Contents

Chapter 1

Thumb Metacarpal Base Fractures

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INTRODUCTION

Thumb metacarpal fractures account for 14% of all fractures distal to the carpus,[1] with most occurring at the metacarpal base. Owing to its importance in hand function, injuries of the thumb metacarpal base and thumb carpometacarpal (CMC) joint have been subject to rigorous study for decades. While extra-articular metacarpal fractures tolerate high degrees of deformity due to the mobility of adjacent joints, intra-articular fractures may result in pain or loss of thumb CMC motion.

Osseous Anatomy

The thumb CMC joint is the articulation between the trapezium and the base of the thumb metacarpal. A biconcave joint, the articulation consists of two reciprocally interlocking saddle shapes. This unique anatomy allows for a range of movements including prehension, opposition, and circumduction. Relative to the rest of the hand, the thumb CMC joint sits 80° pronated, 40° abducted, and 50° flexed.[2] From this position, the CMC joint further allows motion of 27° flexion-extension, 67° adduction-abduction, and 10° pronation-supination.[3] Both intrinsic and extrinsic muscles cross the CMC joint.[2] Distally, the metacarpal articulates with the thumb proximal phalanx, allowing motion mainly in the flexion-extension plane.

Ligamentous Anatomy

Due to the inherent instability of the bony anatomy, ligamentous structures are critical thumb CMC stabilizers. As many as 16 ligaments have been described around the joint,[4] but work by Ladd et al suggests that there are seven principal ligaments categorized into three groups based on anatomic location: three dorsal, two volar, and two ulnar.[5] The two *volar* ligaments are named (1) the anterior oblique ligament (also called the volar beak ligament) and (2) (somewhat confusingly) the ulnar collateral ligament. Historically the anterior oblique ligament was cited as the primary stabilizer of the thumb CMC joint, but this has been questioned. Cadaveric studies show the anterior oblique ligament to be structurally more like capsule than ligament, and it becomes taut only when the thumb is extended into the hitchhiker position (abduction, extension, pronation). The dorsal ligament complex is a more robust ligamentous structure that, in cadaveric testing, serves as the primary restraint to subluxation in positions of opposition.[4–6]

THUMB METACARPAL BASE FRACTURES

Assessment and Diagnosis

Fractures of the thumb metacarpal occur when an axial load is applied to a flexed metacarpal shaft. Gross deformity may be evident, especially if the thumb CMC joint is subluxated. Radiographic evaluation should include PA, lateral, and oblique views of the wrist or hand. A true lateral view of the thumb metacarpal base can be obtained by pronating the hand 20° and angling the beam 15–20° distal to proximal (Figure 1-1).[7] A traction view can be obtained which may better demonstrate the fracture pattern and degree of comminution.

FIGURE 1-1
A true lateral view of the thumb metacarpal demonstrates the volar lip of the metacarpal base.

Fracture Types

Base of thumb metacarpal fractures can be divided into extra-articular and intra-articular types. Extra-articular fractures are typically of a transverse or oblique pattern, most commonly occurring at the junction of the metaphysis and diaphysis. Within the AO classification these are type A fractures, which present usually in apex dorsal angulation with adduction, flexion, and supination of the distal fragment. Closed reduction of extra-articular thumb metacarpal fractures is performed via traction, extension, and pronation, with pressure applied to the apex of the fracture. Angulation less than 30° is usually well tolerated, and closed treatment with thumb spica immobilization can commence with radiographic follow-up to ensure the reduction is stable. Because angulation >30° may lead to compensatory thumb metacarpophalangeal joint hyperextension, closed reduction and pinning is the preferred treatment if closed reduction is unsuccessful or unstable.

Intra-articular fractures can be classified as either AO type B or type C but are usually referred to eponymously. A Bennett's fracture (AO type B) consists of a single, volar-ulnar fragment from the metacarpal base, often with CMC joint subluxation. A Rolando's fracture (AO type C) is a T- or Y-shaped fracture of the metacarpal base (Figure 1-2A and 1-2B). In parlance, however, any comminuted fracture of the metacarpal base is often referred to as a Rolando's fracture. In Bennett's fractures, the volar-ulnar fragment of the

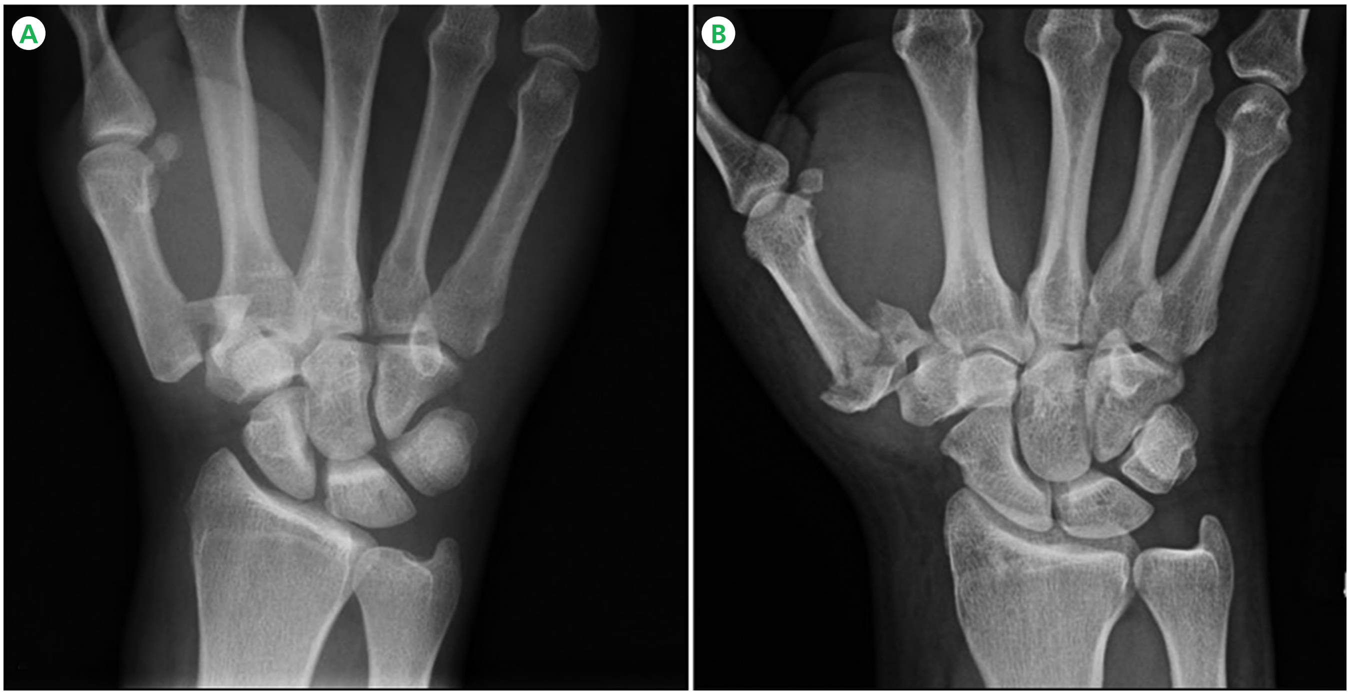

FIGURE 1-2
Intra-articular fractures at thumb metacarpal base. **(A)** Bennett's fracture with a volar-ulnar fragment and joint subluxation. **(B)** Rolando's fracture.

fractured metacarpal base was traditionally believed to be held in place by the anterior oblique ligament attachment while the remaining articular surface displaces. A recent cadaveric study suggests, however, that the other volar ligament, the ulnar collateral ligament, remains attached to the palmar fragment.[8] Most consider the deforming muscular forces to consist of the adductor pollicis (AdP), abductor pollicis longus (AbPL), and the extensor pollicis longus (EPL) (Figure 1-3A and 1-3B). In Bennett's fractures, these forces flex the metacarpal shaft (AdP) and move the metacarpal base dorso-radially then proximally relative to the trapezium (AbPL and EPL). In Rolando fractures, these muscles cause angulation, translation, and rotation across the fracture rather than subluxation at the CMC joint.

Treatment—Bennett's Fractures

Closed Reduction

Bennett's fractures are reduced by extending, pronating, and abducting the thumb metacarpal. The reduction maneuver has two goals: (1) correcting joint subluxation (thumb metacarpal shaft relative to the trapezium) and (2) improving articular congruency by reducing step-offs and gaps. The relative importance of these features is debated. In a cadaveric study of simulated Bennett's fractures, Cullen et al demonstrated no increase in contact pressures at the CMC joint despite a 2 mm step-off, concluding that reduction of the metacarpal shaft relative to the trapezium should be the priority of treatment.[9] In some clinical studies, however, a persistent step-off or gap >1–2 mm is correlated with radiographic arthritis.[10,11]

Nonoperative Treatment

If the fracture is not displaced, or if closed reduction is successful (no residual subluxation and no articular step-offs or gaps >2 mm), 4–6 weeks of thumb spica immobilization may be attempted. Maintaining this reduction in a splint/cast as definitive treatment may be difficult, however, given the deforming forces at the injury site. Close clinical and

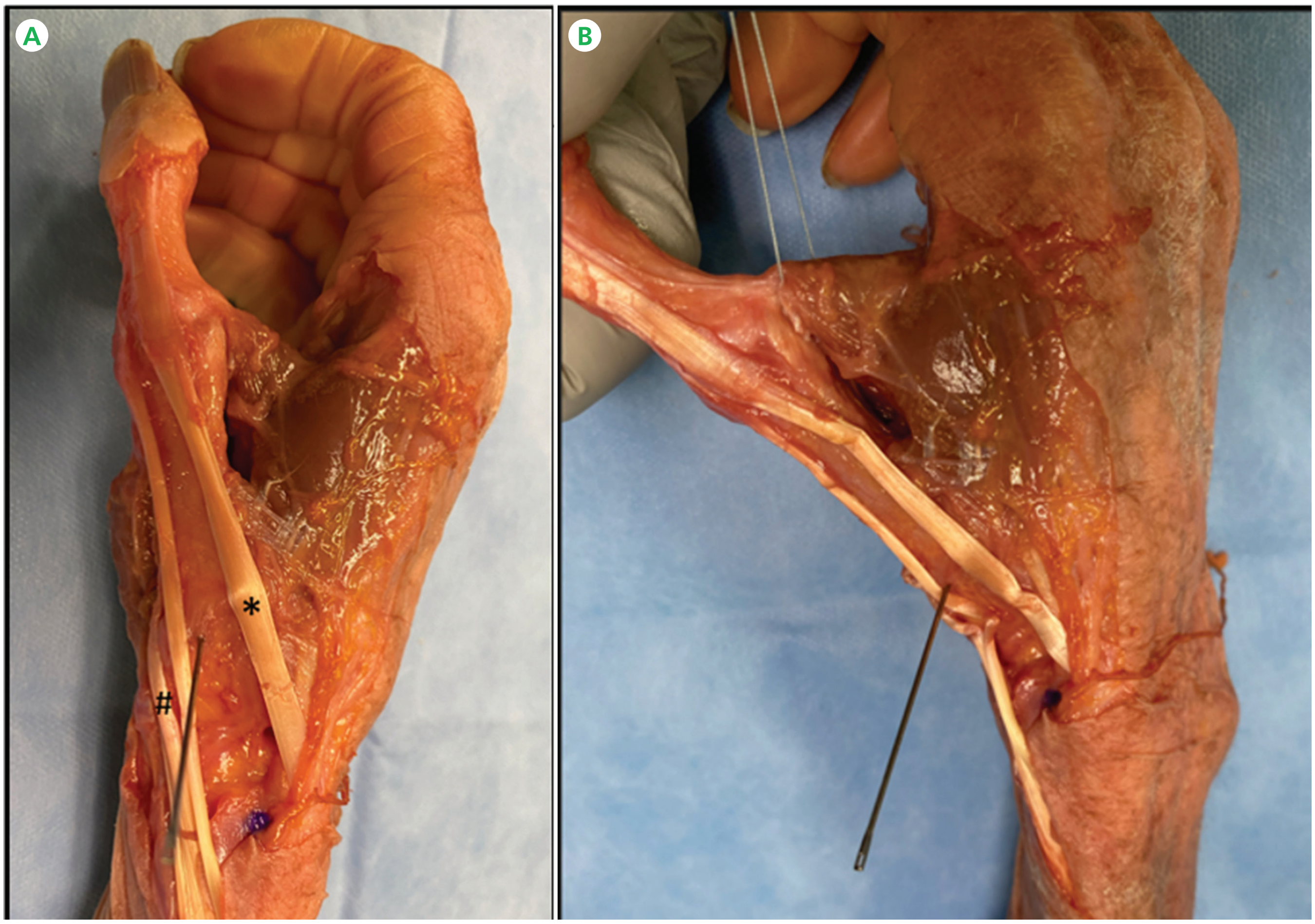

FIGURE 1-3
Cadaveric photos showing potential musculotendinous forces at the thumb CMC joint. **(A)** Forces that pull the metacarpal dorsally and proximally include the abductor pollicis longus (#) and the extensor pollicis longus (*). The needle denotes the CMC joint. **(B)** The adductor pollicis is seen looped with a suture and pulls the distal metacarpal toward the palm.

radiographic follow-up is necessary if attempting closed treatment. If joint subluxation or unacceptable articular incongruity develops, treatment should be converted to operative.

Operative Treatment

Reduction and internal fixation is indicated for Bennett's fractures with joint subluxation and/or articular incongruency that cannot be reduced or cannot be held reduced by thumb spica immobilization. If the fracture and thumb CMC joint is satisfactorily reduced by closed technique, percutaneous pinning is the most common technique of fixation. Usually 2 or more K-wires are used, with fixation into the index metacarpal and/or the carpus (Figures 1-4A and 1-4B). K-wires are removed in 4–6 weeks.

One concern with closed reduction techniques is the accuracy of assessing joint reduction via fluoroscopy.[12] Open reduction has the advantage of direct visualization of the fracture line and joint and is performed through either a volar approach (Figure 1-5A–C) lifting thenar musculature or a dorsal approach (Figure 1-6A–C) curving into the first webspace.[13,14] Given the location of the typical fracture, considerable deep dissection is required with either approach. After joint reduction, internal fixation can be performed with screws or tension bands.[13,14] The benefit of direct visual confirmation of fracture reduction and internal fixation must be weighed against the soft tissue stripping necessary to achieve this. To facilitate direct visualization of the fracture and minimize soft tissue dissection, arthroscopic assisted reduction and internal fixation has been described.[15,16]

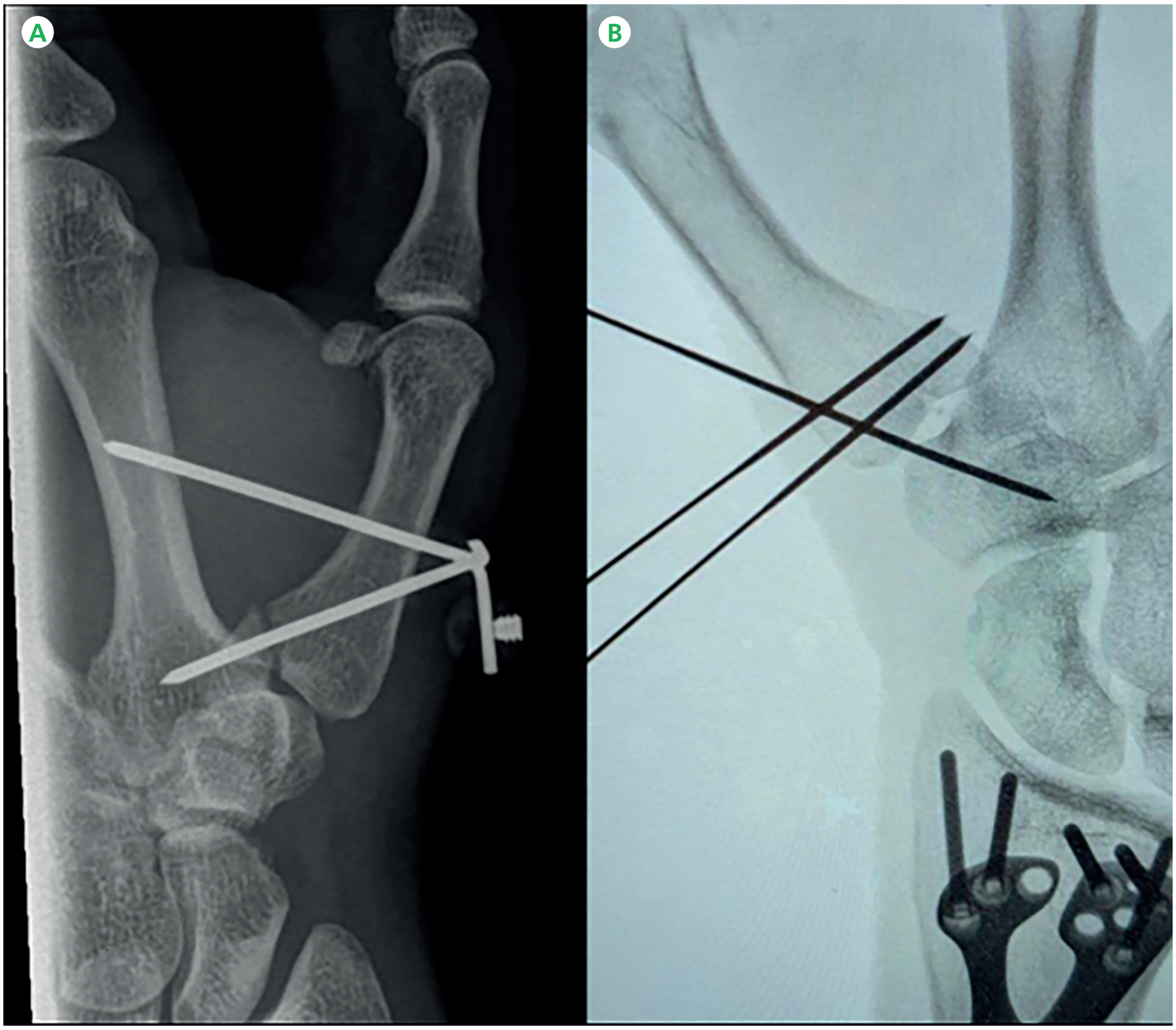

FIGURE 1-4
A variety of K-wire configurations can be used to stabilize a Bennett's fracture. **(A)** K-wires placed in the volar-ulnar fragment and index metacarpal, and **(B)** K-wires placed crossing the CMC joint.

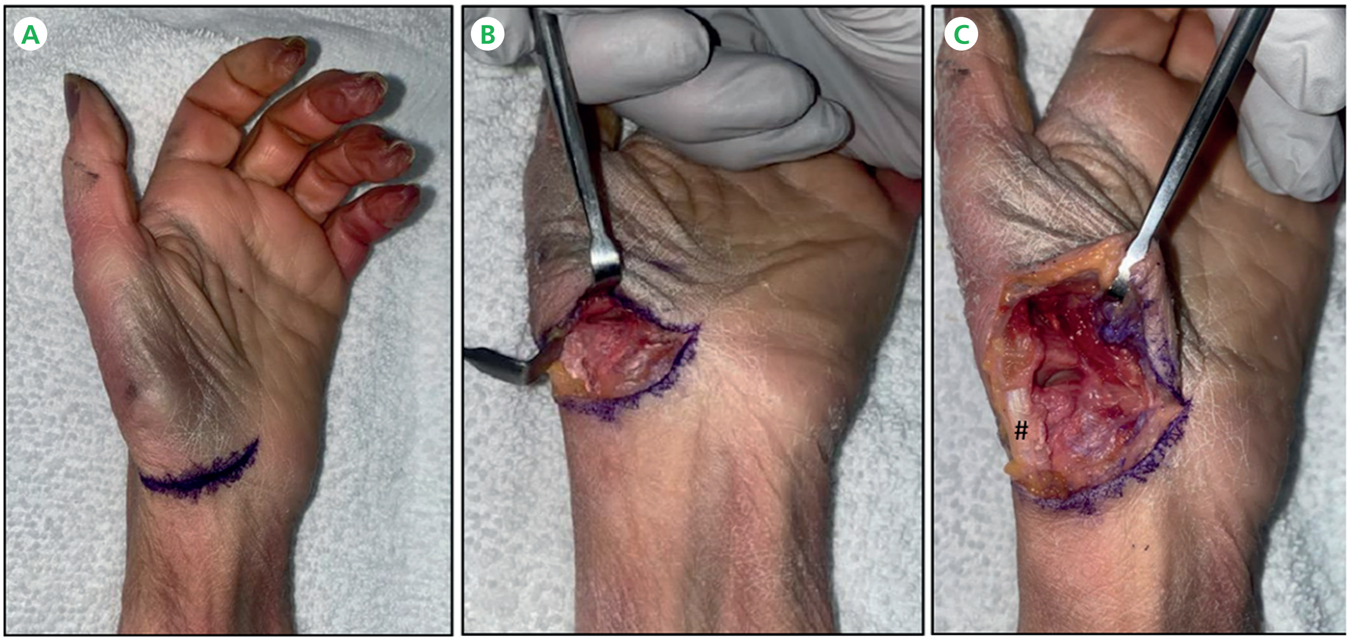

FIGURE 1-5
Volar surgical approach to the thumb metacarpal base. **(A)** Skin incision from volar midline to abductor pollicis longus. **(B)** Skin elevation and mobilization of the thenar muscles expose the CMC joint. **(C)** Further elevation of the thenar muscles exposes the volar surface of the metacarpal base. The abductor pollicis longus is seen at the radial extent of the exposure (#).

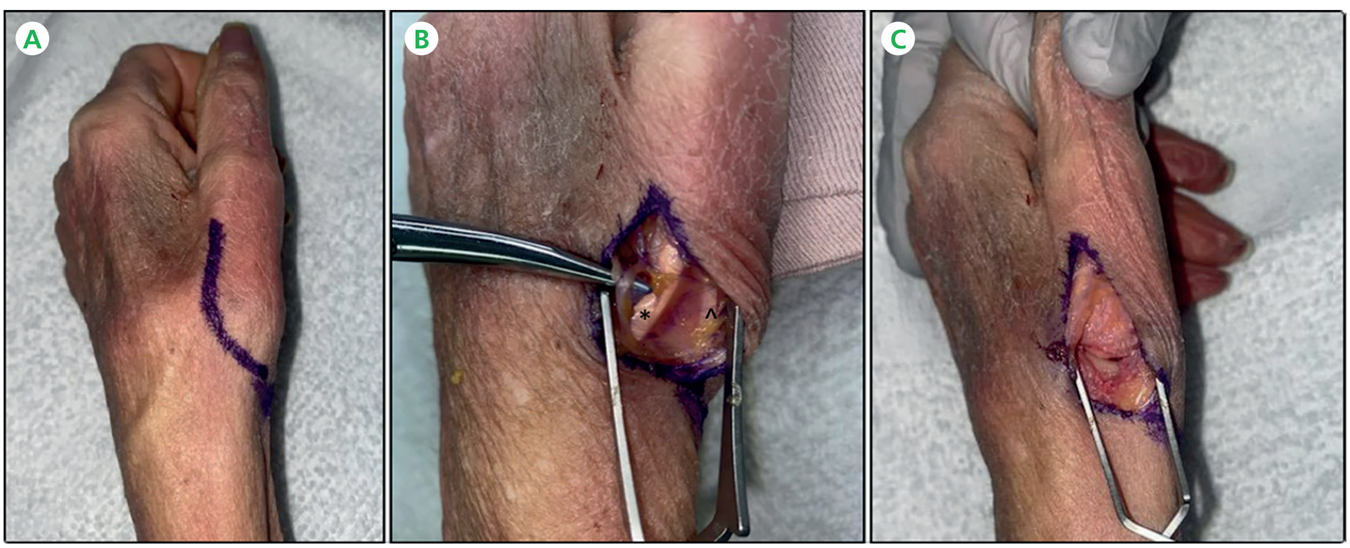

FIGURE 1-6
Dorsal surgical approach to the thumb metacarpal base. **(A)** Skin incision. **(B)** The superficial branch of the radial nerve (elevated by scissors) encountered during the subcutaneous dissection which proceeds between the extensor pollicis longus (*) and extensor pollicis brevis (^). **(C)** Deep, subperiosteal dissection exposes the thumb metacarpal base.

Treatment—Rolando's Fractures

Closed Reduction

Rolando's fractures are reduced by applying "oblique traction" to counter the forces causing shortening and varus angulation.[17] If the fraction is severely angulated, closed reduction and thumb spica immobilization may improve tissue perfusion and patient comfort. However, reduction will not likely be maintained in fractures longitudinally unstable and/or malrotated.

Nonoperative Treatment

There is no consensus on what defines an acceptable reduction of a Rolando's fracture. If the metacarpal is not excessively shortened and is satisfactory aligned in the coronal and sagittal planes, AND the joint surface lacks gaps and step-offs >2 mm, nonoperative treatment with thumb spica immobilization for 6 weeks can be considered. Monitoring for loss of reduction with close clinical and radiographic follow-up is necessary if nonoperative treatment is untaken.

Operative Treatment

Surgical intervention is indicated for fractures with unacceptable shortening, malalignment, and/or articular step-offs and gaps. Open reduction and internal fixation with plate and screw constructs can be performed if the fracture fragments are large enough.[18] Either a volar or dorsal approach is used to apply a T- or L-shaped plate. Since considerable soft tissue stripping is necessary for plating, most surgeons favor closed reduction and percutaneous fixation with K-wires or a mini external fixation system. The use of external fixation involves minimal dissection while providing stability in the longitudinal and rotational planes. Monolateral constructs that span the thumb CMC joint[19–23] and multiplane constructs, which usually incorporate the index metacarpal,[24] have been described (Figure 1-7).

FIGURE 1-7
Example of multiplane external fixation construction for Rolando's fracture, with pins placed into the thumb metacarpal, index metacarpal, and distal radius.

OUTCOMES AND SEQUELAE OF INTRA-ARTICULAR BASE OF THUMB METACARPAL FRACTURES

The goal of fracture treatment is a stable, congruently reduced thumb CMC joint. Studies of patients with Bennett's fractures treated nonoperatively demonstrate a high incidence of reduced motion at the thumb CMC joint, diminished pinch strength, and radiographic arthrosis.[25–28] Interestingly, most of these patients did not have clinically important pain. Because joint incongruity and/or instability is believed to be a primary cause of post-traumatic arthritis, most surgeons recommend operative intervention when faced with a Bennett's fracture that is displaced or subluxated. Currently, there is no consensus as to which type of surgery should be used for treating Bennett's fractures. Several retrospective studies have compared CRPP with open reduction and internal fixation and shown equivalent outcomes,[14,29,30] with open reduction having a higher rate of reoperation and persistent paresthesia.[31]

Outcome studies after Rolando's fracture treatment are similarly retrospective, and most series are small. Langhoff et al evaluated 17 patients with Rolando's fractures at an average of 5.8 years treated with either ORIF or percutaneous K-wire fixation. Better fracture reduction was achieved with open reduction, and 6/11 patients examined radiographically had degenerative changes at the CMC joint. However, no relationship was found between quality of reduction, clinical symptoms, and radiographic arthritis.[32] Duan et al treated 41 intra-articular base of thumb fractures with a K-wire/cement external fixation frame, 11 of which were Rolando's fractures. At an average follow-up of 27 months, injured thumbs had reduced motion, grip strength, and pinch strength, but the majority had excellent functional scores.[19] Mumtaz et al treated 9 Rolando's fractures with open reduction and 2.0 mm plate fixation, reporting excellent/good results in six patients. Four patients underwent later hardware removal for persistent tenderness over the implant.[18]

In summary, most patients with Bennett's and Rolando's fractures heal their fractures but have reduced motion at the CMC joint and decreased pinch strength. Few patients report pain or functional deficit, however. While radiographic arthrosis is commonly observed, this does not usually correlate with pain or function. Symptomatic arthritis at the CMC joint can be managed with CMC arthrodesis or arthroplasty.

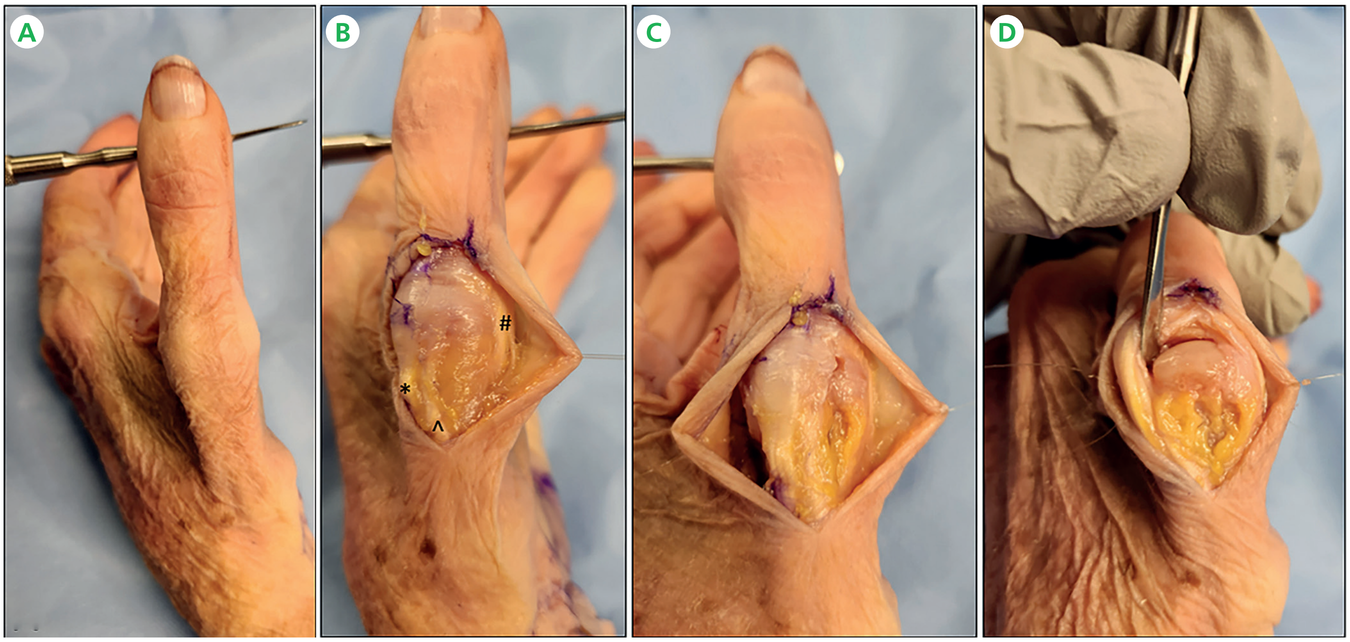

FIGURE 1-8
Surgical approach to thumb metacarpal head. **(A)** The dorsum of the thumb at the level of the metacarpal-phalangeal joint. **(B)** After longitudinal incision, skin flaps are raised to expose the interval between the extensor pollicis brevis (^) and radial collateral ligament (#). The extensor pollicis longus (*) is adjacent to the brevis. **(C)** The interval is opened by incising the dorsal capsule of the joint and extensor hood. **(D)** With retraction of the extensor tendons and dorsal capsule, the distal articular surface of the thumb metacarpal is visualized.

THUMB METACARPAL HEAD FRACTURES

Thumb metacarpal head fractures are rare, especially if open injuries from saw injuries are excluded. Displaced intra-articular fractures require anatomic reduction. If the articular surface of the thumb metacarpal can be reduced by closed means, K-wire fixation is appropriate. Open reduction is performed by a dorsal incision and mobilization of the extensor mechanism (Figure 1-8A–D). The collateral ligament origin should not be stripped from the metacarpal fragment, if possible. Fracture fragment size and comminution determines the internal fixation strategy.

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In this cadaveric study, Bennett's fractures were created dynamically and the soft tissue attachment to the volar-ulnar portion of the thumb metacarpal was examined. Of the 2 volar ligaments, the ulnar collateral ligament, not the anterior oblique ligament, was the primary ligament that remained attached to the bone. The new model described and the findings of the ligament analysis have furthered the understanding of the thumb carpometacarpal joint.

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