Fractures and Dislocations

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Basic Anatomy of the Thumb

The thumb consists of only two phalanges, the proximal and distal, and one metacarpal, but it has greater movement than the other fingers, and it also has three plane motions from the trapeziometacarpal joint like flexion, extension, abduction, adduction, opposition, and retropulsion. The thumb interphalangeal (IP) and metacarpophalangeal (MCP) joints are hinge joints stabilized by proper and accessory collateral ligaments and volar plate. At the MCP joint, the proper collateral ligament arises from the lateral condyles and inserts on the volar aspect of the proximal phalanx. The accessory collateral ligaments arise more volarly and insert on the volar plate and sesamoids. The trapeziometacarpal joint, the key joint of the thumb, gives movements in three planes like sagittal, coronal, and axial planes with the unique anatomy, so-called the saddle joint. This joint consists of the concavo-convex articular surfaces of the thumb metacarpal base and the trapezium oriented in opposition to one another with perpendicular axes similar to two reciprocally opposed saddles. The joint is stabilized by its capsule and the palmar oblique, intermetacarpal, dorsoradial, and dorsal oblique ligaments. The primary restraints to dorsal subluxation and dislocation are the palmar oblique ligament and dorsoradial ligament [1].

All these three planar movements are controlled by extrinsic and intrinsic muscles like the flexor pollicis longus, the abductor pollicis longus, the extensor pollicis brevis, the thenar muscles (the adductor pollicis brevis, flexor pollicis brevis, and opponens pollicis), and the adductor pollicis muscle. The median nerve innervates most thumb muscles except the adductor pollicis and the deep head of the flexor pollicis brevis, which are innervated by the ulnar nerve. The blood supply is mainly from the princeps pollicis artery. Because of the thumb's unique, oblique orientation with respect to the palm, radiographs need to be taken orthogonally to the thumb, the lateral with the thumbnail perpendicular to the X-ray film, and either the posteroanterior or the anteroposterior (Robert) view with the thumbnail parallel to the cassette. The thumb carpometacarpal joint is best evaluated with a Robert view in which the forearm is fully pronated with the dorsum of the thumb on the cassette and the X-ray beam angled 15° from distal to proximal. (Fig. 6.1).

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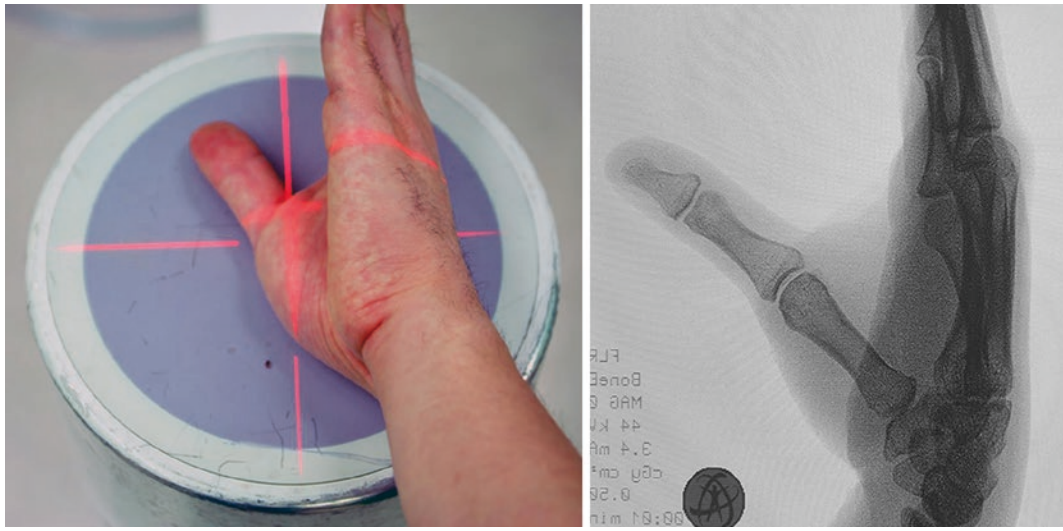

Fig. 6.1 The thumb carpometacarpal joint is best evaluated with a Robert view in which the forearm is fully pronated with the dorsum of the thumb on the cassette and the X-ray beam angled 15° from distal to proximal

Thumb Phalangeal Fractures

Distal Phalanx Fractures

Extra-articular Fractures

Distal phalanx fractures are common sport- and work-related injuries and account for around 50% of all hand fractures [2]. These fractures are commonly from direct trauma or crush injuries, and the nail matrix and nail plate are often injured together because the nail bed adheres closely to the dorsum of the phalanx. Sometimes severe soft tissue injuries combine with distal phalangeal fractures. Deep laceration, hyperextension, hyperflexion, rotation, and, uncommonly, axial load can produce these fractures. The most common types of distal phalanx fractures are comminuted distal tuft fractures, longitudinal fractures, transverse fractures, avulsion fractures, and intra-articular fractures of the base.

A fracture of the fine cancellous bone at the distal tip of the phalanx is termed a tuft fracture. Tuft fractures are usually caused by a crush injury and comminuted in nature and are almost always associated with damage to the nail matrix or pulp or both. The tuft fractures are generally stable due to the adherence of the fibrous septa. Splint immobilization including the IP joint for 3–4 weeks is usually indicated without reduction or fixation. When there is painful subungual hematoma, it should be evacuated. Dermal and nail matrix lacerations should be repaired when indicated. Follow-up radiographs often do not show full osseous union, but it does not mean the need of operative treatment. Stable fibrous union is usually asymptomatic.

Transverse shaft fractures of distal phalanx tend to be quite unstable and often presented with a pseudomallet appearance as the fracture line is often just distal to the insertion of the extensor pollicis longus tendon. Transverse fractures should be evaluated for angulation as these are at greater risk of displacement. Widening of the fracture line may indicate entrapment of the nail bed within a transverse distal phalanx fracture (Fig. 6.2). If the fractures are minimally displaced or stable after reduction, they can be immobilized with an extension splint and care of soft tissue injury. If avulsed, the nail plate should be reduced beneath the nail fold to reapproximate the nail matrix and stabilize the fracture. However, in case reduction cannot be held in a splint, it necessitates an insertion of a longitudinal Kirschner wire driven in a retrograde fashion from the distal hyponychium just under the nail plate across the fracture and into the head of the proximal phalanx (Fig. 6.2). The Kirschner wire is removed after achieving clinical bone union usually around 4 weeks after surgery.

Fig. 6.2 Transverse fracture of the distal phalanx of the thumb. Two longitudinal K-wires were driven to maintain reduction in a retrograde fashion from the distal hyponychium just under the nail plate across the fracture and into the head of the proximal phalanx

Fig. 6.3 Open comminuted longitudinal fracture of the distal phalanx of the thumb. The fracture was reduced and pinned after repair of the nail matrix and reduction of the nail plate

Longitudinal extra-articular shaft fractures of the distal phalanx are not common, and these fractures are usually nondisplaced and stable. If displaced, the fracture can be reduced and pinned (Fig. 6.3). Seymour fractures are open fractures of the distal phalanx in children due to a fracture at the physis (Salter-Harris type I or II). Like other open fractures, Seymour fractures need

operative irrigation and debridement. Then, the entrapped nail matrix should be pulled out to reduce the fractures.

Intra-articular Fractures and Avulsions

Mallet Thumb

Avulsion fractures of the dorsal base of the distal phalanx are designated a "mallet finger." Although mallet finger is a common fingertip injury, mallet thumb is relatively uncommon (only 2–3% of all mallet injuries). Like other mallet fingers, mallet thumb is caused by forced flexion of an extended fingertip. Less common hyperextension or hyperextension/axial loading tends to cause the larger fractures and volar subluxation of the distal phalanx. In children, mallet thumb causes Salter-Harris type III or IV fractures. The goal of treating mallet fractures is to establish a congruent joint and minimize the final extension lag. If the fracture involves less than 30% of the joint and without volar subluxation of the distal phalanx, it can be treated by continuous extension splinting of the IP joint for 6 weeks. However, the fractures associated with volar subluxation of the distal phalanx or joint incongruity and the fractures greater than 30% of the joint should be treated surgically to avoid consequences like traumatic osteoarthritis, swan neck deformity, and persistent IP joint stiffness. Various surgical techniques have been described to treat mallet fingers like extension block pinning, percutaneous direct fragment fixation, external fixator, tension band wire technique, pullout wire technique, internal suture, tenodesis, and open reduction with Kirschner wire fixation or fixation with plate and/or screws, and they can be used to treat mallet thumbs as well.

Extension Block Technique

The mallet thumb is placed on a receiver of an image intensifier to get a true lateral image. Then, the IP joint of the thumb is in maximum flexion while checking the mallet fracture fragment to move distally and little bit volarly. A 0.9 mm K-wire is introduced just posterior to the fragment and driven into the proximal phalangeal head at an angle of 30–45° to its long axis. The fracture is reduced with the IP joint in traction and slight extension but still in 10° flexion. When the dorsal fragment is not reduced exactly, a second dorsal block wire can be needed to reduce it. The other 0.9 mm K-wire is then advanced from the volar or lateral side of the finger and across the IP joint to hold it in slight flexion [3]. The wires are cut short, and a volar aluminum splint is applied to protect. The wires are removed at 6 weeks, followed by intermittent volar splinting for 2 weeks.

Open Reduction and Fixation

Occasionally an open reduction and fixation is required to reposition significantly displaced mallet fragments or chronic mallet fractures to remove the callus that prevents indirect reduction. There are several dorsal approaches using variants of extensile incision to the interphalangeal joint for the manipulation and fixation of the fracture fragments [4]. When indicated, a transverse crease incision is placed directly over the fracture site, which can be localized with the aid of fluoroscopy. Once the fracture site is exposed, the fracture fragment is intentionally displaced, and the hematoma, if present, is removed. Then, the fracture fragment is manipulated and reduced with the aid of a periosteal elevator or a similar instrument with blunt tip and fixed with 0.7 mm or smaller diameter K-wires or sometimes hypodermic needles to maintain its reduction. In this step, surgeons need to be careful not to break the small dorsal fragment with reduction forceps and not to damage the terminal tendon insertion. The wires are removed at 6 weeks, followed by intermittent volar splinting for 2 weeks. If the fragment is big enough, a specially designed plate like a hook plate can be applied to fix it (Fig. 6.4). The plate construct can be removed at 3 months when the fracture has healed completely.

Avulsion Fractures of the Volar Lip

Avulsion fractures of the volar lip of the base of the distal phalanx usually represent impaction fractures after a dorsal IP dislocation or, rarely, avulsion of the flexor pollicis longus, called the

Fig. 6.4 Mallet fracture of the distal phalanx of the thumb. A hook plate was applied to fix the displaced fragment with a dorsal approach

Fig. 6.5 Volar lip fracture of the distal phalanx of the thumb with dorsal subluxation of the distal interphalangeal joint which was transfixed with two K-wires after reduction

bony jersey finger. If the avulsion fractures are associated with unstable IP joints, disruptions of the collateral ligaments and the volar plate will be present. In these cases, the IP joints can be transfixed with a K-wire to immobilize them for 4 weeks (Fig. 6.5). The bony jersey finger is uncommon but usually needs surgical fixation with suture anchor, pullout wire/button, or mini-screws depending on the size of bony fragments using a volar zigzag incision [5]. Open fixation is usually possible when that is diagnosed within 10 days of injury.

Proximal Phalanx Fractures

Displaced spiral or oblique fractures of the proximal phalanx can be treated by percutaneous pinning or by open reduction using either Kirschner wires or interfragmentary screws. Transverse proximal phalanx fractures tend to angulate the apex volarly by the pull of the thenar intrinsics on the proximal fragment and the extensor pollicis longus on the distal fragment. If there is more than 20–30° of angulation in the lateral plane, it results in an extensor lag of the IP joint, so it should be reduced and maintained by percutaneous pinning or by open reduction with either Kirschner wires or interfragmentary screws (Fig. 6.6). If open reduction of a fracture of the proximal phalanx is indicated, a dorsal "Y"-shaped incision with sparing the extensor pollicis longus insertion is useful. Then, the fracture can be reduced indirectly or directly while moving the extensor pollicis longus side to side.

Metacarpal Fractures

Fractures of the thumb metacarpal can occur in three locations: shaft and base fractures and intra-articular fractures of the trapeziometacarpal joint.

Extra-articular Fractures

Extra-articular fractures through the base are common and are usually transverse or mildly oblique. Angulation up to 30° is acceptable for extra-articular thumb metacarpal fractures due to the motion at the TM joint. However, apex dorsal angulation of more than 30° will narrow the web space between the thumb and index finger and cause compensatory metacarpophalangeal joint hyperextension, which can result in unacceptable malunion. So, the extra-articular metacarpal frac-

Fig. 6.6 Bicondylar fracture of the proximal phalanx of the thumb. Multiple mini-screws were inserted after open reduction to fix the fragments of the proximal phalanx

tures which are angulated more than 30° are indicated for closed or open reduction to prevent unacceptable malunion. A true lateral radiograph, having superimposition of the thumb MP joint sesamoids, is necessary to evaluate the degree of angulation. The majority of extra-articular metacarpal fractures can be treated with immobilization in a thumb spica cast or splint that excludes the distal phalanx with or without reduction maneuver. The displaced thumb metacarpal fractures can be easily reduced by longitudinal traction, downward pressure on the apex of the fracture angulation with mild pronation of the distal fragment, and thumb extension. If an acceptable reduction cannot be maintained with immobilization alone, these fractures are needed to fix with crossed two Kirschner wires (Fig. 6.7). Some surgeons prefer open reduction and internal fixation with plate and screws because its construct provides a more stable fixation than K-wires that can permit earlier motion and return to daily activities. The fracture is approached by splitting the dorsal apparatus between the extensor pollicis longus and extensor pollicis brevis.

Comminuted thumb metacarpal shaft fractures are usually the result of direct trauma and are often associated with soft tissue injury. Fracture stabilization must be individualized. Open shaft fractures may require an external fixator to prevent metacarpal shortening and to allow soft tissue healing. Extension of the frame to the index metacarpal helps prevent a thumb/index finger web contracture.

Intra-articular Metacarpal Fractures

Metacarpal Head Fractures

Metacarpal head fractures are unusual because the longitudinally directed force that produces them is usually dissipated at the proximal metaphysis or trapeziometacarpal joint. Displaced intra-articular fractures require anatomic reduction. Fixation can be obtained with percutaneous Kirschner pins or by open reduction. The fracture is approached by splitting the dorsal apparatus

Fig. 6.7 Extra-articular fracture of the metacarpal base of the thumb. Angulation could be reduced and fixed with closed or open method

Fig. 6.8 Fracture of the metacarpal head of the thumb. The fracture was approached by splitting the dorsal apparatus between the extensor pollicis longus and extensor pollicis brevis and fixed with a headless compression screw

between the extensor pollicis longus and extensor pollicis brevis (Fig. 6.8). With pin fixation, the thumb is immobilized for 2–3 weeks before initiating motion. With screw fixation, motion is initiated at 5–7 days postoperatively.

Articular Fractures and Dislocations of Thumb Metacarpal Base

Bennett's Fracture

Bennett's fracture refers to an intra-articular two-part fracture separating the volar-ulnar intra-articular fragment from the remaining thumb metacarpal. An indirect axial load on the partially flexed metacarpal can cause these fractures. The volar-ulnar fragment is held in place by the anterior oblique ligament (the beak ligament) to the trapezium, and the remaining metacarpal displaces dorsal, proximal, and radial direction by the pull of the abductor pollicis longus, extensor pollicis longus, extensor pollicis brevis, and the adductor pollicis longus [6–8]. These fractures are very unstable due to these tendons' pulls. Previously, Gedda classified the Bennett fractures into three types [8], with type 1 representing a fracture with a large single ulnar fragment and subluxation of the metacarpal base. A type 2 fracture represents an impaction fracture without subluxation of the thumb metacarpal. Lastly, a type 3 fracture represents a small

ulnar avulsion fracture in association with metacarpal dislocation.

Axial traction, palmar abduction, and pronation of the metacarpal are applied to achieve proper reduction of the fracture while applying external pressure over the metacarpal base. Thumb extension (hitchhiker position) should be avoided to prevent the joint from displacement. The goal of reduction is less than 1 mm of articular step-off. Whereas Bennett advocated conservative treatment with a thumb spica cast, surgical fixation is needed because poor outcomes have been reported with casting alone [9–12]. So, while the reduction is held, we drill a Kirschner wire obliquely across the trapeziometacarpal joint or to the second metacarpal. An additional K-wire through the metacarpal to the volar-ulnar fragment may be added (Fig. 6.9) [13–15]. If the closed reduction fails, open reduction and internal fixation should follow, most commonly through a Wagner incision [14]. The longitudinal limb of this incision is over the subcutaneous border of the thumb metacarpal (between the abductor pollicis longus and the thenar muscles) and is extended proximally and ulnarly to the radial border of the flexor carpi radialis. The thenar muscles are reflected subperiosteally, the joint capsule is incised, and the fracture is visualized. When articular congruity has been restored, the Bennett fragment is held reduced with either reduction forceps or a small bone hook. Fixation of large fragments is secured with K-wires or a 1.5 mm or 2 mm small screw. An additional trans-articular pin fixation may be needed to protect the reduction. Postoperatively, if pins are used, the trans-articular pin is removed at 4 weeks, and the pins holding the fracture fragment are removed at 6 weeks.

Rolando Fracture

The term *Rolando fracture* is applied to any comminuted intra-articular fracture of the base of the thumb but ideally should be reserved for Y- or T-pattern fractures that include the volar-ulnar Bennett fragment in addition to a dorsal radial fragment. When there are two large fragments, without considerable comminution, conduct open reduction and internal fixation through the Wagner incision as described earlier (Fig. 6.10). Longitudinal traction is applied first, and the two articular fragments are reduced with a reduction clamp and fixed provisionally with K-wires. Various methods of fixation have been described including K-wires, tension banding, and plate and screw fixation [16, 17].

For comminuted fractures, distraction and reliance on ligamentous reduction of the fragments may be used. Distraction can be achieved with oblique traction pinning. Alternatively, the fracture can be spanned and distracted using external fixation [18].

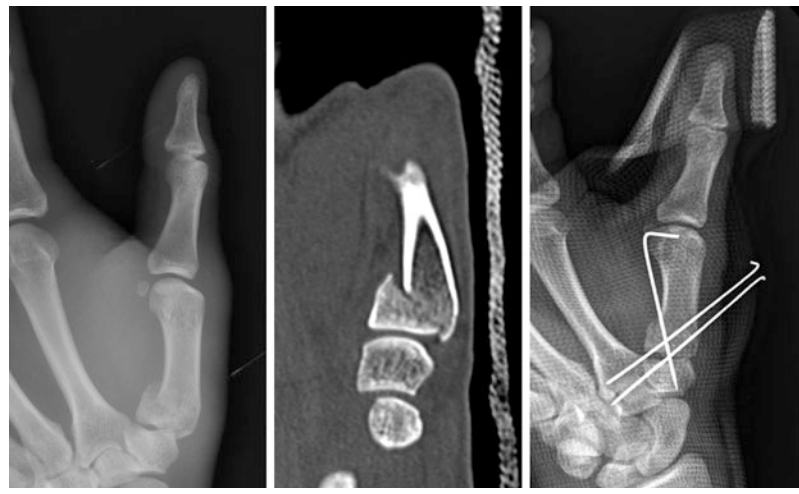

Fig. 6.9 Bennett fracture of the thumb. Proper reduction was achieved with axial traction, palmar abduction, and pronation of the metacarpal while applying external pressure over the metacarpal base. Then, the fracture was stabilized using percutaneous pinning with two K-wires

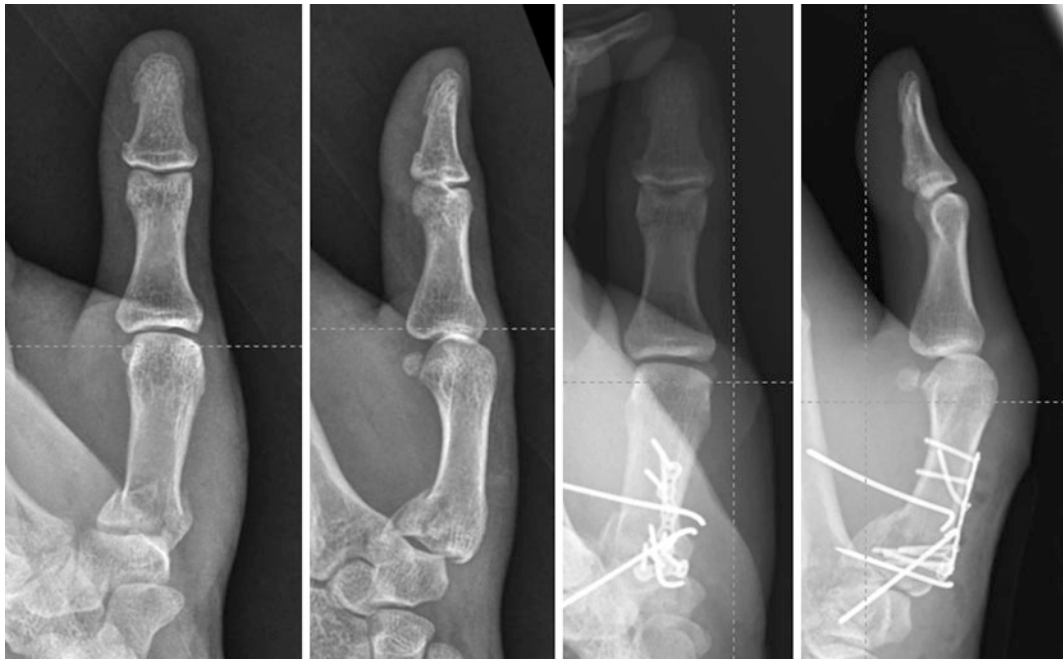

Fig. 6.10 Rolando fracture of the thumb was reduced and fixed through the Wagner incision

Dislocations

Thumb IP Dislocations

Thumb IP joint dislocations are usually dorsal or lateral. Reduction can be easily accomplished with application of direct dorsal pressure on the distal phalanx while applying longitudinal traction under digital block anesthesia [19]. After reduction, stability of the joint should be assessed, and postreduction radiographs should be taken to evaluate for concentric reduction. Treatment consists of immobilization for 2–3 weeks in a finger splint. Instability after reduction is very uncommon.

Irreducible dislocations may be secondary to palmar plate interposition and require open reduction through a dorsal approach. The extensor pollicis longus terminal slip should be protected, and the interposed volar plate should be reduced over the proximal phalanx head. Sometimes partial excision or longitudinal split of the volar plate is required for accurate joint reduction [19]. Trans-articular pinning in full extension for 2–3 weeks is usually adequate if postreduction joint instability is noticed.

Thumb MCP Dislocations

Thumb metacarpophalangeal dislocations are typically dorsal and occur secondary to a hyperextension injury with associated injuries to the collateral ligaments, volar plate, and capsule. Palmar MCP joint dislocations are relatively rare conditions. Dislocations are classified as simple or complex based on reducibility with closed maneuvers. The MCP dislocations present with a hyperextension deformity at the joint and metacarpal adduction. In complex dislocations, the proximally avulsed volar plate or the flexor pollicis longus tendon is often interposed [19, 20]. Before trying closed reduction, proper radiographic evaluation is necessary including standard posteroanterior and true lateral radiographs to evaluate for associated fractures. Closed reduction can be accomplished under local anesthesia with wrist flexion to relax the flexor tendons, gentle recreation of the hyperextension deformity

at the MCP joint, and a palmar-directed force on the base of the proximal phalanx to reduce it onto the metacarpal head. Longitudinal traction should be avoided because the displaced flexor pollicis longus on the ulnar side of the metacarpal head and the displaced adductor pollicis muscle on the ulnar side of the metacarpal can strangle the metacarpal neck and can convert a reducible dislocation into an irreducible one.

If closed reduction fails, open reduction is required, most commonly via a dorsal or volar approach based on surgeon preference. The dorsal approach through the interval between the extensor pollicis brevis and longus has the advantage of minimal risk to the neurovascular bundles, whereas the volar approach with a Bruner incision has the advantage of allowing direct visualization of structures that may be impeding reduction like volar plate, sesamoids, and flexor pollicis longus. After reduction, the thumb is immobilized in a dorsal block splint with the metacarpophalangeal joint in 10° more flexion than the point of instability. Each week thereafter it is extended 10° until terminal extension is obtained. If, after reduction, the joint remains unstable and the collateral ligament is completely torn, operative repair is indicated.

Thumb TM Joint Dislocations

Injuries to the thumb carpometacarpal or trapeziometacarpal joint may be complete or partial. Partial injuries are far more common and result in varying degrees of joint subluxation. Complete injuries with dislocation of the thumb carpometacarpal joint are relatively rare and occur when a flexed metacarpal is loaded axially. Dislocations are invariably dorsoradial and result in tearing of the dorsoradial ligament and volar oblique ligament [1]. These dislocations typically reveal adducted thumbs that reduce with a palmar-directed force or thumb extension. Radiologic evaluation must be performed to rule out associated fractures at the joints.

The dislocated joints need to be reduced immediately and assessed for joint stability. If the joint is well reduced and stable after reduction, immobilization in a thumb spica cast for 4–6 weeks may be sufficient to maintain reduction and achieve long-term stability. However, the joint frequently remains unstable, and if so, open reduction and repair of the dorsal radial ligament with trans-articular Kirschner wire fixation are indicated. If dislocations present more than 3 weeks after trauma or there is persistent instability after proper initial treatment, ligament reconstruction with a radial half of the distally is advised based on flexor carpi radialis tendon as described by Eaton and colleagues with a Wagner incision [21], a dorsoradial incision made along the proximal half of the first metacarpal curving ulnarward proximally around the base of the thenar eminence parallel with the distal flexor crease of the wrist. The carpometacarpal joint of the thumb is exposed subperiosteally, and the distal part of the flexor carpi radialis is isolated. A 6 cm distally based strip of the flexor carpi radialis is harvested from the radial side of the tendon and freed proximally. The thumb metacarpal is then reduced on the trapezium and secured with a Kirschner wire ensuring that its path will not interfere with the site through which the tendon transfer will eventually pass. A hole is drilled transversely through the base of the thumb metacarpal ulnar to the extensor pollicis brevis tendon exiting near the volar beak. The harvested tendon strip is passed through this tunnel deep to the abductor pollicis longus tendon and sutured to the periosteum near its exit. It is then looped around the flexor carpi radialis near its insertion and sutured to the base of the thumb metacarpal. Postoperatively, the thumb is immobilized for 4 weeks in extension and abduction.

Summary

Fractures and dislocations of the thumb are relatively common. The thumb's unique orientation gives the hand great capability and predisposes the thumb to certain injuries, particularly of the metacarpal base. Given the greater movement of the thumb, some residual deformities from extra-articular thumb fractures are more acceptable than that of the other fingers. Rotational deformity rarely induces a disability. However, intra-

articular fractures should be critically treated with the goal of anatomic joint reduction to avoid stiffness and pain with post-traumatic arthritis. Most traumatic dislocations of the thumb can be treated nonoperatively via closed reduction and immobilization. However, surgical treatment is necessary if the joint is not concentrically reduced or unstable after reduction.

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