Malunion and Nonunion of the Metacarpals and Phalanges

David Ring


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Malunion and Nonunion of the Metacarpals and Phalanges

BY DAVID RING, MD

An Instructional Course Lecture, American Academy of Orthopaedic Surgeons

The management of nonunion and malunion is more complex in the hand than it is elsewhere in the skeleton. Good hand function depends on the gliding of complex flexor and extensor tendon mechanisms, joint mobility, sensibility, good skin cover, and adequate vascularity. Preexisting problems related to any of these factors may limit the usefulness of the digit, and operative interventions can cause additional scarring and dysfunction. Consequently, the management of nonunions and malunions in the hand is predicated on a careful analysis of the risks and benefits of operative intervention as well as the functional goals and the likelihood that operative intervention can achieve them.

Nonunion

Nonunion is unusual in the metacarpals and phalanges and, when it occurs, it is frequently associated with a complex injury or a treatment complication. Commonly associated problems include nerve injury, tendon adhesions, joint stiffness, infection, and bone loss. As a result, the nonunion may not be the most important problem, and therefore salvage procedures, such as arthrodesis, and amputation are considered as often as are attempts to achieve union.

It is difficult to definitively establish the presence of a nonunion in a bone in the hand. The radiographic appearance alone is unreliable. It has long been recognized that fracture lines can be seen radiographically for up to a year in a hand fracture that will subsequently heal uneventfully (Figs. 1-A, 1-B, and 1-C). Instability, deformity, and implant failure (after operative treatment) are more reliable clinical indicators of nonunion (Figs. 2-A, 2-B, and 2-C). Persistent pain in the hand after an injury is multifactorial, but pain should increase the suspicion of a nonunion.

In 1935, Smith and Rider presented a detailed radiographic analysis of 100 consecutive phalangeal fractures. They observed delays in radiographic union of as long as fourteen months and concluded that the average time before patients have radiographic evidence of union is longer than the expected time for union.
complete healing is five months; clinical evidence of union (defined as the patient’s ability to return to his or her usual occupation) is apparent in about one-fourth of the time required before radiographic union is observed; and, on the basis of radiographic evaluation, “it cannot be assumed that there is a lack of bony union until at least one year’s time has elapsed.”

Hypertrophic and synovial nonunions are unusual in the hand. The majority of nonunions in the hand are atrophic, and many are associated with bone defects. Infected nonunions are also seen. Most nonunions follow operative treatment, and many can be related to technical shortcomings such as fixation of the fracture in a distracted position or the combination of a devascularizing exposure and inadequate fixation.

Prolonged immobilization is not warranted for a delayed union in the hand, primarily because the hand cannot tolerate immobilization; it becomes permanently stiff after a relatively short duration of inactivity. Immobilization for more than six weeks is rarely justified. Exercises are generally advanced in spite of the radiographic appearance. The role of ultrasound or electrical stimulation of fracture-healing in the hand is limited as these modalities require the digit to be immobilized, which is contraindicated because of its effect on overall hand function. Also, most nonunions are atrophic and these modalities are less effective for atrophic nonunions. Nonunions in the hand are usually associated with other problems, such as tendon adhesions or joint contracture, that require operative treatment, and usually all of the patient’s hand-related problems can be operatively managed at the same time. Operative intervention is undertaken when there are clinical and radiographic signs of nonunion.

Amputation is preferred for nonunions associated with permanent sensory loss in the finger, chronic infection, severe stiffness, or poor skin coverage. In general, the finger is a liability when it is being effectively excluded or bypassed during functional tasks, and it is likely to remain a liability even if the bone unites. Stiff fingers and fingers that require protection often lead to stiffness in adjacent fingers, which further compromises hand function. The removal of the offending finger usually improves the function of the hand, and recovery is rapid.

Arthrodesis is useful for treatment of periarticular or intra-articular nonunions when the involved joint is stiff. The stiff joint is unlikely to regain...
useful motion even if the fracture heals. Arthrodesis of the stiff joint allows the internal fixation to cross the joint, which facilitates stable internal fixation. The internal fixation device can be longer than an implant used to stabilize a periarticular or intra-articular fracture without fusion of the adjacent joint. When an arthrodesis is combined with treatment of a nonunion, both the joint and the nonunion must be débrided, bone-grafted, and stabilized.

Internal fixation and autogenous bone-grafting to obtain union is reserved for digits that will provide useful function once the fracture has healed. In most cases, tenolysis and arthrolysis are needed both to improve the functional result and to limit stresses on the implants during active motion. The operative fixation of the nonunion and the required releases can and should be done at the same time.

Stable and strong internal fixation is required to maintain alignment, achieve healing, and allow immediate functional exercises after the tenolysis and arthrolysis. As a general rule, it is advisable to treat nonunions with an implant that is slightly larger than an implant that would be used for a fracture of the same bone. For example, a nonunion of a phalanx is treated with a plate with 2.0-mm screws rather than with the 1.5-mm screws that are typically used for most acute fractures of the phalanx. Nonunions near the joint can be secured with a T-shaped plate, a small blade-plate, or a plate with fixed-angle screws.

Autogenous bone is still the standard for grafting, particularly in the hand. Nonstructural (cancellous) bone graft provides adequate stimulation of healing in most cases. Structural (cortico cancellous) bone grafts facilitate sharing of the mechanical loads with the implants (Fig. 3). A semistructural graft can be fashioned from compacted cancellous bone graft: a 1.0-mL tuberculin syringe is used to compress the cancellous bone graft and compact it into a bone peg that can be placed into a defect and engage the medullary canals of both fragments (Figs. 4-A through 4-G).
Infected nonunions are treated with parenteral antibiotics and débridement of infected and devitalized bone and soft tissue. Temporary external fixation or a wire cement spacer can be used to maintain length and alignment during this period. Stable, compliant, well-vascularized skin coverage is necessary and may require ancillary skin procedures. Once the milieu has been optimized, internal fixation and autogenous bone-grafting can be performed.

There are few published reports of the results of treatment of metacarpal and phalangeal nonunions. Jupiter et al. described twenty-five consecutive delayed unions and nonunions (sixteen in the phalanges and nine in the metacarpals) in twenty-three patients, excluding those with nonunion associated with bone defects or replantation. In contrast to Smith and Rider, Jupiter et al. defined a delayed union as lack of osseous consolidation on radiographs made four months after the injury, arguing that immobilization for longer than four months would seriously compromise function. In their study, fifteen fractures were the result of a complex injury mechanism (six were machine-related, eight were crush injuries, and one was a gunshot injury). Thirteen fractures were open, and two were infected. Twelve patients had tendon injuries, six had substantial soft-tissue loss, and four had a nerve injury. Only ten nonunions were unstable. This finding, combined with the fact that Jupiter et al. diagnosed nonunion relatively earlier than did Smith and Rider, suggests the possibility that they overinterpreted delayed radiographic consolidation. A variety of treatment techniques were used in the study by Jupiter et al., and, while the results of plate-and-screw fixation (with tenolysis, arthrolysis, and bone-grafting) seemed to have achieved a more functional digit than did Kirschner wire fixation, treatment resulted in few digits with good function. Thus, nonunion in the hand is typically such a complex problem that even optimal treatment cannot be expected to result in a well-functioning digit.

**Malunion**

Malunion of a bone in the hand presents a combined functional and aesthetic problem. For instance, slight overlap of adjacent digits due to rotational malunion may be unsettling and unsightly but it is consistent with good hand function. However, substantial overlap with finger flexion can be quite dysfunctional. Similarly, a patient with a malunion associated with a substantially angulated fracture of the metacarpal neck of the small finger (a so-called boxer’s fracture) may be upset that the knuckle has seemingly changed positions (sunken knuckle), but hand function is usually normal or nearly normal. Likewise, a more proximal diaphyseal malunion of the small-finger metacarpal can contribute to tendon imbalance and flexion contracture of the proximal interphalangeal joint, but the hand may function very well.

While most malunions involve a combination of rotational or angular deformities, shortening, and/or articular incongruity, usually there is one...
Figs. 4-A through 4-G  A cancellous bone graft can be compacted into a semistructural cylinder (case courtesy of Jesse B. Jupiter, MD).  **Fig. 4-A** A complex thumb injury with bone and skin defects was treated with external fixation.  **Fig. 4-B** The skin defects were grafted, and a bone defect resulted in a nonunion at the base of the proximal phalanx.

As part of the operative treatment of the nonunion, a 1-mL tuberculin syringe was used to compress the cancellous bone graft (Fig. 4-C), which created a relatively compact and solid core of bone (Fig. 4-D).
major component to the deformity that is causing the functional problem and leading to the consideration of operative intervention.

Strauch et al. examined the relationship between shortening of the metacarpal and an inability to fully extend the metacarpophalangeal joint (extensor lag) in a study of cadavera. They observed an average 7° lag for every 2 mm of shortening. They speculated that the fact that this amount of lag is not usually observed clinically may be related to the capacity of the metacarpophalangeal joint to hyperextend.

Vahey et al. performed a similar cadaver study to determine the effect of shortening and angulation of the proximal phalanx on extensor lag at the proximal interphalangeal joint. A linear relationship was observed between the lag and shortening (12° of lag/1 mm of shortening), and increased angulation was seen to result in a proportionately increased lag.

Surgeons have debated about whether it is preferable to correct the malunion at the site of the fracture or to perform a corrective procedure at a separate site. For instance, malrotation of a phalangeal fracture can be addressed with a rotational osteotomy of the metacarpal. The advantages of correction at the site of the original fracture are that the procedure can address combined deformity, provide the ability to perform tenolysis and capsulolysis, and avoid the zigzag finger deformity that can occur when a compensatory deformity is intentionally created at the metacarpal to address a phalangeal deformity. In addition, only relatively minor corrections are possible (about ≤15°) through the metacarpal. However, metacarpal rotational osteotomy is technically easier and avoids additional handling of the extensor hood over the phalanges, which can increase stiffness. I prefer to perform corrective osteotomy at the original fracture site when feasible.

Correction of the deformity at the site of the malunion can be accomplished with a closing or an opening wedge osteotomy. A closing wedge osteotomy is easier and avoids the need for bone graft, but it shortens the digit. A structural bone graft is not necessary with an opening wedge osteotomy if secure fixation with a plate and screws is accomplished, but a cancellous bone graft should be used. Rotational malalignment of the digit can be addressed with an osteotomy at the base of the metacarpal. Fixa-

Fig. 4-E
The core of bone was inserted into the fracture site and the medullary canal of the phalanx. The fracture was stabilized with a 2.0-mm condylar blade-plate.

Although the hand remained stiff, the thumb was made stable.
tion with Kirschner wires is easier to adjust than is plate fixation, but stable plate-and-screw fixation allows exercises of the hand to begin immediately to limit stiffness. Alternatively, a rotational step-cut osteotomy can be performed at the diaphyseal level and can be fixed with a cerclage wire.

Gross and Gelberman performed experiments on cadavers to determine the maximal rotational correction of a phalangeal malunion that can be achieved with a metacarpal osteotomy. The deep transverse metacarpal ligament limits maximum rotation. They thought that, with the use of Kirschner wires and protractors, it was possible to correct up to 18° of malrotation in the index, long, and ring fingers and up to 30° of malrotation in the small finger, depending on the direction of the malrotation.

The timing of operative intervention is important. If fracture malalignment is addressed within ten weeks after an injury, it is often possible to recreate the original fracture line by mobilizing the fracture callus. When there is enough malalignment to predict functional loss, there is no value in waiting to perform the correction. Osseous union was obtained in all patients, and satisfactory correction was achieved in 76%. A net gain in motion was observed in 89% of the patients.

Trumble and Gilbert described eleven patients who had been treated with an extra-articular osteotomy for a malunited unicondylar fracture of the phalangeal head. Their technique involves an intercondylar wedge resection combined with a sliding osteotomy of the malunited condyle and supporting cortex (Fig. 7). This creates a larger fragment that is easier to manipulate and to repair with screws.

Buchler et al. reviewed the results in fifty-seven patients in whom a total of fifty-nine osteotomies had been performed to correct deformities in one or more planes. The osteotomy was done at the site of the malunion, and 50% of the patients had a concomitant teno-capsulolysis. Osseous union was obtained in all patients, and satisfactory correction was achieved in 76%. A net gain in motion was observed in 89% of the patients.

Trumble and Gilbert described eleven patients who had been treated with an extra-articular osteotomy se-
Fig. 6-A A twenty-five-year-old man was seen four weeks after a fracture of the distal phalanx. The deformity was thought to be inconsistent with good finger function. Fig. 6-B An open reduction was performed prior to complete fracture-healing. Fig. 6-C The fracture healed in good alignment, and functional motion was achieved.

Unicondylar malunions can be difficult to handle. a: Osteotomy of the fracture fragment creates a small, articular fragment that can be difficult to secure internally and may be more susceptible to osteonecrosis. b: An alternative suggested by Teoh et al. is to resect a wedge of bone between the condyles. c: Next, a counter cut is made at the diaphyseal level, and the entire malunited condyle is advanced. d: The larger fragment thus created is easier to manipulate and secure. (Reprinted, with permission, from: Teoh LC, Yong FC, Chong KC. Condylar advancement osteotomy for correcting condylar malunion of the finger. J Hand Surg [Br]. 2002;27:31.)
cured with a plate and screws to correct a complex phalangeal malunion. Union and correction of the deformity were achieved in all patients. The average gain in motion at the proximal and distal interphalangeal joints was 15° and 10°, respectively.

Overview
Nonunions and malunions in the hand present challenges that differ from those created by similar problems at other skeletal sites. A poorly functioning finger may represent a liability to the hand, and achievement of union or improved alignment alone may not be sufficient to justify retention of the digit. Similarly, with periarthicular nonunions, the high likelihood of severe stiffness of the adjacent joint after union of the fracture often makes arthrodesis a more appealing option. Even when union, stability, and improved alignment are achieved, the majority of fingers will remain stiff and have limited function. Operative intervention to treat nonunion and malunion in the metacarpals and phalanges is worthwhile only when the goals of intervention are well defined and achievable.

David Ring, MD
Hand and Upper Extremity Service, Department of Orthopaedic Surgery, Massachusetts General Hospital, Yawkey Center, Suite 2100, Boston, MA 02114. E-mail address: dring@partners.org

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