, and surfaces adhere, and the water-logged ligaments become so short and thick that movement is lost.^{39,40} Lanz et al opined that “damage of the gliding ability of tissues around the fractured digit is always irreparable.”⁴¹ We know this is not necessarily true today, but finger stiffness remains a concern to hand surgeons. With this in mind, a dialogue about the management of hand fractures is warranted, given today’s large body of evidence-based medicine literature.

Conservative measures, including buddy taping, orthosis, and early range of motion, are employed in these circumstances.^{3–8} The term “early range of motion” is one that most hand surgeons embrace to prevent stiffness. The definition of early range of motion varies, however. Early motion may mean starting motion of digits immediately following the injury, or to some after 3 weeks of immobilization. There is controversy over which fractures would require immobilization for a period of time without allowing motion and which fractures would require the “early range of motion.” Almost every article that is written about the management of metacarpal fractures or phalangeal fractures mentions early motion.^{1–13,42} For most, the strength and rigidity of the fixation defines how aggressive one is with motion and defines the timing of the early motion. The early motion protocols often allow for some swelling to decrease and pain to subside before embarking upon therapy. Many times this can be started within days of the fracture. It is also well known that early motion helps decrease adhesions, which limits stiffness. Furthermore, some element of motion can promote wound healing and fracture healing. Cellular and biomechanical properties of the soft tissue and bone are enhanced with limited motion.^{41–44} Hand and finger edema, joint effusions, and tendon gliding all diminish with increased motion of the fingers.^{42–47} Conversely, prolonged splinting results in prolonged swelling, periarticular fibrosis, tendon adhesions, and joint contractures, leading to stiffness and decreased function of the fingers.^{43,45}

So, if one wants to utilize early motion, to prevent stiffness, which method of management provides the best outcome: surgery or therapy alone? Peer-reviewed literature has historically identified certain fracture patterns that should be treated with operative intervention.^{48–50} Yet, clinically, many surgeons have employed early motion with no fixation for many of these exact fracture patterns.^{44,48,49,51} Distal metacarpal neck fractures, for instance, have certain defined degrees of angulation that are acceptable for conservative management. Angulation of 10 degrees or less for the index and long finger, 20 degrees or less for the ring finger, and 30–45 degree or less of the little finger are considered acceptable without the need for operative intervention.^{4–13,52} The reasons for these published dogma include a change in the pre-fracture biomechanics of the finger resulting in extensor lags, prominent metacarpal head in the palm that causes pain on holding objects, bone shortening decreasing strength, and aesthetic disfigurement.^{12–14} It is true that the greater the degree of apex dorsal angulation, the more of a dorsal prominence will be identified on the dorsum of the hand, which can be cosmetically unappealing. There is limited evidence in the literature, however, that corroborates operative indications for metacarpal neck fractures. One could argue that we should not treat the x-ray but rather treat the patient. If the patient has normal range of motion despite what the degrees of angulation are observed on x-ray, they do not need an operation.⁴⁸ In fact, Ford et al noted that metacarpal neck fractures of the ring and small finger can tolerate up to 70 degrees of angulation (Fig. 3A–C).⁵³ The main sequela of dorsal angulated metacarpal fractures is either

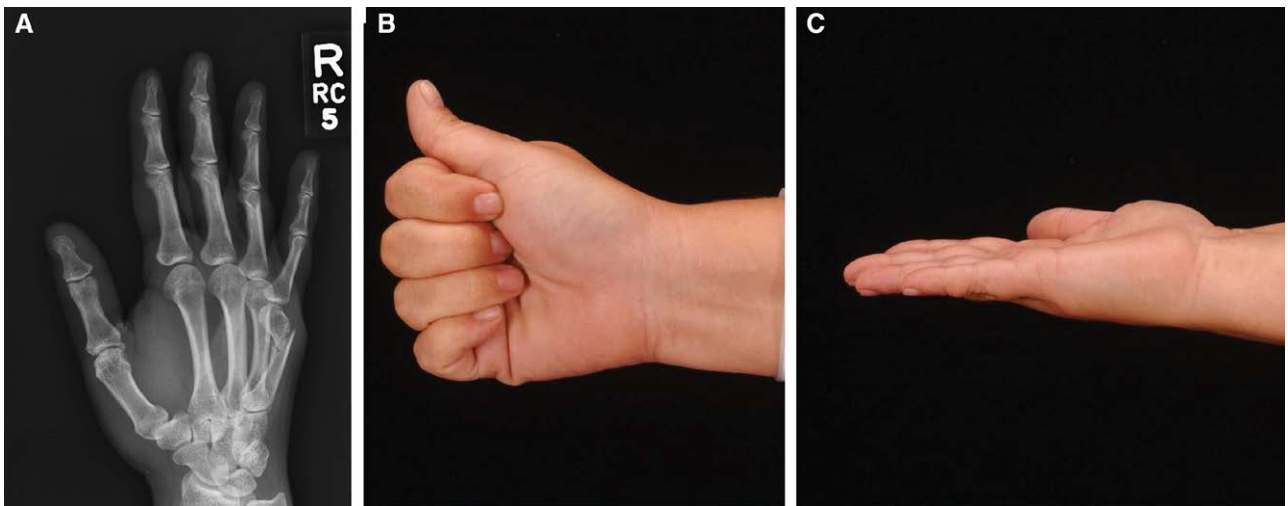


Fig. 3. Right fifth metacarpal neck fracture. A, A 24-year-old woman sustained a fracture of the neck of the right little finger metacarpal. Oblique view of the right hand shows that the fracture had minimal apex dorsal angulation. B, C, The patient presented with normal range of motion and function with flexion and extension, respectively.

some degree of extensor lag, which is usually less than 10 or 15 degrees of the affected digit, or an aesthetically unappealing dorsal hump on the back of the hand from the dorsal apex fracture pattern. (Fig. 4A–D) The literature also does not support a prominent metacarpal head

in the palm as being a significant factor in metacarpal neck fractures. Similarly, multiple metacarpal fractures do not destabilize the hand, and patients can still function normally without fixation but rather start immediate controlled motion and night splinting (Fig. 5A–D).⁴⁸

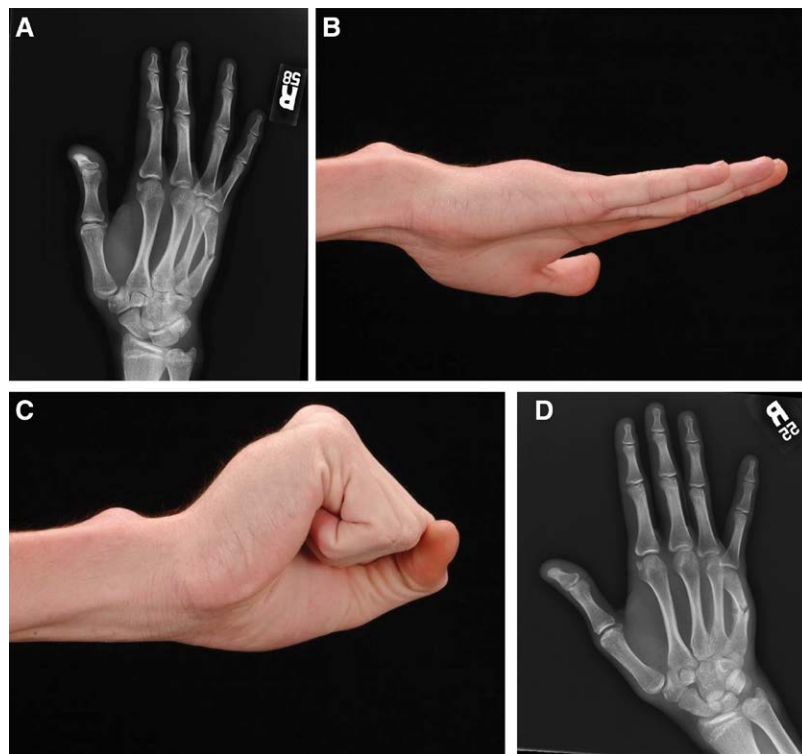


Fig. 4. Right fifth metacarpal shaft fracture. A, A 22-year-old man sustained a fracture to the little finger metacarpal. Apex dorsal angulation is observed and reduction attempted, but the fracture pattern resumed the pre-reduction position. B, C, The range of motion remained normal and therefore the patient did not require operative intervention. A prominent dorsal hump remained without effect on functional range of motion. D, Evidence of uneventful fracture healing despite ongoing motion.

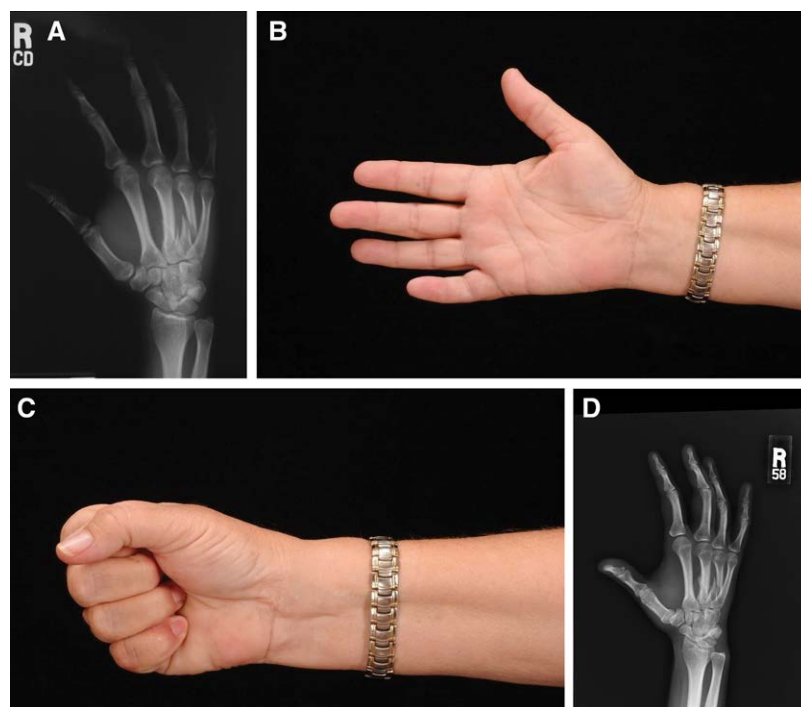


Fig. 5. Right third and fourth metacarpal fractures. A, A 61-year-old woman sustained multiple metacarpal fractures (third/fourth) of the right hand. B, C, Her range of motion was excellent on initial presentation. D, Despite immediate motion, the fractures healed uneventfully.

Friedrich et al.⁴⁹ identified that the highest quality of evidence in the management of metacarpal fractures was found in studies of nonsurgical treatment. Al-Qattan, in a series of 42 patients, found that 54 metacarpal spiral fractures, often considered inherently unstable, had normal range of motion when treated with immediate mobilization.⁵⁴ All extensor lags resolved and grip strength was 94% of the contralateral uninjured hand. In a prospective study of proximal phalangeal fractures treated with immediate controlled range of motion irrespective of fracture geometry, Rajesh et al found that 72% of patients had normal range of motion.⁵⁵ There are limited studies that comparatively evaluated nonsurgical versus surgical management of hand fractures. Westbrook et al had performed a retrospective comparative study of operative versus nonoperative fractures and found that patients treated nonoperatively had better disabilities of the arm, shoulder, and hand and aesthetic scores.⁵⁶ Overall, however, there was no significant difference between groups. The key conclusion was that early motion was inherent and important for both groups. Feehan and Bassett conducted a systematic review to determine the scientific evidence for the effect of early motion, defined as less than 21 days after a fracture, and had an effect on fracture healing with functional outcomes.⁵⁷ Their review concluded that simple closed metacarpal fractures treated with early motion had the potential to result in early recovery of mobility and strength, accelerated early return to work, and did not affect fracture alignment.

One fear of uncontrolled motion is nonunion. Nonunion of metacarpal and phalangeal fractures is rare.

Nonunion rates are similar for conservative and operative approaches.⁵⁶⁻⁶³ Stiffness, on the other hand, is a common complication. Motion is needed to counteract stiffness. Mills et al reported the first examination of the nonunion rates of various fractures in a large population. The article reviews 4895 patients with nonunion.⁵⁸ Hand fracture nonunion occurs at low frequencies (at least those symptomatic) compared with other frequently fractured bones of the body.⁵⁹ Zura et al recently reported on 309,330 fractures attempting to identify probability of nonunion from specific risk factors.⁵⁹ The risk factors identified were multiple concurrent fractures, nonsteroidal anti-inflammatory prescription medications, opioid use, open fractures, anticoagulant use, and rheumatoid arthritis. The lowest nonunion rate was identified with metacarpal fractures at 1.5% and as high as 15.5% in scaphoid fractures. In general, nonunion rate appears to be a function of fracture severity, fracture location, disease comorbidity, and medication use.⁵⁹⁻⁶⁴

Kollitz et al conducted a review of metacarpal fractures treatment and complications.⁶⁵ Although parameters for operative intervention were documented, much of these recommendations were based on low-level evidence such as expert opinion. Cadaver studies identifying effects of foreshortening of metacarpals as a result of a fracture demonstrate that every 2 mm of shortening lead to 7 degrees of extensor lag, but these findings may not translate to physical findings clinically. Clinical correlation studies do not exist. Similarly, angulation parameters are based on old doctrines and not current evidence-based literature.⁶⁵

Kollitz et al stated that “Careful attention on exam must be paid to the ability to extend the PIP in both MCP flexion and extension.”⁶⁵ This implies that if this motion is preserved, surgery is not warranted despite an appearance of an x-ray. Interestingly, Tosti et al found that radiograph angles of fractures rather than the patient’s clinical physical examination was a significant determinant of surgeons’ desire for operative intervention.⁶⁶ There is a paucity of clinical evidence through large cases series, comparative studies, or randomized clinical studies that confirms fracture deformation angles, extent of foreshortening, fracture type or location, or presence of multiple fractures, or the so-called unstable fractures should define the decision of operative intervention. There are a number of studies, however, that identify the complication rates of operative intervention of hand fractures.⁶⁷⁻⁷²

Freeland observed the most frequent consequence of hand fracture management was stiffness.⁶⁷ He makes note of the fact that surgery designed to promote healing may cause harm by overzealous dissection which accentuates the stiffness. He goes further by stating that closed treatment may minimize the risk. Attempts to get the most anatomical reduction through soft tissue release from the bone fragments may violate tissue planes, which can result in more scarring, but it may also diminish the blood supply to the remaining bone fragments, resulting in avascular necrosis and subsequent fibrosis around the fragment. His principles, and those followed by many hand surgeons, include minimizing dissection, avoiding periosteal stripping,

providing anatomic alignment, maintaining length, and providing stability to the fracture.^{68,69} One surgeon may prefer to use plates and screws while others prefer to use K wires. Comparative studies on the various fixation techniques do not, in general, favor one technique over the other. The choice of fixation technique that is the most optimal is really multifactorial, including the surgeon’s preferences and beliefs, regardless of the fracture site and pattern, soft tissue damage, patient’s comorbidity and compliance, and whether the fracture is open or closed.

Complication rates of operative treatment of phalangeal and metacarpal fractures are not insignificant, reaching as high as 64%.⁶⁸ Stiffness is the most commonly reported complication.^{1-7,17,33,45,68,70} Residual extensor lag has been reported as high as 14% with open reduction internal fixation techniques.⁶⁸ Page and Stern reported a 92% total complication rate of phalangeal fractures treated operatively, with stiffness being the most frequent at 67%.¹⁷ Thirty-six percent of metacarpal fractures had complications with a 13% stiffness rate. Many of these patients required secondary surgeries to treat the stiffness. Ip reported a 10% stiff finger rate of the 924 fractures treated operatively.⁷¹ Of these patients, 91% required secondary surgeries to treat the stiffness. In their review of the literature, Lutsky et al concluded that patients should be counseled that if digits are stiff after surgical intervention for hand fractures, restoration of full motion is unlikely despite further surgeries to regain motion.⁷² Kollitz et al also noted that surgery to alleviate stiffness after operative

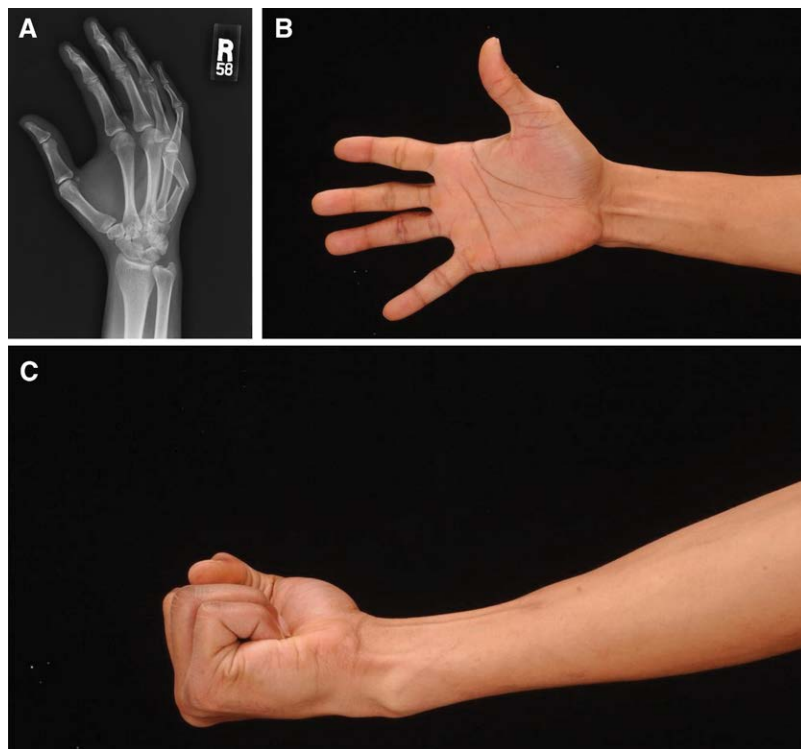


Fig. 6. Right fifth metacarpal shaft fracture. A, Oblique view of the right hand. A 27-year-old man sustained a 70-degree dorsal apex angulation of the right small finger metacarpal. B, C Attempted reduction failed, but function was normal. Nonoperative management was chosen with no long-term stiffness.

treatment of hand fractures has less predictable success while noting that nonoperative treatment of fractures has substantial tolerance to angulation and shortening.⁶⁵

CONCLUSIONS IN PREVENTING STIFFNESS

Operative intervention introduces scarring and may actually create greater stiffness than if a conservative approach had been undertaken. Fractures that will heal effectively where the patient recovers normal function should be treated conservatively. A malaligned fracture does not mean the digit will be malaligned. Obviously, fractures that have a pattern that results in scissoring digits require reduction. If that reduction is not maintained and scissoring continues, an operative intervention is required. If the patient has normal range of motion and normal digital alignment at presentation, then the malaligned, unstable fracture does not warrant an operative intervention (Fig. 6A–C). The over-reaching tenet of preventing stiffness requires moving the fingers. The radiographic fracture pattern alone should not dictate the need for surgery. Furthermore, we can

induce stiffness and impair function through our best intent of fracture stabilization (Fig. 7A–D).⁷³ (See figure 1, Supplemental Digital Content 1, which displays the follow-up range of motion for patient from Figure 7 after fracture healing of the left thumb proximal phalanx fracture demonstrating thumb opposition, extension, and flexion, and composite fist. <http://links.lww.com/PRSGO/B814>.)

Exceptions may include open fractures, intra-articular incongruities that limit motion, fracture-dislocations with subluxation, avulsion fractures with inherent ligamentous or tendon disruption resulting in joint instability (such as mallet, boutonniere, ulnar collateral ligament, or jersey finger fracture avulsions), condylar fractures, some pilon fractures, and Bennett's, Rolando or reverse Bennett's fractures with 2-mm articular surface step offs. These exceptions require individualized management.¹⁻¹⁴ The hand can maintain its normal function with most fractures despite the degree of angulation and despite multiple fractures, even with significant displacement (Fig. 5A).

TENETS OF HAND FRACTURE MANAGEMENT

1. Examine the patient first, not the radiograph. Foreshortened metacarpals, loss of metacarpal head dorsal prominence (MCP joint), dorsal metacarpal hump deformities, and minor extensor lags should be identified but do not necessarily need to be corrected to have normal function of the hand.
2. Assess range of motion at the first encounter. If patients have a normal cascade with normal or near normal range of motion, allow them to continue controlled range of motion without surgery (Fig. 3A–C).
3. Angular deformities are amenable to attempted closed reduction. Maintaining reduction does not necessarily require surgery if range of motion is preserved (Fig. 4A–C, 6A–C).
4. Scissoring requires correction. Attempt closed reduction. If scissoring is corrected, start immediate controlled range of motion exercises. Anatomic reduction is not required but scissoring must be corrected. If scissoring persists, proceed to operative intervention.
5. Edema control. A swollen hand may not permit the surgeons to assess the range of motion appropriately. Provide a protective, removable thermoplast orthosis. Therapists will work on edema control and start gentle controlled range of motion. (See figure 2, Supplemental Digital Content 2, which displays the edema control (compression garments) and assisted (buddy-tape) range of motion exercises utilized for digits limited by swelling. <http://links.lww.com/PRSGO/B815>.)
6. Provide a protective, removable thermoplast orthosis for night time use. This is for pain control and inadvertent human roller injury while sleeping.
7. Orthoses are removed multiple times a day for controlled range of motion exercises throughout the day. Reliable patients need not wear the orthosis during the day



Fig. 7. Left thumb proximal phalanx fracture. A, B, AP view and lateral radiograph of the left hand. A 55-year-old woman sustained a left thumb proximal phalanx fracture with significant displacement. Nonoperative management with splinting and early gentle range of motion was initiated. C, D, Note the degree of bony remodeling on follow up AP and lateral radiographs.

8. Controlled range of motion exercises means allowing gentle active and passive range of motion.
9. Patients are allowed to perform other activities around the house. If a task causes pain, do not do that task. Otherwise the task is permitted as long it is not heavy lifting.
10. The removable orthosis can be discontinued at 3 weeks.
11. Patients require assessment 1 week after the initial visit to evaluate for new malrotation or loss of function. Orthoses are modified as the edema subsides. Patients are then seen 2 weeks after this follow-up encounter. Digit alignment needs to be evaluated in flexion and extension. Note, the little finger has an element of natural overlap with the ring finger. It is only in full flexion can one evaluate minor degrees of malrotation or scissoring in the little finger.
12. Multiple fractures do not necessarily require operative fixation. The same principles apply as noted above (Fig. 5).

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