

Chapter 14:

Radiologic Imaging

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I. History 1

- A. Wilhelm Conrad Roentgen: German Physicist who discovered and named x-rays on November 8, 1895
- B. Professor Roentgen was awarded the first Nobel Prize in Physics
- C. First radiograph made public in 1895 was of a hand
- D. Contrast agents were first used with imaging in 1950
- E. 1971 - CT scan was first used clinically
- F. 1984 - MRI first used for clinical diagnosis

II. Studies 1,2,3,4

- A. Radiographs (X-Ray): An image produced on a photographic plate, film or paper by the action of roentgen rays or radium. Digital imaging with less toxic exposure is currently utilized
 - 1. Variables Affecting Image Produced:
 - a. Length of exposure of subject to radiographic beam
 - b. Intensity and distance of radiographic beam to subject
 - c. Positioning of the subject
 - d. Density of tissue
 - 2. Five Major Densities:
 - a. Air: Radiolucent, absorbs the least number of particles, darkest portion of the Film.
 - b. Fat: Radiolucent, absorbs more beam than air or gas, gray portion of the film.
 - c. Fluid: Intermediate radiolucent, absorbs more beam than air/gas. May include contrast
 - d. Minerals: Radiopaque, various densities within the bone itself and angle of exposure will affect the image.
 - e. Metals: Surgical implants or penetrating traumatic fragments such as bullets and shrapnel injuries.
 - 3. Common Radiographic Views: May be termed plain films, multiple films known as a series
 - a. Anterior - Posterior (AP) – Image produced from a radiographic beam positioned from the anterior to posterior surface
 - b. Posterior - Anterior (PA) - Image produced from a radiographic beam positioned from the posterior to anterior surface
 - c. Lateral – Image produced from radiographic beam positioned at the side of the extremity
 - d. Oblique – Image produced from radiographic beam positioned at an angle to the subject.

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4. Common CT/MRI Radiographic Views:
 - a. Axial: Imaging from proximal to distal or distal to proximal
 - b. Sagittal: Imaging from side to side
 - c. Coronal: Imaging from anterior to posterior or posterior to anterior
 5. Specialized views: (May include but not limited to) 1,2,3
 - a. Hobbs, Rockwood, Neer, or West Point views - Sternoclavicular and Shoulder views (Section III C 1)
 - b. Radial Head View - Supinated elbow radiograph (Section IV B 2)
 - c. Carpal Tunnel/Sunrise View (Section V A 4)
 - d. Clenched Fist – Fisted posterior-anterior view of carpus
 - e. Stress Views - Non – weighted extremity versus weighted extremity
 - f. Serendipity View - A 10 degree cephalic view of the clavicle (Section III B. 1)
 - g. Contrast material may be utilized for an arthrogram (Fig. 1)
- B. Computed Tomography (CT):** Production of axial computerized cross-sectional images from a circular scanning gantry (Figs. 2, 3,4)
1. Used in detection of small occult fractures and in determining degree of healing of fractures.
 2. May also be used with a contrast material.
 3. 3-D CT: Three-dimensional image reconstructed by computer from a series of plane, cross-sectional images made along an axis
- C. Magnetic Resonance Imaging (MRI):** A production of two dimensional computerized images, of internal body tissues, based on the re-emission nuclear magnetic resonance of atoms after the application of radio waves and captured by a magnetic field. The hydrogen atoms in the tissue's fat and water are scattered out of alignment by the radiofrequency prior to realigning with the magnetic field. Coil type and magnet strength affect the image produced.
1. The length of time it takes for the hydrogen atoms to regain the equilibrium state is known as relaxation time.
 2. The repetition time (TR) is the time between successive radiofrequency (RF) pulses and the echo time (TE) is the time between the RF pulse that excites the hydrogen atoms and the arrival of the return signal to the detector.
 - a. Longer TR and TE values produce: more dependent T2 images
 - b. Shorter TR and TE values produce: more dependent T1 images
 3. T1 is the longitudinal relaxation time; best to view normal anatomy.
 4. T2 is the transverse relaxation time; best to show contrast of abnormal tissues, fluid, and inflammation
 5. T1 vs. T2 (Fig. 5):
 - a. Dark on T1 image: Water, CSF, Acute Hemorrhage (fast moving blood), Soft Tissue Tumors, Cortical Bone, Tendons, Air
 - b. Gray on T1 or T2 image: Muscle, Hyaline Cartilage
 - c. Light on T2 image: Water, CSF, Acute Hemorrhage (fast moving blood), Soft Tissue Tumors, Cortical Bone, Fat, Nerves and Bone Marrow

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1. Contraindicated with patients with metal implants or shrapnel.
 2. MRI is used to diagnose: Fractures, soft tissue trauma, growth plate injuries, avascular necrosis or neoplasms.
- D. Magnetic Resonance Arthrography (MRA): The MRI radiographic visualization of a joint after the intra-articular injection of a radiopaque dye.
1. Used in diagnosing cartilage, ligament, tendons and capsular tears
- E. Cineradiography: Radiographs of moving objects in rapid sequence so that motion pictures may be made from the image.
1. Used in determining abnormal carpal shift or instability patterns
- F. Cinefluorography: The radiographic process making motion pictures of radiographic images with the aid of a fluorescent screen; may be termed fluoroscopy; contrast material can be utilized.
- G. Bone Scintigraphy (Bone Scan) (Fig. 6): A diagnostic imaging technique in which a two-dimensional picture of internal body tissue is produced through the detection of radiation emitted by a radioactive substance administered intravenously into the body.
1. Used in diagnosing neoplasm, infection, arthritis, trauma and occult fractures
- H. Terminology 1,2,3,4,5,6,7
1. Fractures
 - a. Simple: One fracture line visible through bone
 - b. Comminuted: Multiple bone fragments and fracture lines
 - c. Oblique: Diagonal fracture pattern through the bone
 - d. Spiral: Fracture with a coiling pattern through the bone
 - e. Transverse: Horizontal fracture line through the bone
 - f. Complete: Complete disruption in the continuity of the bone
 - g. Incomplete: Unicortical injury without contra-lateral cortical disruption
 - h. Open: Any fracture with an external wound exposing the fracture to the external environment
 - i. Closed: Any fracture with no external wound
 - j. Pathologic: Fracture due to metabolic disorder or through an underlying tumor
 - k. Traumatic: Fracture due to external force
 - l. Occult: Hidden or not clearly seen fracture
 - m. Intra-articular: Any fracture that extends into the joint surface or adjacent to the joint surface
 2. Carpal coalition: Conjoining of two or more carpals (usually congenital)
 3. Diastasis: Form of joint subluxation with a widening of a joint articulation
 4. Fat Pad Sign: An abnormal distension of joint synovium displacing the posterior elbow fat pad indicating an intra-articular elbow fracture
 5. Sail Sign: A displaced anterior elbow fat pad visible as a small triangle on a lateral view elbow x-ray
 6. Synostosis: Biological conjoining of two bones; can be congenital or following trauma or surgery
 7. Dislocation: Traumatic joint separation, disruption of a joint with complete loss of continuity between the normal articular surfaces
 8. Subluxation: Increased mobility or motion of a joint without dislocation, disruption of a joint with partial loss of continuity between the articular surfaces
 9. Osteophyte: Arthritic related bone spur

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10. Enthesophyte: Muscle insertion caused bone spur; common at the olecranon.
11. Cortical Ring Sign/Signet Sign: Seen on the AP projection of the wrist in the scaphoid; signifies scapholunate tear.
12. Lucency: Transradiency of the bone
13. Sclerosis: A thickening or hardening of the bone due to increased density
14. Heterotrophic Ossification/Myositis Ossificans (HO) (Fig. 7): Development of bone in the joint or muscle

II. Basic Principles in Reviewing Radiographs

- A. Anatomical alignment of structures: Watch for appearance of fat pad or stripe, soft tissue swelling
- B. No disruption of radiographic lines: Anterior-Humeral line, Gilula's lines, etc
- C. No disruptions in the cortex continuity
- D. No change in bone density or appearance: Color, periosteal reaction, callus formation
- E. Compare to the contralateral extremity¹

III. Shoulder/Clavicle 1,2,3,6,8,10,11

A. Radiographic Views (Figs. 8-11)

1. Other studies may be performed (Figs. 12)

B. Fractures 1,2,3,4,5,8,9,11,12

1. Clavicle Fractures: Fracture locations: Medial, Middle 1/3 (most common), and Lateral. Best viewed with: AP clavicle radiographic series; Specialized views may include Serendipity view (10 degree cephalic view) (Fig. 13)
 - a. Scapular Fractures: Best seen on AP scapular, scapular Y (lateral or outlet view) views.
 - b. Fracture locations: Scapular body, scapular neck, acromion, glenoid or in combination
 - c. Glenoid Fractures: Can occur after a gleno-humeral dislocation. Contributes to Glenohumeral instability if >25% of the glenoid is fractured (Fig. 14)
2. Humeral Fractures: Best seen on shoulder radiographic series, humerus radiographic series, and CT
 - a. Humeral Head Fracture: Best viewed radiographically: AP view of the shoulder with extremity internally rotated (Fig. 15)
 1. Hill Sachs Lesion: Impact fracture of the posterolateral aspect of the humeral head seen after gleno-humeral dislocation
 2. Complication of humeral head fracture: Avascular necrosis (AVN).

(Fig. 16)

- b. Humeral Neck Fracture: Best seen on AP shoulder view (Fig. 17)
- c. Humeral Shaft Fracture: Best viewed radiographically on AP shoulder view
 1. Complication of oblique fracture middle 1/3-distal 1/3 fractures: Radial nerve entrapment at the fracture (Holstein-Lewis Fracture) site. (Fig. 18)

C. Dislocations 1,2,3,4,5,8,9,11,12

1. Sternoclavicular Dislocations(S-C):
 - a. Rare injury: May be anterior or posterior; Posterior S-C dislocation can cause vascular and/or airway compromise.

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- b. Specialized views: Hobbs or Rockwood views (10 degree cephalic tilt) are taken, as typical AP view will often miss dislocation.
 - c. CT also of benefit to determine dislocation verses a fracture of the medial clavicle.
2. Acromioclavicular joint (ACJ) Dislocation:
- a. Common injury with 6 Grades:
 1. Grade I: Radiographically normal
 2. Grade II: Widening of the joint, with mild superior displacement of the clavicle
 3. Grade III: Widened coracoclavicular space (>13 mm or a difference of > 5mm between sides; complete disruption of the ACJ and coracoclavicular ligaments; 100% superior displacement of the distal clavicle.
 4. Grade IV: Posterior dislocation of the distal clavicle into the trapezius fascia
 5. Grade V: Widened coraco-clavicular space with complete disruption of the ACJ and coraco-clavicular ligaments. >100% superior displacement of the distal clavicle
 6. Grade VI: Subcoracoid dislocation of the distal clavicle (rare)
 - b. Best Radiographic views: AP, axial views and 15 degree cephalic tilt; May also have weighted views (Fig.19)
3. Glenohumeral Dislocation (GH): (Fig. 20)
- a. Dislocations may be atraumatic, acquired or traumatic
 - b. Anterior: Most common glenohumeral dislocation (>95%)
 - c. Posterior: Rare dislocation, which is often missed; use of CT to assist with diagnosis. Typically follows seizure or electrocution.
 - d. Shoulder radiographs with Axillary view to determine anterior versus posterior dislocation
 - e. MRI: To assess for chronic dislocations and intra-articular pathology.
- D. Arthritis -1,2,3,4,8,10,11,13
1. Osteoarthritis: Narrowing of the joint space; subchondral sclerosis or cysts; osteophyte formation; usually lacking in osteoporosis with bone generally preserved.
 - a. Acromioclavicular Joint (AC): Common location of osteoarthritis; best radiographic view: shoulder radiograph series
 - b. Glenohumeral Joint: Best radiographic view: shoulder radiograph series (OA of the AC and Glenohumeral Joint) (Fig.21)
 2. Rheumatoid: Larger joint involvement; osteoporosis common; fusiform soft tissue swelling; periarticular erosions, articular erosions present. Best radiographic view: shoulder radiograph series.
- E. Soft Tissue Pathology^{1,2,3,4,8,10,11,13}
1. Impingement Syndrome: Clinical diagnosis of rotator cuff (RC) tendonitis/subacromial bursitis caused by pinching of the RC by the undersurface of the acromium; can be confirmation by MRI
 2. Rotator Cuff Tears (RTC): May have high riding humeral head noted on AP view with massive RTC injury
 3. Bankart Lesion: Detachment of anterior-inferior glenoid labrum following glenohumeral dislocation; confirmed with MRI/MRA (Fig. 22)

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4. SLAP Lesions: Tear of the superior labrum anterior to posterior; confirm with MRA
5. Rotator Cuff Calcific Tendonitis: Best radiographic view: Shoulder radiograph series, MRI (Fig. 23)
6. Adhesive Capsulitis: Narrow joint space noted on shoulder radiographic series.

IV. Elbow/Proximal Forearm

A. Radiographic Views^{1,2,3,6,11,14,15}

1. Posterior Anterior View (PA) (Fig. 24)
2. Lateral View (Fig. 25)
3. Oblique View (Fig. 26)

B. Fractures^{1,2,3,4,5,6,7,11,12,15,16,17}

1. Distal Humeral Fractures

- a. Supracondylar Fracture: Fracture between the humeral diaphysis and condyles. Best radiographic views: AP, Oblique and Lateral elbow series.
- b. Transcondylar: Intracapsular and transverse often resulting from low energy fracture occurring in older osteopenic adult. Best radiographic views: AP, Oblique, and Lateral elbow series
- c. Condylar: Intercondylar, condylar, capitellar, trochlear or epicondylar fracture. Best Radiographic views: AP, Oblique and Lateral elbow series
- d. Gunstock Deformity: Cubital varus deformity of the elbow after supracondylar or epicondyle fracture in children

2. Radial Fractures

- a. Radial Head Fracture: Best radiographic view: AP, lateral, oblique and radial head view; (Radial Head View - supinated elbow radiograph); CT depending on comminution (Fig. 27)
- b. Coronoid: Isolated fractures of the coronoid are uncommon; usually associated with elbow dislocation. Best radiographic view: Lateral view (Fig. 28)

3. Essex-Lopresti: Injury to interosseous membrane after axial load injury; Clinical diagnosis supported with elbow radiograph series; usually associated with radial head fracture; Best view after radiographs: Cinofloroview of the forearm with axial load.

4. Midshaft Ulna Fracture: Due to trauma; Nightstick fracture; best radiographic view: complete forearm series (Fig. 29)

C. Combination Radius and Ulna Fractures/Dislocations^{1,2,3,4,5,6,9,11,12,15,16,17}

1. Monteggia: Fracture of the ulna with a dislocation of the proximal radius. The proximal radius dislocation can displace anteriorly, posteriorly, or laterally. Best radiographic view: forearm radiographic films and elbow films. (Figs. 30)

2. Galeazzi Fracture: Fracture of the distal 1/3rd of the radius with dislocation of the distal ulna; May be called a reverse Monteggia fracture.

3. Terrible Triad: Fracture dislocation of the elbow with radial head fracture, coronoid fracture and lateral collateral ligament disruption. (Fig. 31)

4. Midshaft fractures: May be referred to as “both bone” forearm arm fractures; Greenstick Fracture is an incomplete fracture of the radius and ulna; Best radiographic view: forearm radiograph series (Fig. 32)

D. Dislocations^{1,2,3,4,5,6,11,12,14,15,16,17}

1. Posterior Elbow Dislocation: Most common elbow dislocation; best radiographic views: AP and Lateral views (Fig. 33)

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2. Radial Head Congenital Dislocation: Best radiographic view: lateral elbow view (Fig. 34)

E. Arthritis^{1,2,3,4,6,9,11}

1. Osteoarthritis: Best viewed radiographically on a complete elbow series.(Fig. 35)
2. Rheumatoid: Best viewed radiographically on a complete elbow series (Fig. 36)

F. Soft Tissue Pathology^{1,2,3,4,5,6,11,13,14,15,18}

1. Olecranon Bursitis: Soft tissue swelling noted on lateral elbow radiograph
2. Biceps/triceps ruptures: “Fleck sign” best viewed radiographically on the lateral elbow view (Fig. 37)
3. Ligamentous injury: Radiograph elbow series; Best view for injury assessment is an MRI; may also have MRA
 - a. Ulnar Collateral ligament
 - b. Radial Collateral ligament
 - c. Annular ligament
 - d. Interosseus Membrane (review Essex-Lopresti Injuries Section IV. B. 3)

V. Distal Forearm/Wrist

A. Radiographic Views^{1,2,3,4,6,11,19,20}

1. Posterior Anterior (Fig. 38)
2. Lateral (Fig. 39)
3. Oblique (Fig. 40)
4. Carpal Tunnel View (Fig. 41)
5. Scaphoid View (Wrist In Ulnar Deviation) (Fig. 42)

B. Terminology^{1,2,3,4,5,6,11,19,20,21}

1. Palmar Tilt: Assessment with the lateral wrist radiograph; determined by the angle between the plane of the distal articular surface of the radius and perpendicular to the long axis of the shaft of the radius (Fig. 43)
 - a. Average palmar tilt is positive (+) 11 degrees
 - b. Dorsal tilt is noted with a negative sign (-).
 - c. Best Radiographic view: Lateral wrist
2. Radial Inclination or Angulation: The angle between a line tangential to the distal articular surface of the radius and perpendicular to the radial shaft on the AP or PA view (Fig. 44)
 - a. Average Inclination: 22 degrees
 - b. Best Radiographic view: Posterior-Anterior view of a wrist series
3. Radial Length: Distance in millimeters between two parallel lines perpendicular to the center axis of the radius as seen on the PA or AP view. One line is at the level of the radial styloid and the other is at the proximal articular surface. (Fig. 45)
 - a. Average = 9 mm
 - b. Best radiographic view: Posterior-Anterior view of a wrist series
 - c. Ulnar Variant: Length of the ulna in relationship to radius; may be positive, negative or neutral; affected by pronation of forearm on PA view. Best viewed radiographically: Zero Rotation PA view (Fig. 46)
4. Gilula’s Lines: Used in review of PA wrist views, defining normal carpal arcs (Fig. 47)
 - a. Arc I: Smooth proximal convex outline of the scaphoid, lunate and triquetrum

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- b. Arc II: Smooth distal concave curvatures of the scaphoid, lunate and triquetrium
- c. Arc III: Smooth convex curvature of the capitate and the hamate
- 5. “3C’s” noted on Lateral view of Wrist: Assessment of normal radiolunatecapitate alignment, radioscaphoid, lunoscaphoid and capitolunate relationships (Fig. 48)
 - a. The head of the capitate fits concentrically within the distal concavity of the lunate
 - b. The lunate articulates with the lunate fossa of the distal radius
 - c. The scaphoid is superimposed on the lunate and the capitate
 - d. The axis of the lunate, capitate and radius are collinear
- 6. Scapholunate Angle (Fig. 49)
 - a. Normal between 30-60 degrees
 - b. Best viewed on lateral view of the wrist
 - c. DISI pattern will have a greater than 60 degree angle
- 7. Capitulate Angle (Fig. 50)
 - a. Normally less than 30 degrees
 - b. Best viewed on lateral view of the wrist
- 8. Carpal Height Ratio: Assessment for carpal collapse
 - a. Length of the Carpus = A
 - b. Length of the 3rd MCP = B
 - c. $A \div B = .54 \pm 0.03$

C. Fractures^{1,2,3,4,5,6,7,11,19,20}

- 1. Distal Radius Fractures (Fig. 51)
 - a. Colles’ Fracture: Fracture of the distal radius with dorsal angulation; common in older women; also known as a dinner fork fracture; may have concurrent injuries. Best radiographically viewed with a PA and lateral views of wrist radiograph series.
 - b. Smith’s Fracture: Fracture of the distal radius with volar angulation; may be called Reverse Colles’ fracture; common in younger population often from a fall; Non articular. Best radiographically viewed with a lateral and PA wrist radiograph series.
 - c. Barton’s Fracture: Shear fracture of the articular surface of the radius; angulation may be volar or dorsal; Best viewed radiographically with a lateral view of a wrist series.
 - d. Radial Styloid Fracture: Chauffer’s Fracture or Hutchinson’s fracture; Best viewed radiographically PA with of a wrist series.
 - e. Die Punch Fracture: Intra-articular Lunate fossa depression seen on wrist radiograph series: may also have a CT.
- 2. Distal Ulna Fractures:
 - a. Avulsion fracture of the ulnar styloid
 - b. Ulnar neck fracture seen with distal radius shaft fracture

D. Dislocations^{1,2,3,4,5,6,7,11,12,16,17,19,20,21,22}

- 1. Distal Radial Ulnar Joint: Best viewed with PA and lateral of wrist radiograph series; may have CT, MRI series (Fig. 52)
 - a. Galeazzi’s Fracture: Fracture of the distal 1/3rd of the radius with dislocation of the distal ulna; may also be called a reverse Monteggia fracture.

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- b. Radioulnar line assessment for joint displacement
- E. Carpals^{1,2,3,4,5,6,7,9,11,12,19,20,22,23,24,25,26}
1. Scaphoid: Most commonly fractured carpal (Fig. 53)
 - a. Fracture locations: Distal (5-10%), Waist (70-80%) and Proximal Pole (15-20%); best radiographic views: wrist series to include ulnar deviated (scaphoid) view; may have CT, MRI
 - b. Cortical Ring/Signet Sign: Best seen on AP view of wrist series
 - c. MRI used to assess avascular necrosis, occult fractures
 - d. CT study to assess for healing of fracture, assess morphology of the fracture prior to surgical planning
 2. Scaphoid Nonunion Advanced Collapse (SNAC) Wrist (Fig. 54)
 - a. Stage 1: Simple non union of the scaphoid, rotary subluxation, AVN
 - b. Stage 2: Unstable non union of the scaphoid
 - c. Stage 3: Non union of scaphoid with early degenerative changes
 - d. Stage 4: Non union of scaphoid with advanced degenerative changes
 3. Lunate: Watch position of “teacup” viewed with a lateral wrist series. Fracture of the lunate is rare accounting for less than 3% of carpal fractures; best radiographic view: wrist series lateral view assessing lunate long the long axis of radius; CT.
 - a. Avascular Necrosis (AVN) of the Lunate or Kienbock’s Malacia (Fig. 55): May be associated with ulnar minus variant; best radiographic view: complete wrist series; bone scan, MRI or CT may be used
 - b. Perilunate Dislocation: Best radiographic view: a lateral view of the wrist series assessing the capitate along the long axis of the radius; may be in conjunction with fracture termed with prefix trans – transscaphoid perilunate dislocation
 1. Type 1: Scapholunate dissociation
 2. Type 2: Lunocapitate disruption
 3. Type 3: Lunotriquetrial disruption
 4. Type 4: Lunate dislocation (Fig. 56)
 - c. Dorsal Intercalated Segmental Instability (DISI) (Fig. 57)
 1. Lunate extends dorsally due to disruption of scapholunate ligament; scaphoid flexes volarly
 2. May be associated with advanced arthritis
 3. Scapholunate angle is greater than 60 degrees; Capitulum angle may or may not change
 4. Best radiographic view: Lateral, AP of a wrist series
 5. May have a dynamic instability pattern. Best seen with cinefluroradiographic study

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- d. Volar Intercalated Segmental Instability (VISI) Wrist (Fig. 58)
 1. Lunate is flexed volarly due to disruption of lunotriquetrial ligament; scaphoid flexes volarly
 2. Scapholunate angle is ≤ 30 degrees; Capitollunate angle is ≥ 30 degrees
 3. Best Radiographic views: Lateral, AP of a wrist radiographic series
 4. May have a dynamic instability pattern which is best assessed with fluoroscopy
- e. Scapholunate Advance Collapse (SLAC) Wrist (Fig. 59)
 1. Stage 1: Degenerative changes to the radial aspect of the radioscaploid joint
 2. Stage 2: Degenerative changes to the entire radioscaploid joint
 3. Stage 3: Narrowing and sclerosis of the capitollunate joint and the entire radioscaploid fossa, radiollunate joint spared
 4. Stage 4: Carpal collapse with advanced degenerative change
4. Triquetrium: 2nd most commonly fractured carpal; common avulsion fracture; Best radiographic view: on lateral and oblique view of wrist radiograph; CT
5. Pisiform: Uncommon fracture; often due to blunt force; Best viewed radiographically with wrist series, supinated oblique and carpal tunnel view
6. Trapezium/Trapezoid (Fig. 60): Usually associated with OA changes with basilar thumb joint (Fig. 61)
7. Capitate: Rare fracture accounting for 1-3% of carpal fractures; associated with trauma; May be in-conjunction with scaphoid fractures or perilunate dislocations; Best radiographic views: complete wrist series; CT scan.
8. Hamate (Fig. 62): Fracture is typically the hook of the hamate rather than body. Articulation of the 5th MPJ may have instability issues to include dorsal dislocation. Best radiographic view: carpal tunnel view for the hook of the hamate fractures as well as a CT; Best radiographic view: lateral and pronated oblique hand views for hamate body fractures
9. Carpal Coalitions (Fig. 63): Conjoining of carpals; Lunotriquetrial is the common; Capitoamate is also common.
- F. Arthritis^{1,2,3,4,6,9,11,12,19,20,22,23,26}
 1. Osteoarthritis: Best seen on wrist radiographic series (Fig. 64)
 2. Rheumatoid: Best seen on wrist radiographic series
- G. Soft Tissue Pathology^{1,2,3,4,5,6,7,11,12,13,19,20,21,22,23,25,26}
 1. Scapholunate Dissociation (Figs. 65-66):
 - a. “Terry-Thomas Sign” due to disruption of the scapholunate ligament; scaphoid will have rotary subluxation and volar tilt producing “cortical ring sign” or “signet sign.” Abnormal widening of greater than 2 mm
 - b. Best radiographic view: Clenched Fist Views – compare to the contralateral wrist. AP, Ulnar Deviation, Wrist series and MRI/MRA.
 2. TFCC: Triangular Fibrocartilage Complex (Fig. 67)
 - a. Wrist radiographs may be normal
 - b. AP view may show ulnar positive variant
 - c. Best radiographic study: Wrist series, Arthrogram, MRI/MRA (Fig. 68)
 - d. May be associated with ulnar styloid fractures or ulnar abutment.

- e. Acute injuries with styloid fracture vs. chronic – associated with ulnar positive (+) variance

VI. Hand**A. Radiographic Views**^{1,2,3,6,11,23}

1. Posterior Anterior (Fig. 69)
2. Lateral (Fig. 70)
3. Oblique (Fig. 71)
4. Other Studies: MRI (Fig. 72)

B. Metacarpals (MCP)^{1,2,3,4,5,6,7,9,11,12,19,23}

1. Fractures: Hand series including AP and Lateral views; CT for intra-articular base fracture
 - a. Bennett's Fracture (Fig. 73): Intra-articular fracture at the base of the 1st Metacarpal (MC); Best viewed radiographically: complete hand series, CT.
 - b. Reverse Bennett's Fracture (Baby Bennett's Fracture) (Fig. 74): Fracture at the base of the 5th Metacarpal (MC); Best viewed radiographically: complete hand series, CT.
 - c. Boxer's Fracture (Fig. 75): Fracture of the 5th Metacarpal (MC) Head/Neck; May have volar angulation; Best viewed radiographically: oblique view of complete hand series; occasionally CT if comminution is present.
 - d. Rolando's Fracture (Fig. 76): Comminuted Bennett's fracture; intra-articular fracture at the base of the 1st MCP; may have Y, V or T pattern; Best viewed radiographically: complete hand series and CT.
 - e. Midshaft Metacarpal Fracture (Fig. 77)

2. Dislocations^{1,2,3,4,5,6,7,11,12,19,20,23}

- a. Metacarpalphalangeal Joint (MPJ):
 1. Gamekeeper's/Skier's Thumb: Best viewed radiographically: a complete hand series; Abduction stress view of the thumb; Arthrogram to assess for entrapment/disruption of the ulnar collateral ligament
 2. Digits 2-5 MPJ: Rare dislocation
- b. 5th Carpal-Metacarpal (CMC) joint dislocation is a common injury; maybe associated with fracture; Best viewed radiographically: Oblique view of complete a hand series; occasionally CT. (Fig. 78)

3. Arthritis^{1,2,3,4,6,9,11,12,23}

- a. Osteoarthritis: Best seen on Hand Series (Fig. 79)
- b. Rheumatoid: Best seen on Hand Radiographic Series (Fig. 80)

4. Soft Tissue Injuries^{1,2,3,4,6,7,11,12,13}

- a. Plain radiographs not usually of assistance; MRI to assess for ligament injury
- b. Cinefluorography, cineradiography used to assess for instability patterns

C. Phalanges^{1,2,3,4,5,6,7,11,12,13,23}

1. Fractures: Best viewed with Hand series including AP and Lateral views.
 - a. Proximal Phalanges (P1) (Fig. 81):
 - b. Middle Phalanges (P2)
 1. Volar Plate Avulsion: Common fracture best seen on Lateral view of hand or finger series (Fig. 82)

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2. Middle Phalangeal fractures may have variety of fracture patterns; best viewed with hand or finger radiographic series (Fig. 83,84)
 - c. Distal Phalanges (P3):
 1. Tufts fracture: Best viewed radiographically on complete finger radiographic series
 2. Boney Mallet (Fig. 85): Avulsion fracture with involvement of the terminal tendon of the extensor hood mechanism; best viewed radiographically on lateral view a complete finger series
 3. Amputation (Fig. 86): Best radiographic view: complete hand or finger series
 2. Dislocations
 - a. Proximal Interphalangeal Joint (PIPJ) Posterior Dislocation (Fig. 87): Common injury; Best viewed with a hand radiographic series
 3. Combination Injuries^{1,2,3,4,5,6,7,11,12,23}
 - a. Fracture and Dislocation (Fig. 88): Trauma association; Best radiographic view: complete hand series; additional studies depending on mechanism of injury
 4. Arthritis^{1,2,3,4,6,11,23}
 - a. Osteoarthritis (Figs. 89-90): Best radiographic view: hand or finger series
 - b. Rheumatoid: Best radiographic view: Hand series
 5. Soft Tissue Pathology^{1,2,3,4,6,11,23} (Fig. 91): Appearance on Hand or Finger series; additional studies not typically required for boutonniere or swan neck deformity due to limited osseous involvement
- VII. Upper Extremity Conditions To Review With Care^{1,2,3,4,9,10,11,12,13} (Figs. 92,93,94,95)
1. Tumors/Cysts: Care regarding exam due to potential benign versus malignant lesions; appropriate radiographic series, CT, MRI/MRA, additional studies per physician.
 2. Questions to Review:
 - a. Are there multiple lesions?
 - b. Where is the location of lesion?
 - c. Type of margin of lesion?
 - d. Is there soft tissue involvement?
 - e. What is the density/appearance of the bone?
 - f. Any calcifications or fractures?
 3. Pediatric Injuries:^{1,2,3,4,11} Review with care due to potential injury to growth plates; see above sections for appropriate radiographic series
 - a. Salter Harris Classification: Useful classification for pediatric injuries affecting the physis, metaphysis, epiphysis or all of the above. (Fig. 96)
 1. Salter Harris Type I – Fracture through the growth plate
 2. Salter Harris Type II – Fracture through the growth plate and metaphysis
 3. Salter Harris Type III – Fracture through the growth plate and epiphysis
 4. Salter Harris Type IV – Fracture through the growth plate, metaphysis, and epiphysis
 5. Salter Harris Type V – Compression fracture through the growth plate.

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4. Infections:^{1,2,3,4,9,10,13,19} Bone destruction to include sclerosis, periosteal reaction and osteoporosis; soft tissue swelling and joint effusion. Appropriate radiographic series, may have CT or MRI. (Fig. 97)

The views expressed are those of the author(s) and do not reflect the official policy of the Department of the Army, The Department of Defense or the U.S. Government.

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Fig. 1. Arthrogram of carpus with contrast.



Fig. 2 Sagittal CT.

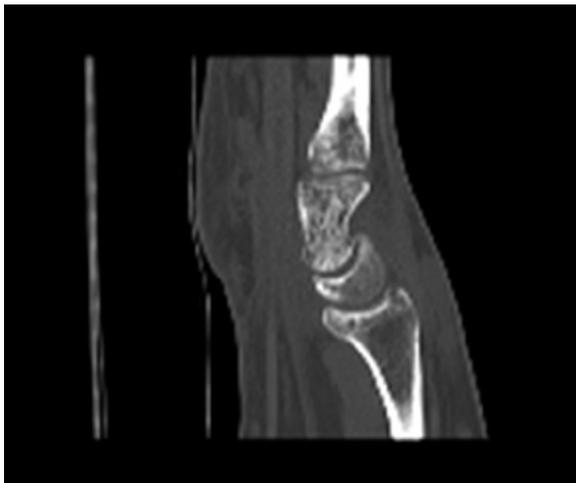


Fig. 3. Sagittal wrist CT.

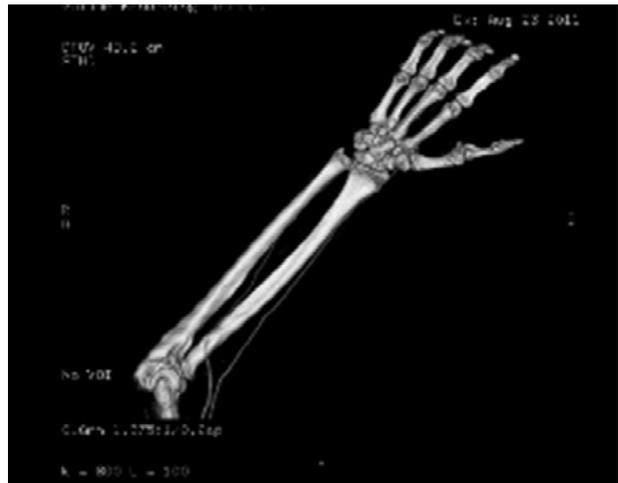


Fig. 4. 3-D Forearm/Hand CT.

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Fig. 5. T1 of the carpus (left). T2 image of the carpus (right).

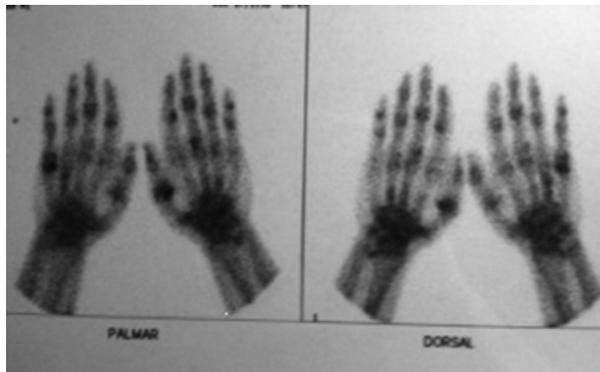


Fig. 6. Bone Scan of the Hand.

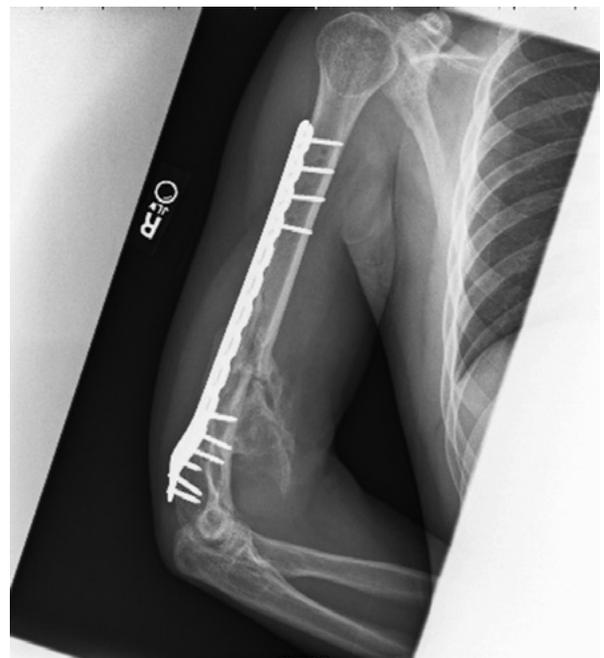


Fig. 7. HO after a Fracture.

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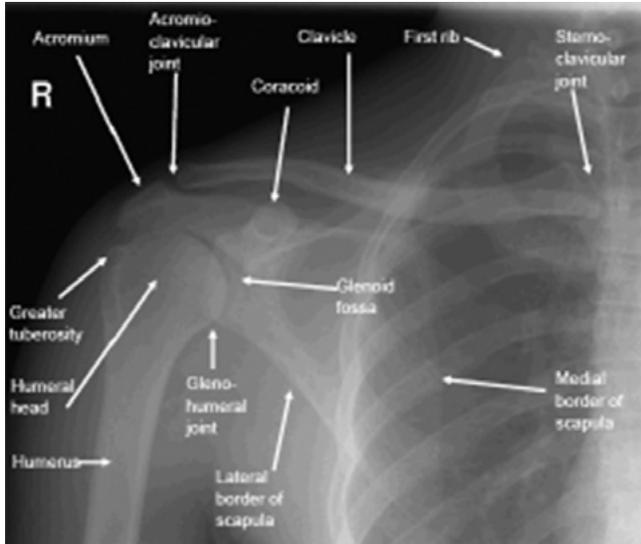


Fig. 8. Anterior-posterior view (AP).

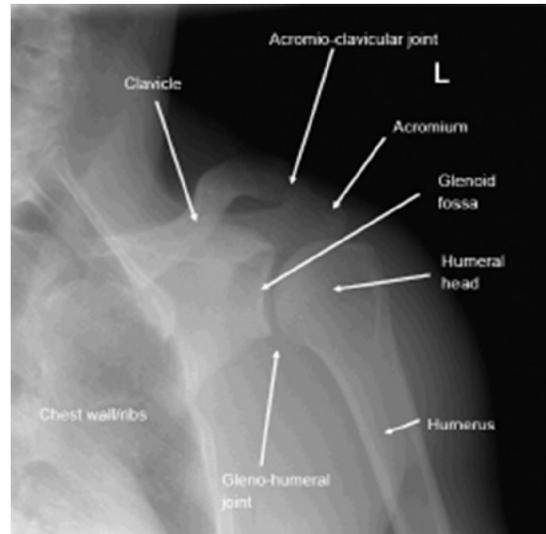


Fig 9. True AP of the shoulder.

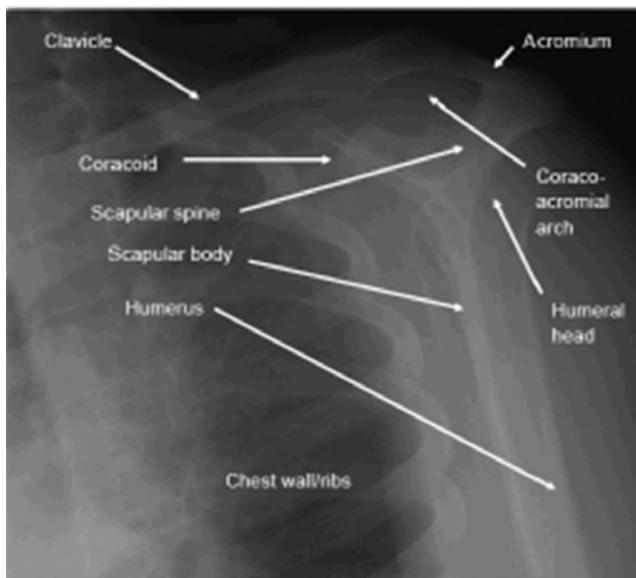


Fig. 10. Scapular Y or suprascapular view.



Fig. 11. Axillary view.

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Fig. 12. 3D CT of the Shoulder.



Fig. 13. AP of Middle 1/3rd Clavicle Fracture.

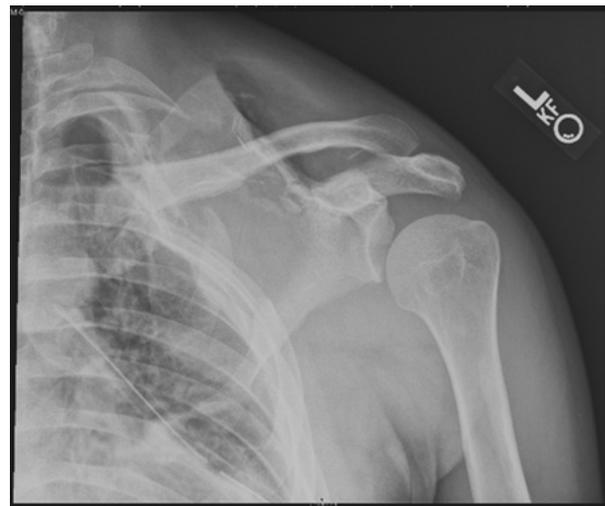


Fig. 14. Radiographs of Comminuted Scapular Fracture.

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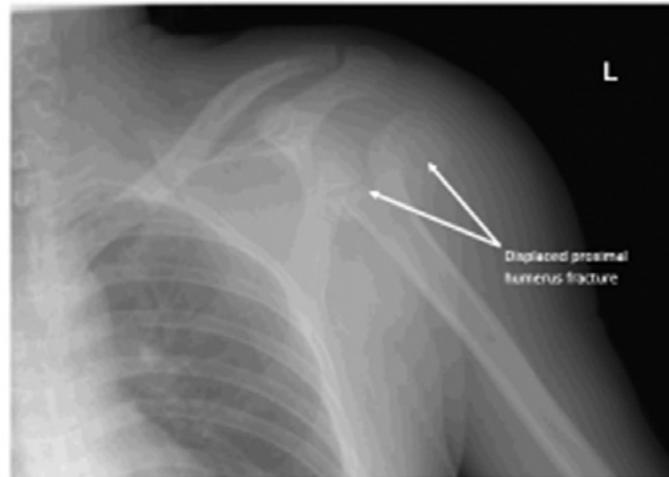


Fig. 15. AP view of the shoulder with extremity internally rotated.

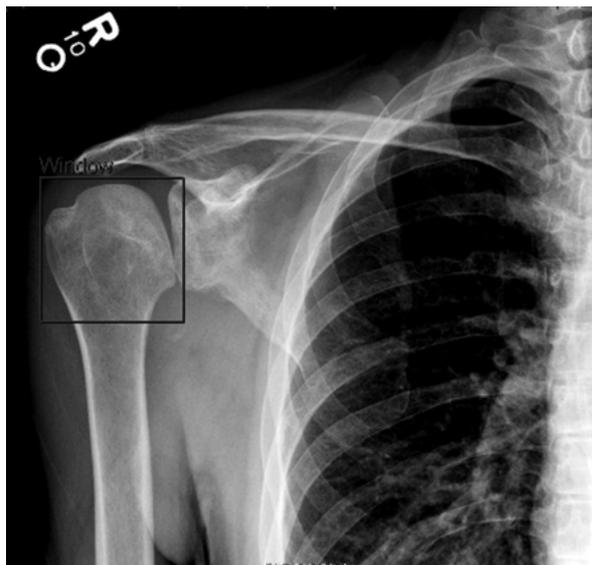


Fig. 16. AVN of Humeral Head.

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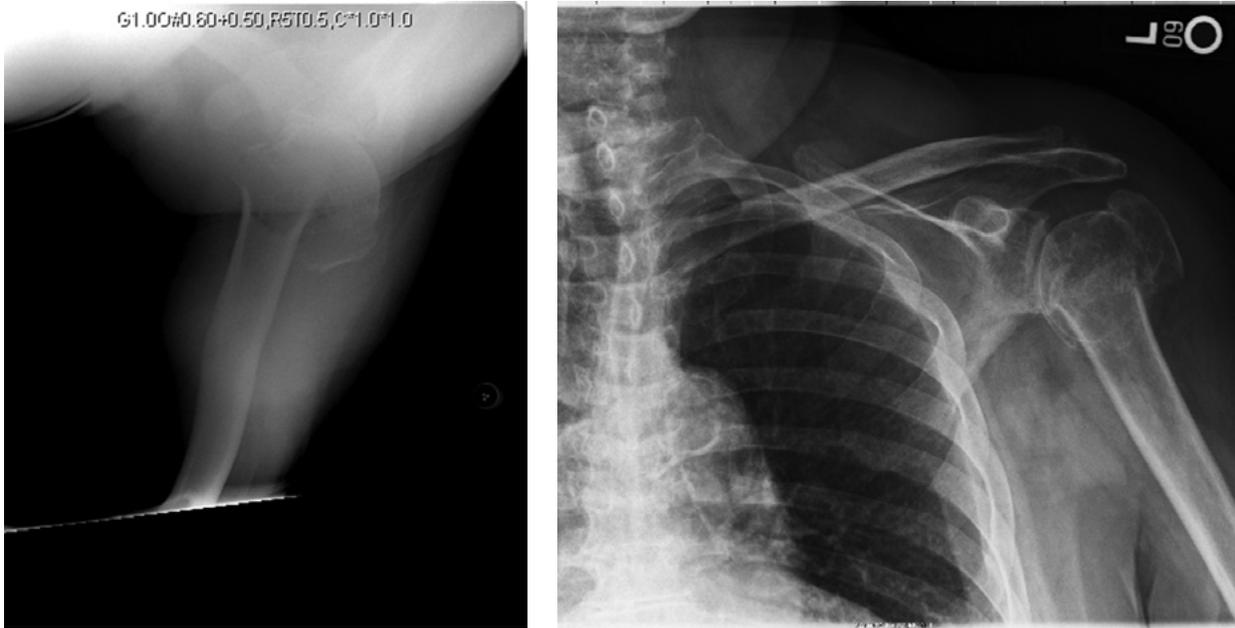


Fig. 17.



Fig. 18. AP of Middle Humeral Fracture.

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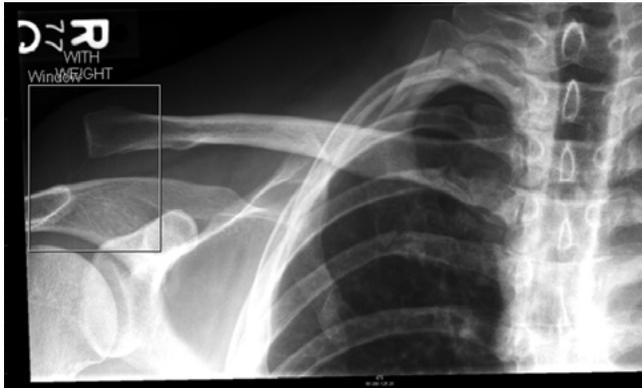


Fig. 19. AP of Acromioclavicular Joint (ACJ) Dislocation.

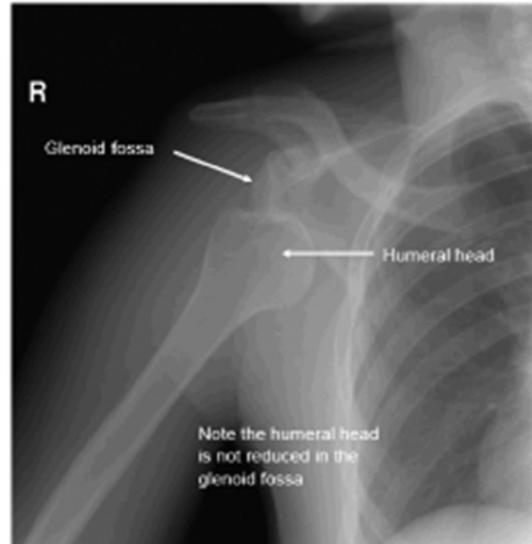


Fig. 20. Glenohumeral dislocation.



Fig. 21. OA of the AC and Glenohumeral Joint.

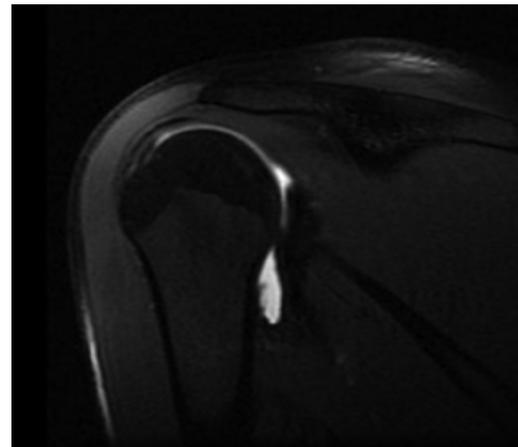


Fig. 22. MRA of a Bankart Lesion.

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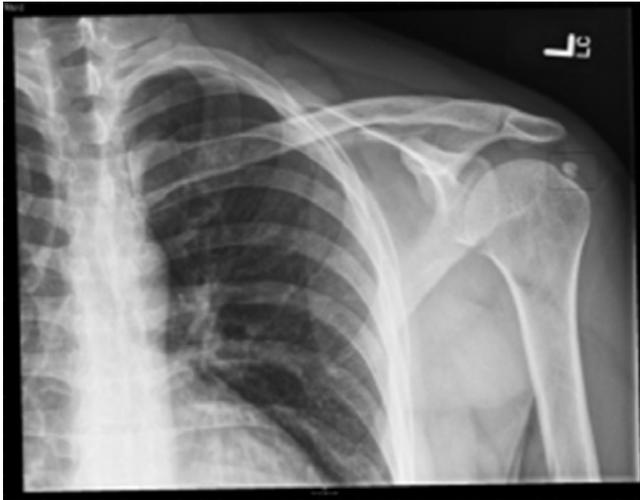


Fig. 23. Rotator Cuff Calcific Tendonitis



Fig. 24 Posterior-Anterior View (PA)



Fig. 25 Lateral View



Fig. 26 Oblique View

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Fig. 27 Lateral Elbow view of Radial Head Fracture



Fig. 28 Coronoid Fracture



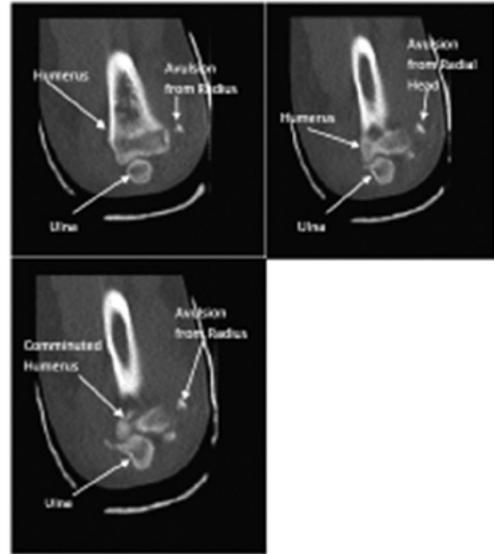
Fig. 29. Comminuted Midshaft Ulna Fracture with associated soft tissue damage.



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Fig. 30 Monteggia Fracture



**Fig. 31. CT of distal humerus/radius/
ulna fracture/dislocation – Terrible
Triad Injury.**

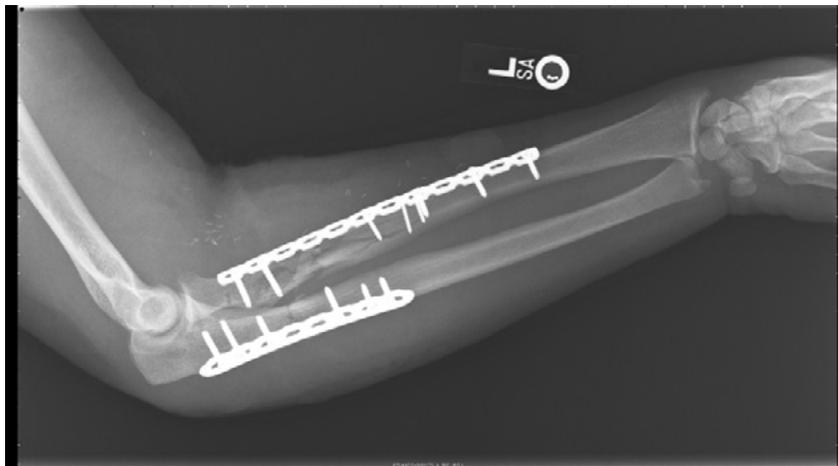


Fig. 32. Operative fixation of a "Both Bone" Forearm Fracture.

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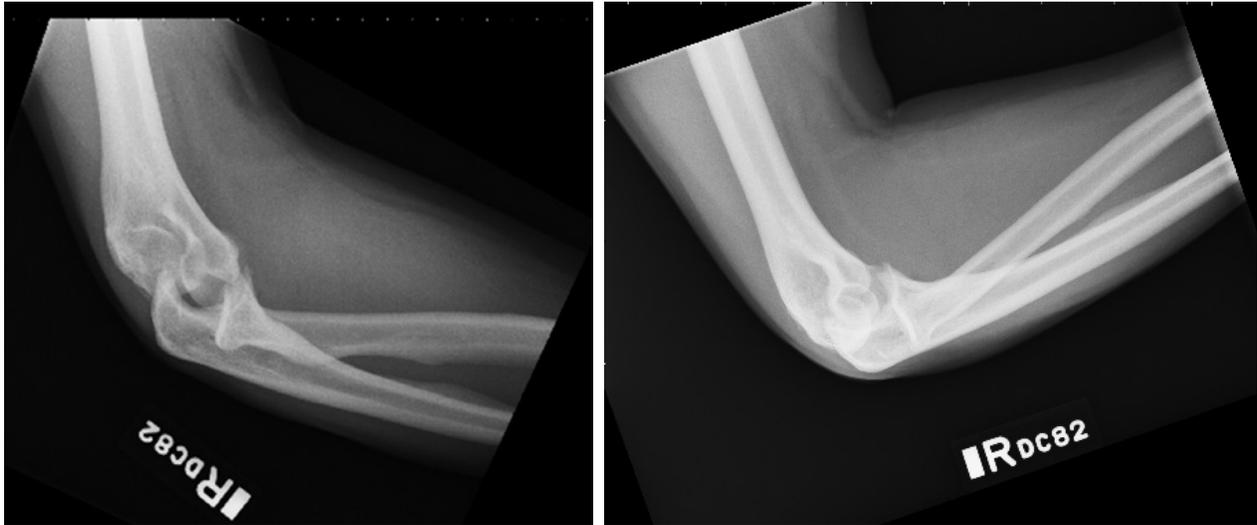


Fig. 33. Posterior Elbow Dislocation

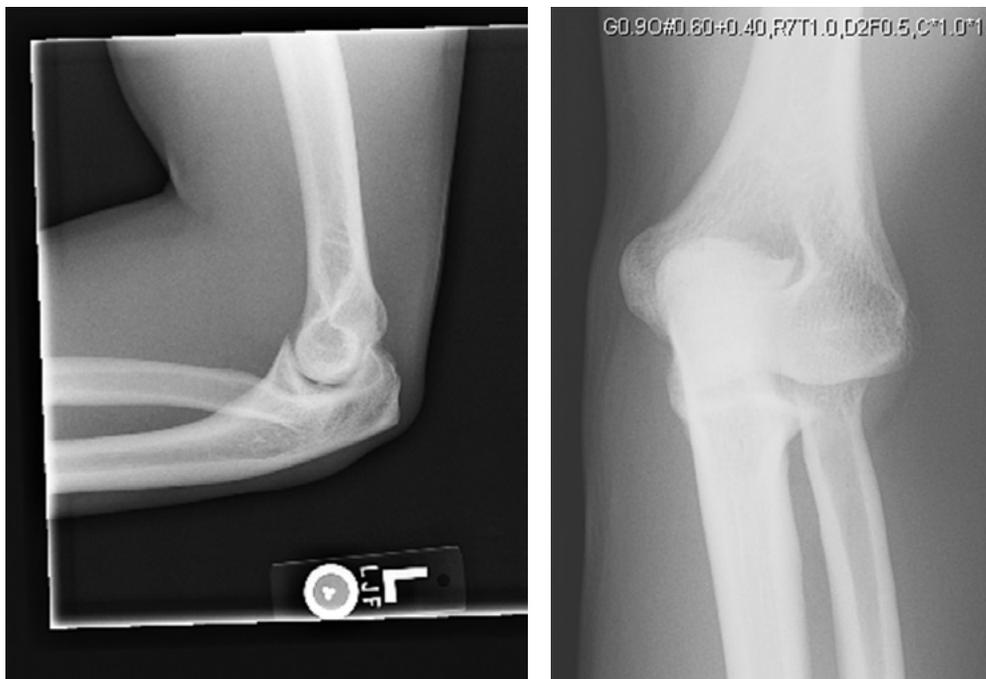


Fig. 34. Radial Head Congenital Dislocation on Lateral and PA views.

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Fig. 35. OA.



Fig. 36. RA.

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Fig. 37. Olecranon Fleck Sign seen after a Triceps avulsion.



Fig. 38 Posterior-Anterior View (PA)



Fig. 39 Lateral View



Fig. 40 Oblique View

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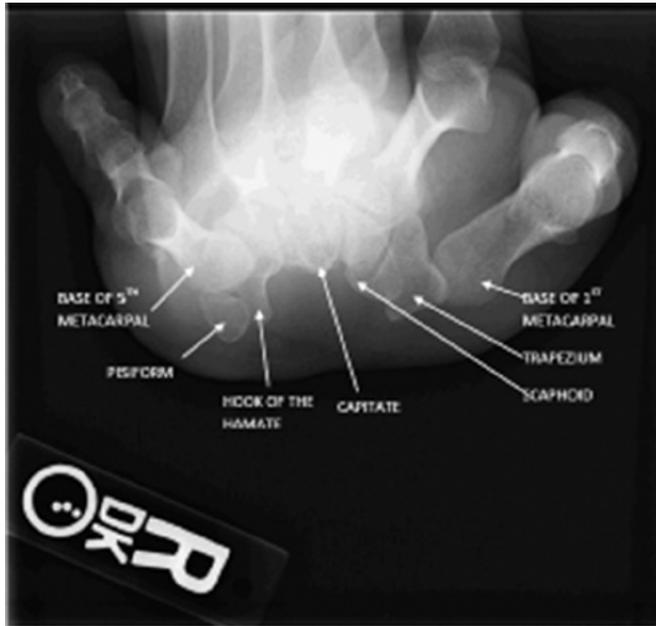


Fig. 41 Carpal Tunnel View



**Fig. 42 Scaphoid View
(Wrist in ulnar deviation)**



Fig. 43. Palmar Tilt.



Fig. 44. Radial Inclination.

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Fig. 45. Radial Length.



Fig. 46. Negative Ulnar Variance.



Fig. 47. Gilula's Lines.



Fig. 48. Lateral Wrist Radiograph with 3C's.

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Fig. 49
Scapholunate Angle



Fig. 50
Capitulate Angle



Fig. 51. Radiographic Series of a Distal Radius Fracture.

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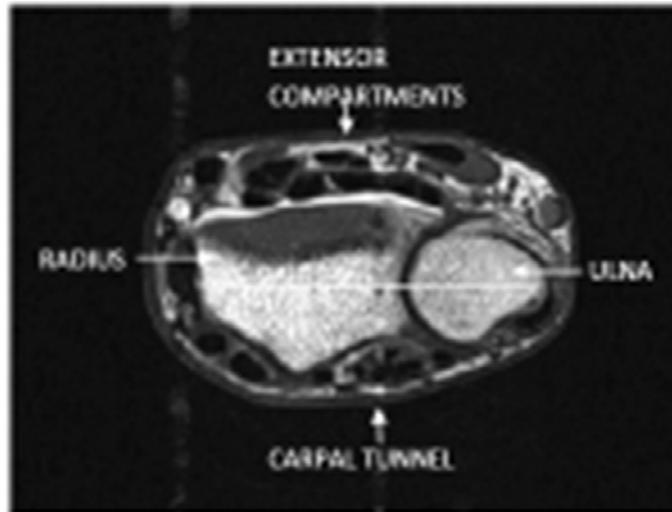


Fig. 52. Carpal Tunnel View of the Carpus.



Fig. 53. Scaphoid Fracture.

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Fig. 54. SNAC wrist and Proximal Row Carpectomy after SNAC wrist.



Fig. 55. AVN of Lunate with density change.

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Fig. 56. Radiographic Series of Lunate Dislocation.



Fig. 57. Radiographic views of DISI.

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Fig. 58. Lateral Radiograph of VISI pattern with flexed lunate.



Fig. 59. SLAC wrist.



Fig. 60. Trapezium Fracture.



Fig. 61. Basilar Joint OA.

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Fig. 62. Fracture of the Hamate.



Fig. 63. Lunotriquetral and Distal Carpal Row coalitions.

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Fig. 64. AP of advanced wrist OA.



Fig. 65. SL Dissociation with cortical ring sign.

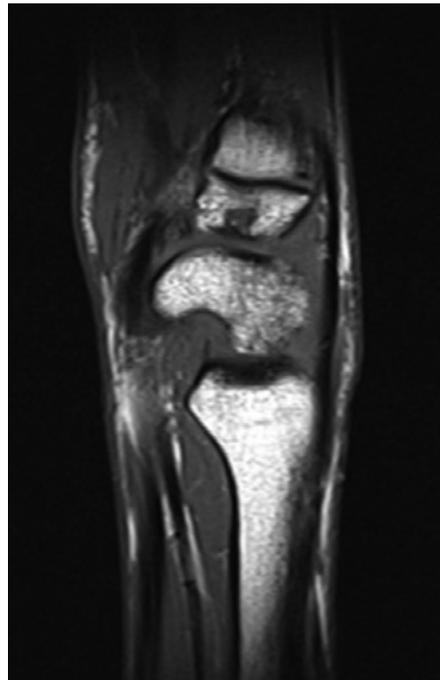
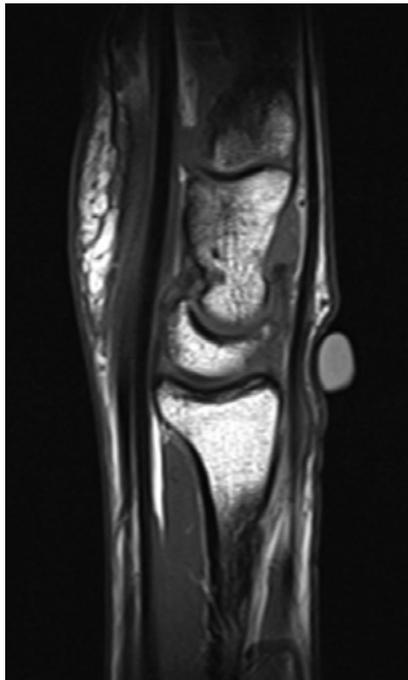


Fig. 66. MRI T1 Sagittal view of SL Dissociation, Lunate extended dorsal, Scaphoid flexed volar.

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Fig. 67. SL dissociation with ulnar styloid fracture associated with TFCC injury.

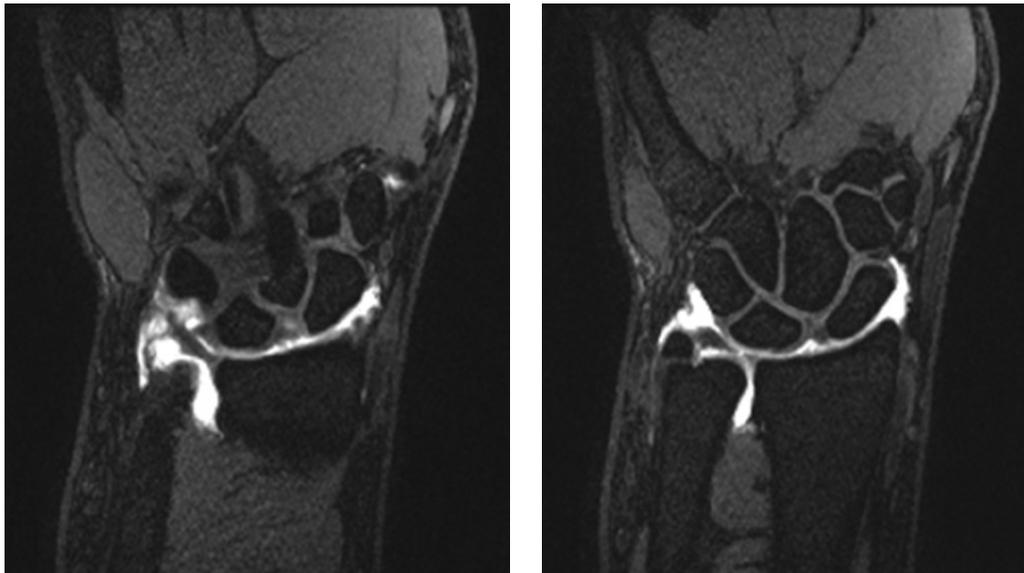


Fig. 68. MRA of TFCC Injury.

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Fig. 69 Posterior-Anterior View (PA)



Fig. 70 Lateral View

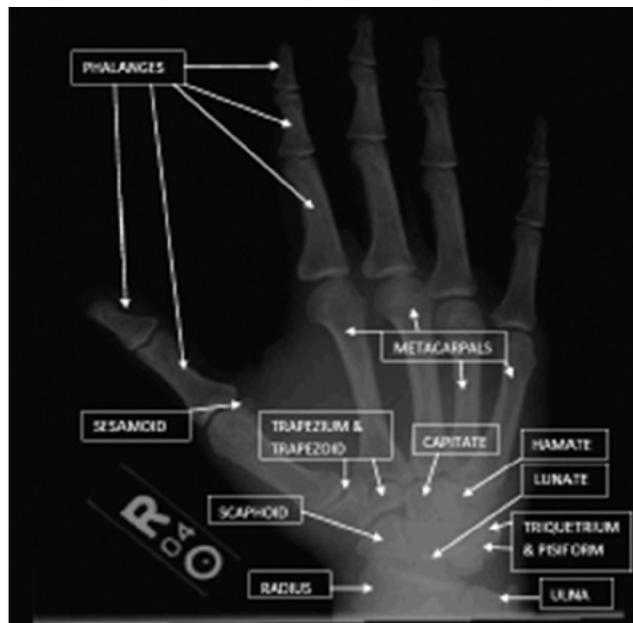


Fig 71 Oblique View

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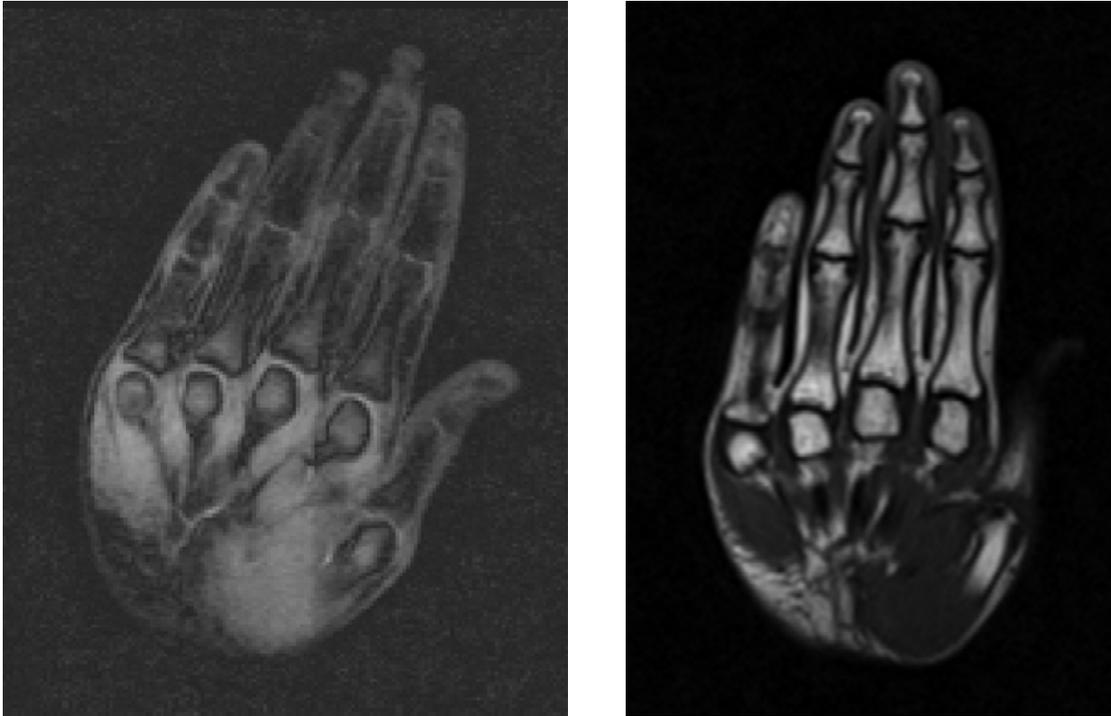


Fig. 72. T1 image and T2 Image.



Fig. 73. Intra-articular fracture at base of 1st MC.

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Fig. 74. Reverse Bennett's Fracture.



Fig. 75. 5th Metacarpal Fracture.



Fig. 76. Rolando's Fracture.



Fig. 77. Comminuted midshaft 3rd MCP fracture.

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Fig. 78. PA/Oblique of 5th CMCJ dislocation, also foreign body noted.



Fig. 79. PA of Hand with OA with osteophytes, decreased joint space.



Fig. 80. PA of hand with RA. Carpal Collapse, osteophytes, ulnar drift of the MCPJs present.

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Fig. 81. PA and Oblique x-rays of P1 Fractures.



Fig. 82. Volar Plate Avulsion Fracture.



**Fig. 83. Right Index Finger
Oblique view P2 Fracture.**

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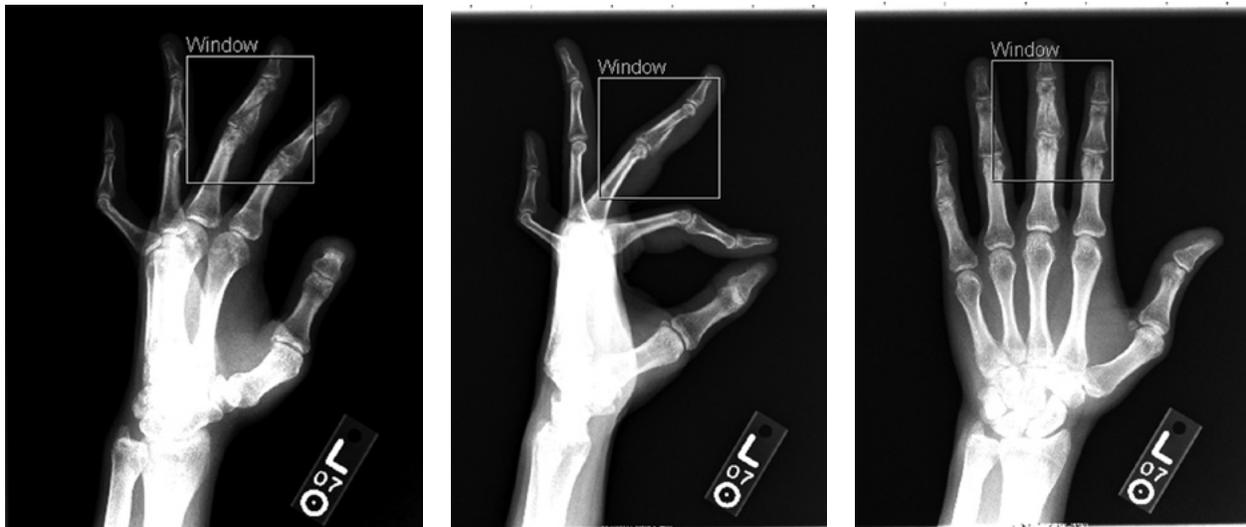


Fig. 84. Oblique/Lateral/PA views of P2 comminuted fracture.



Fig. 85. Boney Mallet.



Fig. 86. PA of L Index Finger P3 Amputation.

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Fig. 87. PA of L Small Finger PIPJ Dislocation.



Fig. 88. Fracture/Dislocation of R thumb Distal Phalanx.

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Fig. 89. Oblique view of Ring Finger with PIPJ OA.



Fig. 90. OA changes of the R thumb and R IF DIPJ; R SF PIPJ Boutonniere deformity.

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Fig. 91. Mallet Finger Deformity.



Fig. 92. Enchondroma of L RF P1 and R IF P3.

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Fig. 93. PA of hand with density changes to the R RF/SF from a soft tissue lesion.

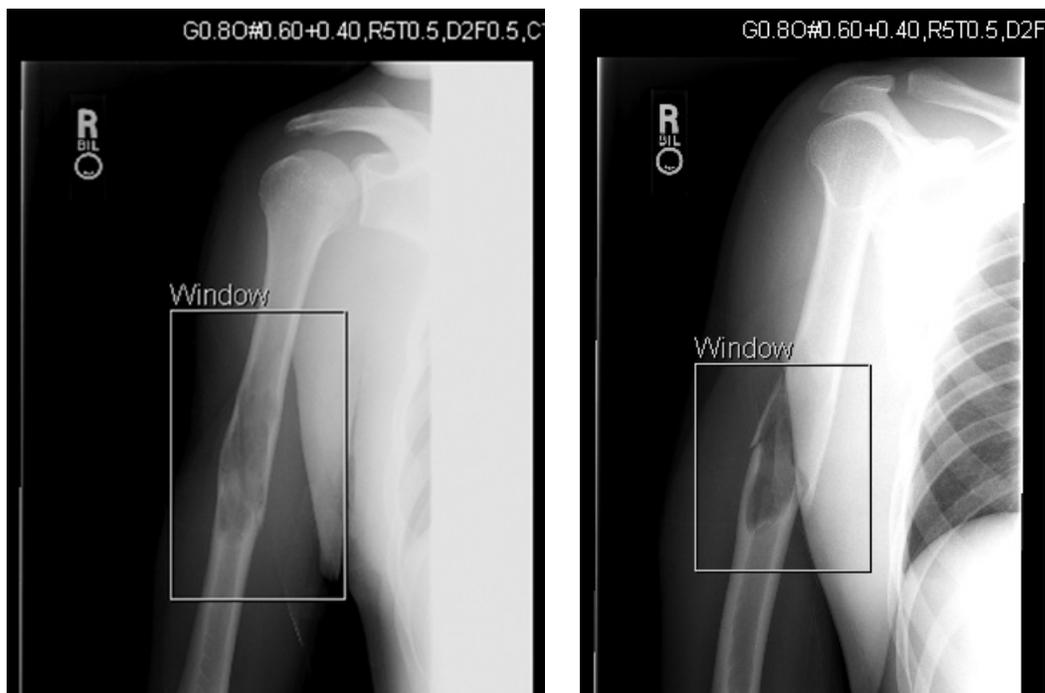


Fig. 94. Humeral PA prior to and after fracture through lesion.

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Fig. 95. PA and MRI of R hand with soft tissue mass.

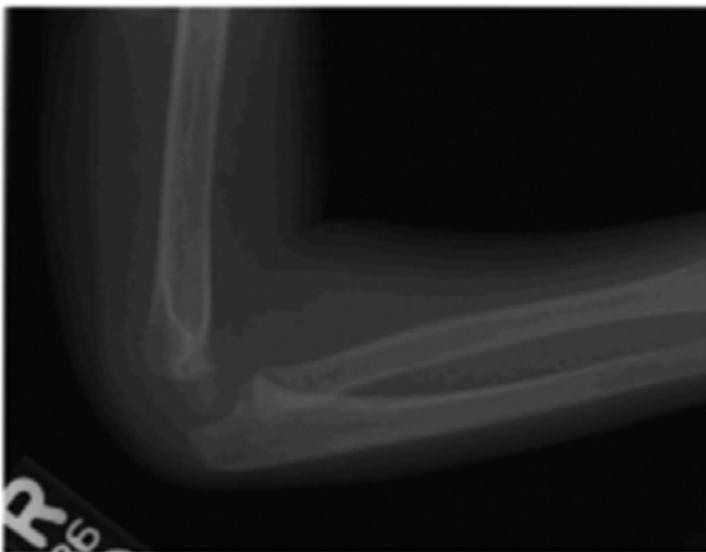


Fig. 96. Lateral Elbow view of Pediatric Elbow.



Fig. 97. R Hand Oblique with ORIF of fracture, osteomyelitis.

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Chapter 14: Radiologic Imaging

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Multiple Choice Questions

1. When a hook of the hamate fracture is suspected, what is the best view to confirm the diagnosis?
 - A. Oblique view of the wrist
 - B. A/P view of the wrist
 - C. Lateral view of the wrist
 - D. Carpal tunnel view
2. On an A/P view of the wrist, the lunate is noted to be more opaque than the other carpal bones. What is the most likely suspected diagnosis?
 - A. Lunotriquetral ligament tear
 - B. Kienbock's Disease
 - C. Scapholunate ligament tear
 - D. Triangular Fibrocartilage complex tear
3. When a Cortical Ring/Signet Sign is identified on a wrist radiograph, this is evidence of:
 - A. Scapholunate dissociation
 - B. Scaphoid fracture
 - C. Lunate avascular necrosis
 - D. Lunotriquetral dissociation
4. When measuring the scapholunate interval on a wrist posterior anterior view (PA), what distance is the interval considered widened:
 - A. 4-5mm
 - B. 6-7mm
 - C. 3-4mm
 - D. 7-8mm
5. A 5th Carpal metacarpal fracture-dislocation is best viewed radiographically with:
 - A. Lateral view of a hand radiograph series
 - B. Oblique view of a hand radiograph series
 - C. Posterior-Anterior view of a hand radiograph series
 - D. Clench fist view of the hand
6. The first published radiograph was an image of a:
 - A. Hand
 - B. Wrist
 - C. Elbow
 - D. Shoulder
7. A diagnostic imaging technique in which a two-dimensional picture of internal body tissue is produced through the detection of radiation from an injected radioactive substance is:
 - A. Bone scintigraphy
 - B. Magnetic Resonance Imaging
 - C. Computed Tomography
 - D. Arthrogram

Multiple Choice Questions

8. On a posterior anterior wrist radiographic view, what sign is indicative of a scapholunate ligament dissociation:
 - A. Sail Sign
 - B. Fat pad sign
 - C. Terry Thomas sign
 - D. Fat blood interface sign
9. What is lucency?
 - A. A form of joint subluxation
 - B. A transradiency of the bone
 - C. A thickening or hardening of the bone
 - D. Development of bone in a joint
10. A Fat Pad Sign is:
 - A. A sign of labral tear of the glenoid
 - B. An indication of scaphoid fracture
 - C. An indication of a triangular fibrocartilage complex injury
 - D. An abnormal distension of joint synovium
11. Magnetic resonance imaging is contraindicated for:
 - A. Metal implants or shrapnel
 - B. Growth plate injuries
 - C. Occult fractures
 - D. Neoplasms
12. Variables affecting radiographic image production do not include:
 - A. Length of exposure of the subject to the radiographic beam
 - B. Environmental light surrounding the subject
 - C. Density of the tissue
 - D. Positioning of the tissue
13. When reviewing a posterior anterior view of the wrist, what defines the normal carpal arcs:
 - A. Palmar tilt
 - B. Radial inclination
 - C. Radial length
 - D. Gilula's lines

**Multiple Choice Question Answer Key
Chapter 14**

1-D, 2-B, 3-A, 4-C, 5-B, 6-A, 7-A,
8-C, 9-B, 10-D, 11-A, 12-B, 13-D

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