BROKEN BONES

THE RADIOLOGIC ATLAS OF FRACTURES AND DISLOCATIONS

Felix S. Chew | Catherine Maldijan | Hyojeong Mulcahy

SECOND EDITION

Broken Bones

Second Edition

Broken Bones contains 434 individual cases and 1,101 radiologic images illustrating the typical and less typical appearances of fractures and dislocations throughout the body. The first chapter describes fractures and dislocations of the fingers, starting with fractures of the phalangeal tufts and progressing through the distal, middle, and proximal phalanges and the DIP and PIP joints. Subsequent chapters cover the metacarpals, the carpal bones, the radius and ulna, the elbow and upper arm, and the shoulder and thoracic cage. The cervical spine and the thoracic and lumbosacral spine are covered in separate chapters, followed by the pelvis, the femur, the knee and lower leg, the ankle, the tarsal bones, and the metatarsals and toes. The final three chapters cover the face, fractures and dislocations in children, and fractures and dislocations caused by bullets and nonmilitary blasts.

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To our families, without whom nothing would be possible or worthwhile.

Broken Bones

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Second Edition

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Preface

This book is an atlas of fractures and dislocations, as depicted by radiologic imaging. It was my intention to illustrate all the common and uncommon fractures that may be encountered in clinical practice, and also include as many of the rare injuries as possible. This book is intended for the use of anyone with an interest in the diagnosis, treatment, and management of patients with fractures or dislocations.

When the first edition of *Broken Bones: The X-Ray Atlas of Fractures* was published in 2009, it was the first full-sized radiology textbook written specifically as an e-book for the Amazon Kindle 2 and Apple iPhone 3GS platforms. With the subsequent introduction and proliferation of the Apple iPad and its competitors and of high-resolution large-screen smart phones, many handheld computing devices now rival or exceed clinical radiology workstations in display quality. All of the radiographic images in the new edition were originally acquired with state-of-the-art digital x-ray equipment and faithfully reproduced to provide the reader with images that take advantage of the excellent display technology now available. While retaining its anatomic organization and case-based format, the book has been expanded from 369 to 434 individual cases, 234 of which are new to the second edition. There are now 1,101 radiologic images, increased from the original 939. The new and revised text for each case is self-contained for the reader who is only able to read the book in snippets, yet the organization of cases within each chapter and the organization of the chapters within the book as a whole provide a logical progression and story arc for the reader with longer blocks of time.

The book is organized by anatomic region. The first chapter describes fractures and dislocations of the fingers, starting with fractures of the phalangeal tufts and progressing through the distal, middle, and proximal phalanges and the DIP and PIP joints. Subsequent chapters cover the metacarpals, the carpal bones, the radius and ulna, the elbow and upper arm, and the shoulder and thoracic cage. The cervical spine and the thoracic and lumbosacral spine are covered in separate chapters, followed by the pelvis, the femur, the knee and lower leg, the ankle, the tarsal bones, and the metatarsals and toes. The final three chapters cover the face, fractures and dislocations in children, and fractures and dislocations caused by bullets and nonmilitary blasts.

The radiologic images have been carefully chosen to illustrate the typical and less typical appearances of fractures and dislocations. It would have been ideal but impractical to include all of the images that were obtained for clinical diagnosis in these cases. To meet the limitations of the textbook format, the images have been cropped, resized, reoriented, and re-leveled. Radiographs are presented in standard fashion, generally looking at the hands, wrists, and feet as if they were the viewer's own, and the other body parts as if the patient were facing the viewer. For clarity and ease of correlation, cross-sectional images are presented in the same orientation as the radiographs they accompany. Many fracture classifications are described in the text, but the coverage of classifications is not meant to be exhaustive or even complete. Radiologists are usually not called on to classify fractures, but it is important to know which characteristics of various injuries determine how they would be classified, so that the imaging examination and report can be more useful.

In my work as a diagnostic radiologist at the University of Washington in Seattle, I see the images from thousands of injured patients every year, including many from Harborview Medical Center (Seattle, WA), the Level 1 Trauma Center that serves the states of Washington, Wyoming, Alaska, Montana, and Idaho, and the University of Washington Medical Center, the region's leading academic medical center. Additional cases used in this book were drawn from the teaching collections of the authors. A few images have been previously published and are used with permission.

Chapter 1

Fractures and dislocations of the fingers

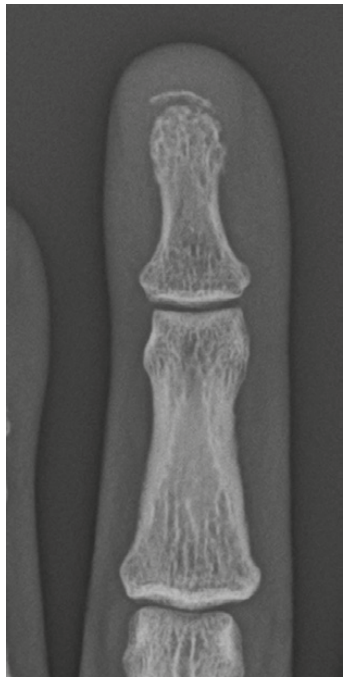
Felix S. Chew, M.D., and Catherine Maldjian, M.D.

Case 1–1

Phalangeal tuft avulsion fracture

(A)

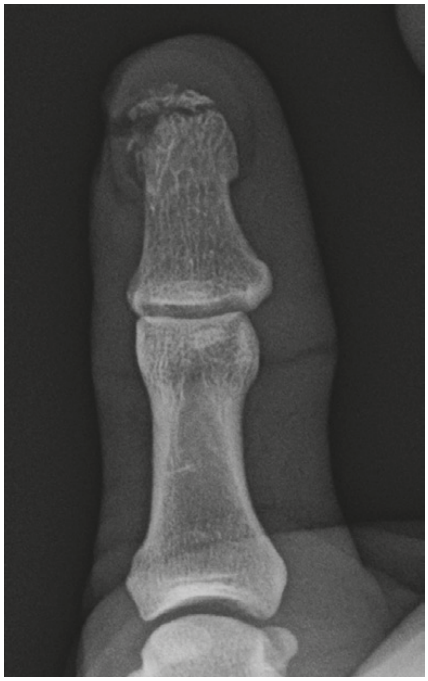
(B)



31-year-old woman injured in a ground-level fall. Lateral (A) and PA (B) radiographs of the left middle finger. There is an avulsion fracture of the very tip of the tuft distal phalanx. The fingernail appears to be intact. The connective tissue septae that support the pulp of the fingertip attach to the tuft of the distal phalanx.

Case 1–2

Phalangeal tuft fracture

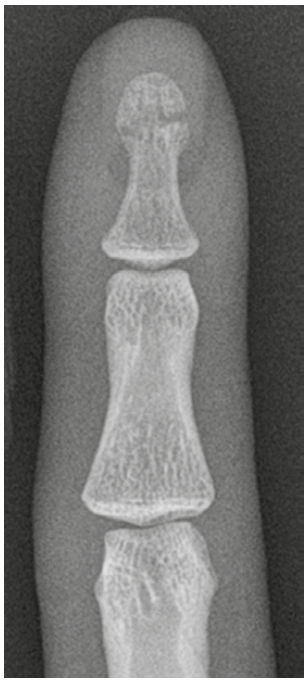


42-year-old man whose thumb was crushed by a tie-down chain while unloading a truck. PA radiograph of the right thumb. There is transverse fracture through the tip of the phalangeal tuft of the thumb with a small amount of comminution. A soft tissue laceration extends from the thumbnail through the fracture site. More than 50% of all phalangeal fractures involve the distal phalanx, most often involving the ungual tuft [1–2]. These may be comminuted or not. The fibrous septae extending from periosteum to the skin resist displacement of fragments.

Case 1–3

Phalangeal tuft fracture

(A)

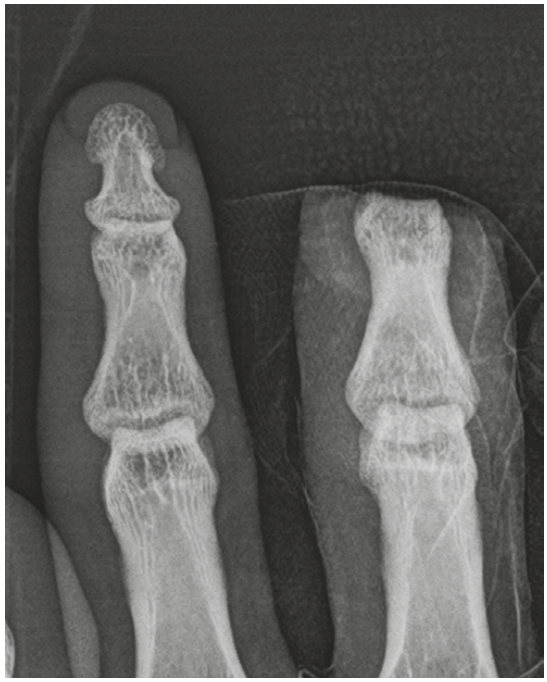


(B)

43-year-old woman who was bitten in the hand by an aggressive dog. PA (A) and lateral (B) radiographs of the right index finger. There is a transverse fracture of the distal phalanx through the phalangeal tuft. There is a soft tissue defect in the nailbed on the lateral view.

Case 1–4 Finger amputation

(A)



(B)

31-year-old man whose hand was trapped in a mechanical laundry press for several seconds. PA radiograph of the right index and middle fingers (A) and of the amputated part of middle finger (B). There has been amputation through the DIP joint of the middle finger with soft tissue degloving injury. The radiograph of the amputated fingertip shows an intact distal phalanx, with fragments of the middle phalanx, and an extensive portion of soft tissues that were degloved from the dorsal aspect of the middle phalanx. The long soft tissue structure coiled around the amputated fingertip is the flexor digitorum profundus tendon to the middle finger with some attached muscle tissue.

Case 1–5 Mallet finger

17-year-old man who jammed his small finger. Lateral radiograph of the right small finger. There is a fracture at the dorsal aspect of the base of distal phalanx with slight flexion of the DIP joint. This injury is an avulsion fracture of the common extensor tendon insertion at dorsal base of the distal phalanx. A direct blow to the fingertip with forced flexion at the DIP joint, as from a baseball in flight against an outstretched finger, gives rise to this fracture pattern, also known as mallet finger or baseball finger [1–3].

Case 1–6

Mallet finger

27-year-old man who injured his small finger several months ago. Lateral radiograph of the right small finger. There is an isolated flexion deformity at the DIP joint, without fracture. This lesion is a soft tissue mallet finger. Rupture of the common extensor tendon results in unopposed flexion at the DIP joint, with the flexed distal phalanx likened to a mallet. Most cases of mallet finger are soft tissue avulsion injuries of the tendon; only 25% of cases of mallet finger will demonstrate an avulsion fracture [1–4].

Case 1–7

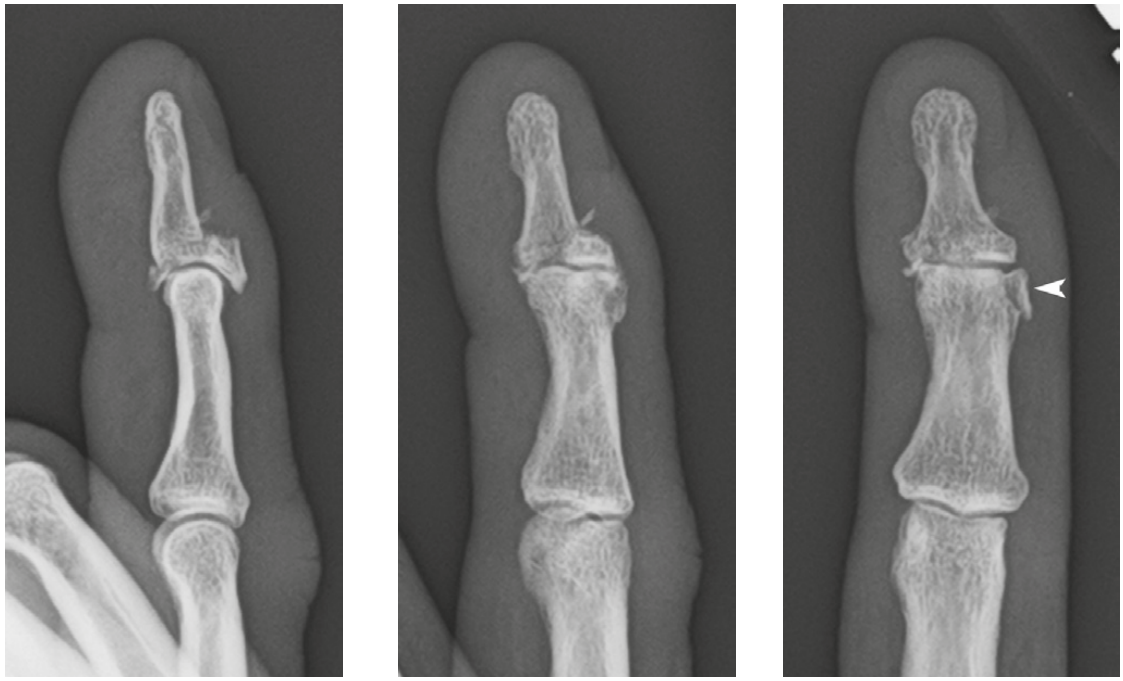
Mallet finger

28-year-old woman who injured her small finger in a bicycle crash. Lateral radiograph of the right small finger. There is an intra-articular fracture of the distal phalanx of the small finger. The small dorsal fragment includes the majority of the articular surface and remains located. The large volar fragment has a minority of the articular surface and is subluxated volarly by unopposed tension from the flexor tendon, resulting in displacement of the fragments.

Case 1–8

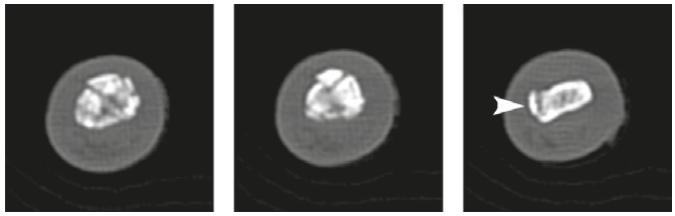
Complete articular fracture of the distal phalanx

(A) (B) (C)



52-year-old man with crush injury to the small finger. Lateral (A), oblique (B), and PA (C) radiographs of the right small finger. There are comminuted intra-articular fractures involving the entire articular surface of the distal phalanx at the DIP joint. There is also a fracture involving the lateral condyle of the middle phalanx (arrowhead).

(D)

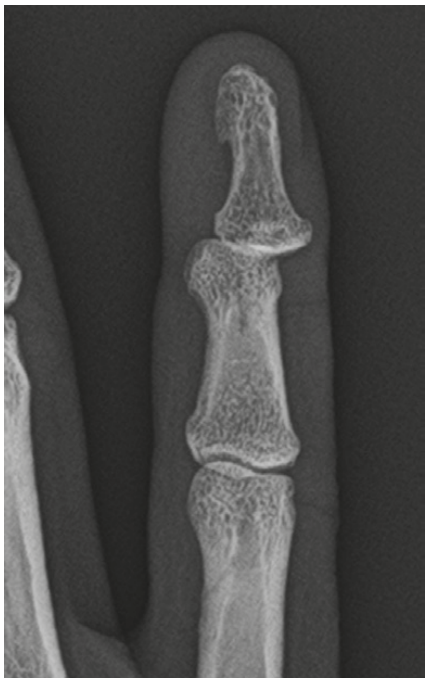


Axial CT through the DIP of the right small finger. There are comminuted fractures of the proximal end of the distal phalanx of the small finger. The lateral condylar middle phalanx fracture is also demonstrated (arrowhead).

Case 1–9

Dorsal DIP dislocation

(A)



(B)

31-year-old woman who jammed her finger trying to catch a basketball pass. PA (A) and lateral (B) radiographs of the right small finger. There is dorsal dislocation of the distal phalanx. Dislocations in the fingers are usually dorsal and easily reducible, often by the patients themselves at the time of injury. The mechanism of injury is typically hyperextension [5–6].

Case 1–10

Volar DIP dislocation

(A)

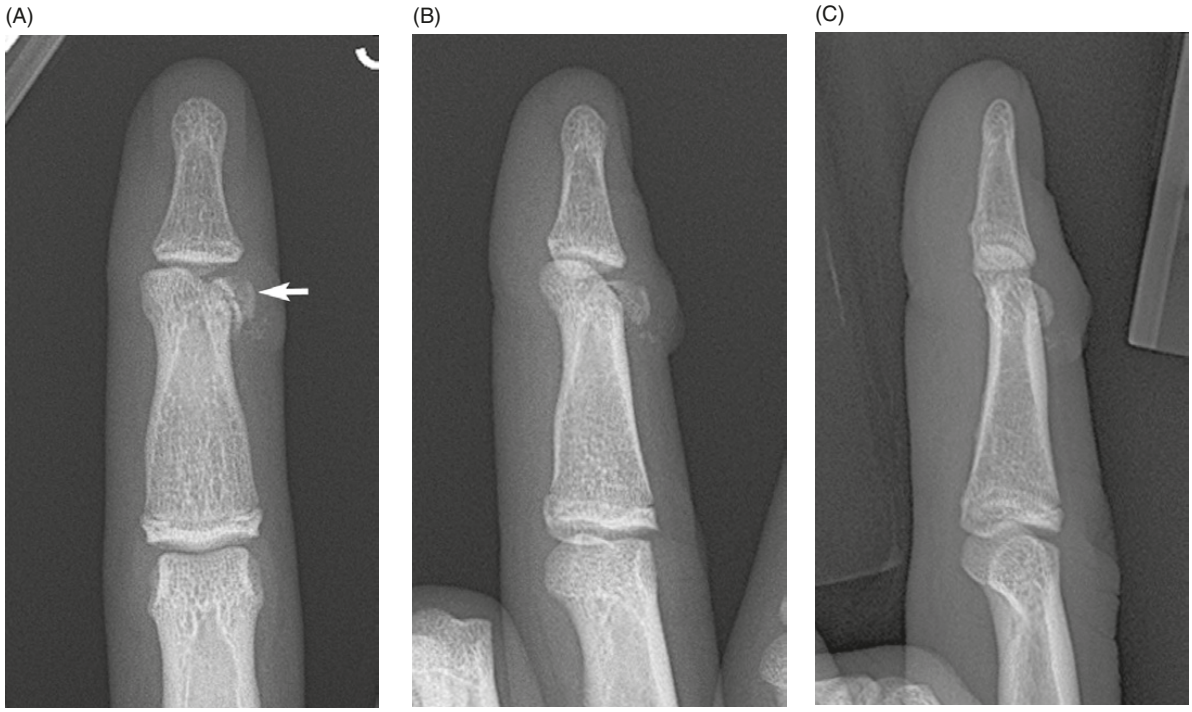
(B)

47-year-old man with a crush injury to the ring finger. PA (A) and lateral (B) radiographs of the right ring finger. There is volar dislocation of the distal phalanx with crush injuries of the soft tissues. Volar dislocations in the fingers are uncommon and often irreducible [5–6].

Case 1–11 Thumb dislocation

46-year-old man who injured his hand in an altercation. Oblique radiograph of the right thumb. There is dislocation of the thumb IP joint with dorsolateral dislocation of the distal phalanx. These are uncommon injuries. Hyperextension and rotation are the mechanism of injury. A ruptured palmar plate or tendon can become interposed into the joint preventing nonsurgical reduction [7].

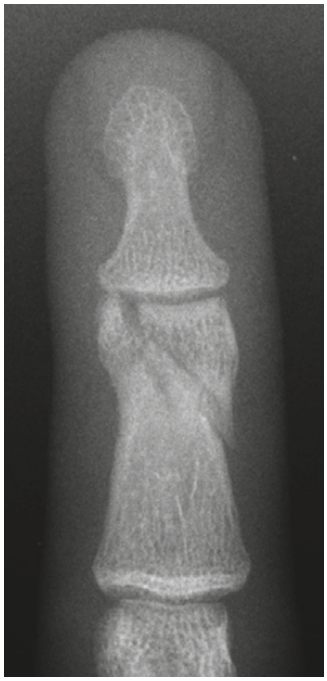
Case 1–12 Medial condyle fracture of the middle phalanx



15-year-old male who injured his finger fighting with a dog. PA (A), oblique (B), and lateral (C) radiographs of the right middle finger. There is a fracture of the medial condyle of the middle phalanx at the DIP joint. This displaced, intra-articular fracture is best seen on oblique views, and may require open reduction and internal fixation. Bicondylar T- or Y-shaped fractures may occur. Intra-articular malunion may lead to posttraumatic osteoarthritis. Stable fixation of the small fragment can be technically challenging [1–2].

Case 1–13

Oblique phalanx fracture



25-year-old man injured his hand playing football. PA radiograph of the right ring finger. There is an oblique fracture of middle phalanx extending to the joint surface. The mechanism of injury for oblique fractures is axial loading. Incongruity at the articular surface typically needs to be addressed surgically when it exceeds 2–3 mm.

Case 1–14

Crush injury of the thumb

(A)

(B)

(C)

30-year-old man who sustained a crush injury to his thumb. Lateral (A), oblique (B), and PA (C) radiographs of the right thumb. There is a near amputation with fracture through the proximal phalanx. Circumferential soft tissue deformity and fracture deformity are at the same level; however, complete detachment has not occurred. Unfortunately, the digit was not replantable, and his hand was reconstructed by deepening the first web space.

Case 1–15
Dorsal PIP dislocation

18-year-old man injured finger playing basketball. Lateral radiograph of the left small finger. There is dorsal dislocation of the middle phalanx. A small bone fragment (arrow) is seen at the volar aspect of the distal proximal phalanx, likely a displaced volar plate avulsion fracture from the volar aspect of the dislocated middle phalanx. PIP joint dislocations are the most frequent dislocations in the hand. Mechanism of injury for dorsal PIP dislocation is forced hyperextension with axial compression. Dislocations that may be easily reduced are considered simple; dislocations that are irreducible and require surgical treatment are considered complex [8]. These injuries are virtually always accompanied by volar plate fracture or soft tissue detachment and sometimes by collateral ligament injuries.

Case 1–16
Volar plate fracture

20-year-old woman who injured her finger in an altercation. Lateral radiograph of the right small finger. There is a mildly displaced volar plate fracture of the middle phalanx at the PIP joint of the small finger. The small triangular-shaped volar fragment comprises only a small fraction of the articular surface and the middle phalanx remains normally located at the PIP joint. When a large fragment is avulsed, the middle phalanx may dislocate dorsally and the injury is unstable [9].

Case 1–17

Volar plate fracture

58-year-old man who jammed his ring finger when he fell on the stairs. Lateral (A) and PA (B) radiographs of the left ring finger. There is focal soft tissue swelling at the PIP joint (arrowhead). There is a very small, minimally displaced fracture of the middle phalanx at the volar margin at the PIP joint that corresponds to the attachment of the volar plate (arrow). Volar plate avulsion occurs from hyperextension injury that typically involves a small fragment of bone that is difficult to see. Small volar plate fractures may be easily overlooked if one does not specifically search for them.

Case 1–18

Volar plate fractures

17-year-old man with finger injury, relocated in the field. Lateral radiograph of the fingers. There are tiny fracture fragments (arrows) at the volar aspect of the base of the middle phalanges of the index and middle fingers, indicative of volar plate injuries. The mechanism of injury is hyperextension injury to the volar plate. Volar plate mechanisms are present at the PIP and MCP joints, and avulsion injuries are typically manifested as fractures at the volar bases of the proximal or middle phalanges.

Case 1–19

Dorsal lip avulsion fracture

(A) (B) (C)

75-year-old man who jammed his ring finger playing basketball. PA (A), oblique (B), and lateral (C) radiographs of the left ring finger. The dorsal lip avulsion fracture of the base of the middle phalanx is best seen on the lateral radiograph (C). The fragment is retracted proximally and there is overlying soft tissue swelling. Dorsal lip avulsion fractures are usually the result of tensile loading of the central slip of the extensor tendon. Such loading may occur with forcible flexion of an actively extended finger or during volar dislocation of the PIP joint.

Case 1–20

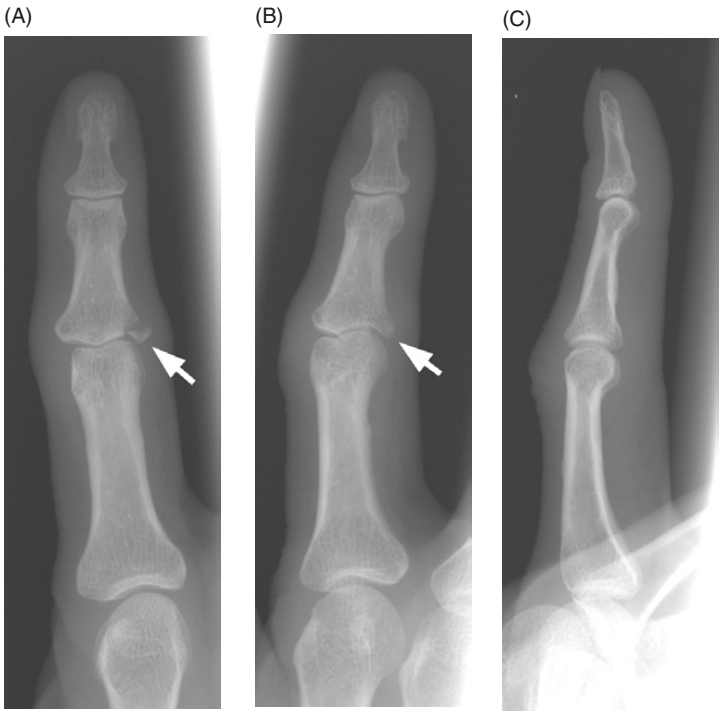
Ulnar PIP dislocation

(A) (B)

62-year-old man who fell down the stairs, injuring his hand. PA (A) and lateral (B) radiographs of the right ring finger. The PIP joint of the ring finger is dislocated toward the ulna (medially). The lateral view shows that, as all three phalanges of the ring finger are in the same coronal plane, there is no dorsal or volar component to the dislocation. Dislocations in the coronal plane are associated with collateral ligament injuries or avulsions. In this case, the radial (lateral) collateral ligament is disrupted. It is possible that the ulnar (medial) collateral ligament is also torn. There is no fracture.

Case 1–21

PIP collateral ligament avulsion fracture



52-year-old woman who jammed her hand carrying a box through a doorway. PA (A), oblique (B), and lateral (C) radiographs of the right index finger. Soft tissue swelling surrounds the PIP joint. There is an avulsion fracture (arrow) of the medial margin of the middle phalanx of the index finger at the PIP joint, indicative of an ulnar (medial) collateral ligament avulsion. This injury may occur with forcible radial (lateral) deviation of the PIP joint. If the ligament tears without fracture, stress views may be necessary to demonstrate the lesion. (Source: Chew FS. Skeletal Radiology: The Bare Bones. 3rd Edition. Copyright © 2010 by Felix Chew.)

Case 1–22

Volar PIP dislocation

42-year-old man who injured his hand and has a history of recurrent dislocations. Lateral radiograph of the small finger. There is volar dislocation of the PIP joint. Volar dislocation is very unusual [8] and may be associated with an avulsion fracture of the dorsal lip of the base of the middle phalanx.

Case 1–23

Lateral condyle proximal phalanx fracture

46-year-old woman who injured her hand playing water polo. The ball struck her extended finger. PA (A), oblique (B), and lateral (C) radiographs of the left small finger. There is a mildly displaced intra-articular fracture of the proximal phalanx of the small finger at the PIP joint that separates the lateral condyle. The fracture extends obliquely from the center of the articular surface to the lateral cortex. As a result, there is mild radial angulation of the finger distal to the fracture.

Case 1–24

Proximal phalanx fracture

38-year-old man injured finger playing basketball. PA (A) and lateral (B) radiographs of the left small finger. There is an oblique fracture of the shaft proximal phalanx of the small finger with mild ulnar angulation of the distal phalanx and proximal distraction. The oblique fracture is characteristic of compressive loading along the long axis of the bone.