Course Objectives:

1. Name common high-risk traumatic injuries, which are easily missed on plain radiographs.
2. Identify subtle fractures in the pelvis and extremities on plain radiographs.
3. Understand the limitations of xrays in identifying traumatic pathology.
MEDICOLEGAL SIGNIFICANCE
1. Missed orthopedic injuries, such as fractures and dislocations, comprise the largest source of malpractice claims in the emergency department, according to a study conducted by the American College of Emergency Physicians during the period of 1974-1985. [44% pelvis / vertebra, 22% extremity, 14% hand]
2. Various studies corroborate that these injuries comprise a significant # of medical claims.
   - Pennsylvania Hospital Insurance Company (1977-1981): 19% of 200 ED malpractice cases were due to “misinterpretation of radiographs.” (Trautlein et al.)
   - Chicago (1975-1994): Retrospective study of 18860 malpractice claims showed 12% involved radiology cases, of which missed diagnoses was the #1 cause of litigation. (Berlin and Berlin)
3. The majority of malpractice claims on misread radiographs are those whose radiographs were taken during “off” hours.
   - 63% malpractice suits occur from incidents during 6 pm-1 am (weekends) and midnight-7 am (weekdays)
   - ED radiograph interpretations during non-business hours are often provided by EP’s.
   - Over 80% acute care hospitals do not have 24/7 radiologist interpretation available.
   - Radiographic interpretation discrepancy rate between an EP and radiologist = 2-11%. (Lufkin et al, Robinson et al, Scott et al)

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…)

<table>
<thead>
<tr>
<th>Dislocations</th>
<th>Occult fracture</th>
<th>Half of injuries missed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scapholunate DS</td>
<td>Scaphoid</td>
<td>Galeazzi</td>
</tr>
<tr>
<td>Perilunate DL and Lunate DL</td>
<td>Triquetrum</td>
<td>Distal Radius Fx + Carpal Injury</td>
</tr>
<tr>
<td>Elbow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radial head DL</td>
<td>Radial head</td>
<td>Monteggia</td>
</tr>
<tr>
<td>Pelvis/ Hip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip DL</td>
<td>Femoral neck Sacrum Acetabulum</td>
<td>Another ring fracture</td>
</tr>
<tr>
<td>Knee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee DL</td>
<td>Tibial plateau Segond Patella</td>
<td>Maisonneuve</td>
</tr>
<tr>
<td>Foot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lisfranc injury</td>
<td>Calcaneus Talus</td>
<td>Thoracolumbar + Calcaneus fx</td>
</tr>
</tbody>
</table>

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

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**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

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**PA View of R Wrist**
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

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

   ![Oblique View of R Wrist](image)

   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

      ![Lateral view of R forearm](image)

   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**

**LATERAL VIEW**
- **Fat pads**: Collections of fat tissue adjacent to elbow joint capsule (appears black on x-rays)
  - **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
  - **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.

**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!
Normal anatomy

**AP View**

**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 alternative) 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.
KNEE

Normal Anatomy

AP View

Lateral View

Femur

Patella

Lateral Femoral Condyle

Medial Femoral Condyle

Lateral Tibial Plateau

Medial Tibial Plateau

Intercondylar Eminence (Spine)

Fibular Head

Fibula

Tibia
**Dislocation**

**KNEE DISLOCATION**

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

Requires angiography

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**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

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**Half of Injuries Missed**

**MAISONNEUVE FRACTURE**

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

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

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**AP View of R Knee**

**Lateral View of R Knee**

**AP View of L Knee**

**AP View of R 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 2\textsuperscript{nd} MT base to 1\textsuperscript{st} cuneiform.

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

**Pearl**: An avulsion fracture of the 2\textsuperscript{nd} metatarsal base alone is a LisFranc fracture DESPITE a normal alignment of the metacarpals 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 3\textsuperscript{rd} 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).


