ERRORS IN RADIOGRAPH INTERPRETATION

Commonly missed, high-risk injuries on radiographs can be remembered by using my mnemonic “DOH.” (similar to what your response might be when a patient is recalled for your incorrect radiology interpretation…)

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**Abbreviations:** “DL” – dislocation, “DS” – dissociation, “Fx” – fracture
WRIST

Normal Anatomy

PA View (R Wrist):
- 3 smooth arcs along carpals
- Intercarpal distance < 3 mm

Lateral View (Right Wrist):
- Alignment: Smooth articulation of distal radius to lunate, lunate to capitate, and capitate to 3rd metacarpal
- Scapholunate angle < 30-60 degrees

Dislocation

1. SCAPHOLUNATE DISSOCIATION
   - Most common and significant ligamentous injury of wrist. Rotatory subluxation of scaphoid into more transverse orientation.
   - Mechanism: Fall on outstretched hand (FOOSH)
   - Xray:
     - PA view: >4 mm widening of scapholunate space (“Terry Thomas sign”)
     - PA view: Scaphoid has “signet ring sign”
     - Lateral view: Scapholunate angle > 60 deg

2. PERILUNATE DISLOCATION
   - Mechanism: Hyperextension of the wrist
Xray:
✓ Lateral view: Capitate is not vertically aligned with the lunate and radius.
✓ PA view: Smooth middle arc alignment of carpal bones is disrupted.
Complications: Median nerve injury, SLAC

3. LUNATE DISLOCATION
Mechanism: Fall backwards on outstretched hand
Xray:
✓ Lateral view: Lunate is rotated out of alignment into “spilled teacup” position
✓ PA view: Smooth proximal arc of carpal bones is disrupted
✓ PA view: Lunate appears triangular (rather than quadrilateral)
Complication: Median nerve injury, SLAC

Occult Fracture

1. SCAPHOID FRACTURE
2nd most common fractured bone of the wrist [#1=distal radius]
At a teaching hospital ED, the “miss rate” was greatest for scaphoid fractures (13%) (Freed and Shields)
Mechanism: FOOSH
Exam: Tenderness to “snuffbox” area of wrist
Xray:
✓ Normal in up to 20% cases (Waeckerle)
✓ Consider obtaining additional scaphoid views
✓ Teaching Pearl: Apply thumb spica splint to all wrists with snuffbox tenderness regardless of normal xrays
Complication:
✓ Avascular necrosis (AVN)
✓ Nonunion rate increases 5-45% when treatment is delayed > 4 weeks (Langhoff and Andersen)
✓ SLAC (Scapholunate Advanced Collapse) – Scaphoid and/or lunate undergoes AVN and collapses

2. TRIQUETRUM FRACTURE
Accounts for 10% of carpal bone fractures
Mechanism: FOOSH
Exam: Tenderness to ulnar aspect of dorsal wrist
Xray: Most easily seen on lateral since triquetrum is most dorsal carpal bone
Half of Injuries Missed

1. **GALEAZZI FRACTURE**
   Distal-third fracture of the radius AND disruption of distal radioulnar joint (DRUJ)
   **Mechanism:** FOOSH with forearm hyperpronated
   **Signs of DRUJ:**
   - Lateral view: Ulna does not overlie radius
   - Lateral view: Ulnar styloid is not aligned with dorsal triquetrum
   - PA view: Ulnar styloid fracture
   - PA view: Widening of DRUJ
   **Complication:** Chronic disability when DRUJ disruption is missed > 10 wks

2. **DISTAL RADIUS FX + CARPAL INJURY**
   Because of the same FOOSH mechanism of injury, scapholunate dissociation may also be present. In a small retrospective study of 52 patients, 69% of distal radius fractures were associated with scapholunate dissociation (Lee et al.)
   Radial styloid fractures are associated with scaphoid / lunate fractures & ligamentous injury.
ELBOW

Normal Anatomy
Capitellum: Portion of distal humerus which articulates with the radial head

LATERAL VIEW
Fat pads: Collections of fat tissue adjacent to elbow joint capsule (appears black on xrays)
- **Anterior fat pad**
  - Can be normal
  - If displaced and elevated, is pathologic (sail sign)
- **Posterior fat pad**
  - Always abnormal if visualized

AP VIEW
Lines: Misalignment of normal structures can be a subtle indicator of a fracture or dislocation
- **Radiocapitellate line**: On both the AP and lateral views, a longitudinal line drawn through the midshaft radius should bisect the capitellum. An abnormal alignment suggests a radial head dislocation.
- **Anterior humeral line**: On the lateral view, a longitudinal line drawn along the anterior aspect of the humerus should bisect the capitellum. An abnormal alignment suggests a supracondylar fracture.
Dislocation

**RADIAL HEAD DISLOCATION**
When identified, must look for a proximal ulnar fracture (see “Monteggia Fracture”)

Occult Fracture

**RADIAL HEAD FRACTURE**
At a teaching hospital ED, the “miss rate” was 2nd greatest for elbow fractures at 10.8%. In adults, these fractures were primarily missed radial head fractures. (Freed and Shields)

**Mechanism**: FOOSH

**Xray**:
- Cortical break in the radial head may be very subtle or even absent in a nondisplaced fx
- Large anterior fat pad (“Sail sign”)
- Any posterior fat pad
- In the study by Freed and Shields: >80% had an associated fat pad and >40% had ONLY a fat pad sign as indicator of a fracture.

**Pearl**: Sling patients with elbow pain and abnormal fat pads despite no obvious fracture.

Half of Injuries Missed

**MONTEGGIA FRACTURE**
Proximal ulna fracture AND radial head dislocation
Missed in 50% pediatric population – importance of alignment of radiocapitellate line (Gleeson and Beattie)

**Mechanism**: FOOSH with rotational forces

**Xray**:
- Obvious proximal ulna fracture
- Misalignment of radiocapitellate line

**Pearl**: Beware of diagnosis of isolated proximal ulna fx!
PELVIS / HIP

Normal anatomy

**Dislocation**

**HIP DISLOCATION**

Most commonly posterior from dashboard injuries in MVA’s.
- **Posterior**: Affected leg is shortened and internally rotated
- **Anterior**: Affected leg is shortened and externally rotated

Since hip dislocations are associated with femoral head / acetabular fx’s, consider a CT for unsuccessful reduction to assess for intraarticular bone fragments.

**Occult Fracture**

1. **FEMORAL NECK FRACTURE**

   Most commonly missed hip fracture
   
   Sometimes elderly patients can weight-bear despite a fx.
   
   **Mechanism**: From direct blunt trauma (fall)
   
   **Xray**:
   - Can be very subtle
   - Cortical disruption or impacted hyperlucency
   - Loss of smooth cortical transition from femoral neck to head.
   - Trabecular disruption

   **Delay in Diagnosis:**
   - Radiographically occult hip fx’s occur in 2-9%.
   - One study had 16/825 missed hip fractures. 15/16 were initially nondisplaced but became displaced secondary to the delayed diagnosis. *(Parker)*

   **Additional Imaging**: Consider MRI (CT is ok alterative, but less sensitive) if still clinically suspicious because of the risk of missing a nondisplaced fracture and having the patient return with a displaced fracture. MRI sensitivity and specificity = 100%.
2. **SACRAL FRACTURE**

In one study: 72% of sacral alar fractures were missed initially. (Jackson et al.)

**Xray:** Subtle break in smooth sacral alar lines

**Additional Imaging:**
- Pelvic “outlet views” improve visualization of the sacrum and rami.
- CT required to assess severity of sacral fracture and additional fx’s.

3. **ACETABULAR FRACTURE**

**Anterior acetabular fracture:** Detected by break in iliopubic line

**Posterior acetabular fracture:** Detected by a break in the ilioischial line; look specifically “behind” superimposed femoral head

**Additional Imaging:**
- Can get additional Judet views to assess for clinically suspicious cases
- Requires CT assessment to assess severity and because 40% of associated intraarticular bone fragments and 50% of femoral head fractures are missed initially. (Lipman)

**Half of Injuries Missed**

**PELVIC RING DISRUPTION**

Because of the inflexible, ring-like structure of the pelvis, pelvic bone injuries are often found in multiples. In addition to the already mentioned injuries, also beware of subtle rami fractures and sacroiliac dissociation.
Normal Anatomy

KNEE
Dislocation

**KNEE DISLOCATION**

Not a subtle clinical or radiographic finding
40% have associated popliteal artery injury
regardless of pedal pulses and reducibility.
Requires angiography

**Occult Fracture**

1. **TIBIAL PLATEAU FRACTURE**

32% of all knee fractures

**Mechanism**: Valgus force with axial load (knee vs. car bumper)

**Sensitivity of radiographs**: 79% for 2-view, 85% for 4-view

**(Gray et al.)**

**Pearl**: When a patient with knee pain from blunt trauma can not walk, be sure that oblique views are obtained to assess for a tibial plateau fracture. Consider CT despite radiographically negative findings in a patient.

**Additional Imaging**:

✓ Oblique views (plain radiographs), CT to assess for severity

2. **SEGOND FRACTURE**

Small proximal lateral tibial avulsion fx
Often associated with an ACL tear

3. **PATELLA FRACTURE**

40% of all knee fractures

**Additional Imaging**: “Sunrise” view

Half of Injuries Missed

**MAISONNEUVE FRACTURE**

✓ Proximal fibula fracture AND medial malleolus (or deltoid ligament) fracture

✓ **Mechanism**: Abduction and external rotation of ankle
**FOOT**

**Normal Anatomy**

**PA View**: The medial edges of the 2nd metatarsal and 2nd cuneiform should align.

**Lateral View**: Bohler’s angle (generated by a line bordering the superior aspect of the posterior calcaneal tuberosity and a line connecting the superior subtalar articular surface and superior aspect of the anterior calcaneal process) normally is 20–40 degrees. A Bohler’s angle < 20 degrees implies an occult calcaneal fracture.

**Oblique View**: The medial edges of the 3rd metatarsal and 3rd cuneiform should align.
Dislocation

**LISFRANC INJURY**

Tarsal-metatarsal (MT) fracture/dislocation pattern
20% are initially missed (Goossens and DeStoop)

LisFranc ligament: Attaches 2nd MT base to 1st cuneiform.

Xray: Fracture of 2nd metatarsal base or Lisfranc ligament and subsequent dislocation of MT #2-5 from the midfoot

Pearl: An avulsion fracture of the 2nd metatarsal base alone is a LisFranc fracture DESPITE a normal alignment of the metatarsals with the tarsal bones, because the LisFranc ligament inserts at its base.

Complications: Compartment syndrome

Occult Fracture

1. **CALCANEUS FRACTURE**

At a teaching hospital ED, the “miss rate” was 3rd greatest for calcaneal fractures at 10%. (Freed and Shields)

Most commonly fractured tarsal bone

Mechanism: Often from fall on heels from a height

Xray:
- A Bohler’s angle < 20 degrees suggests a fracture.

Additional Imaging:
- Consider obtaining a “calcaneal view”
- Often requires CT imaging to assess fragments

Complication: Compartment syndrome

2. **TALUS FRACTURE**

Second most commonly fracture tarsal bone

The neck is the most common location of a talar fracture.

Mechanism: Excessive dorsiflexion of ankle

Xray: Can be subtle cortical break on lateral view

Complications of neck fracture: Avascular necrosis, subchondral collapse, and degenerative arthritis

Half of Injuries Missed

**CALCANEUS FRACTURES:**

10% associated with **THORACOLUMBAR FRACTURE**

because of load on axial skeleton when landing on the heels
REFERENCES

Thompson E, Cordas M. “Fracture-Dislocations You Can’t Afford to Miss.” The Physician and Sports Medicine, Jun 1996; 24(6).