Check Your Blind Spot:
A Radiologist's Guide to Commonly Missed Pediatric Fractures

Mark Bittman, MD

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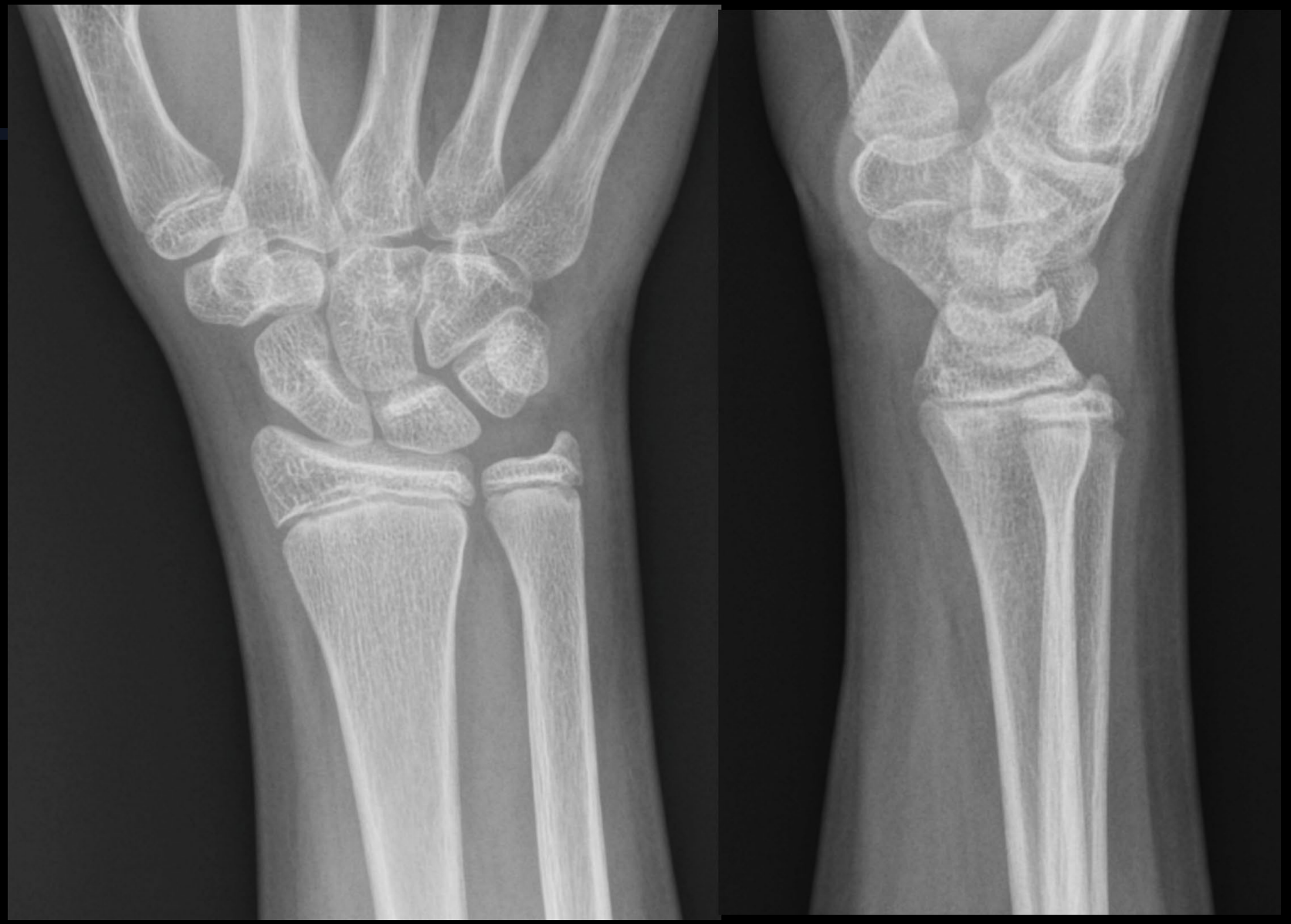
Financial Disclosures

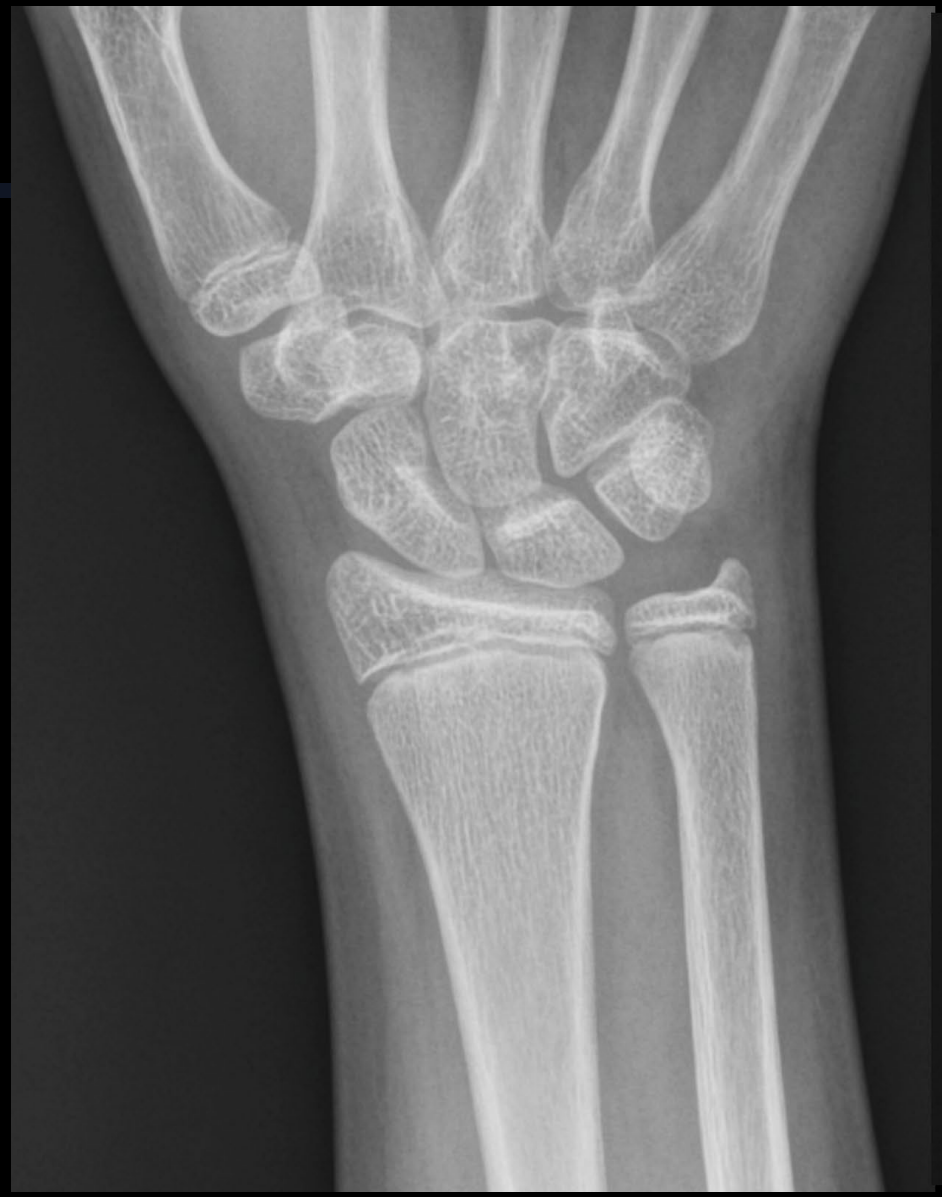
- None

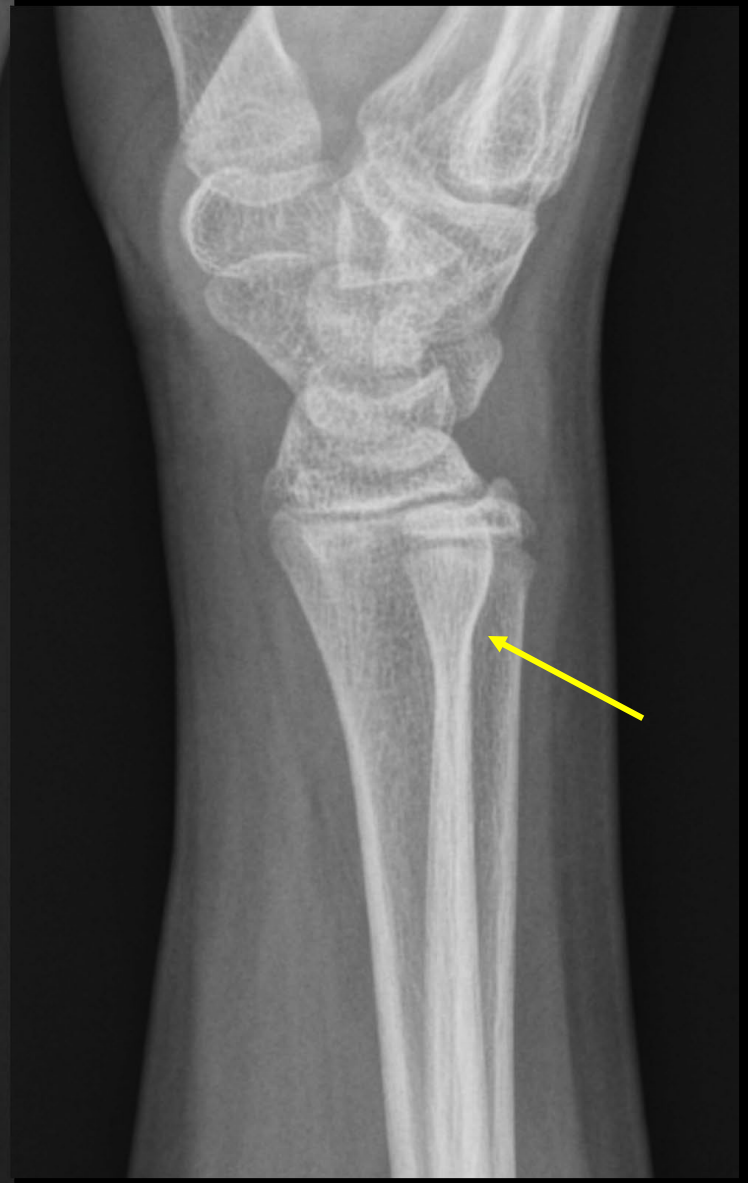
Learning Objectives

- **Identify Commonly Missed Pediatric-Specific Fractures:** Differentiate between adult fractures and pediatric-specific injuries.
- **Salter-Harris Classification:** Apply the Salter-Harris system to growth plate injuries.
- **Recognize Radiographic Signs:** Detect subtle indicators of pathology, and commonly missed fractures in the UC setting.
- **Differentiate Normal Variants from Pathology:** Distinguish pediatric pitfalls, such as accessory ossification centers and growth plates, from acute traumatic fractures.

FOOSH







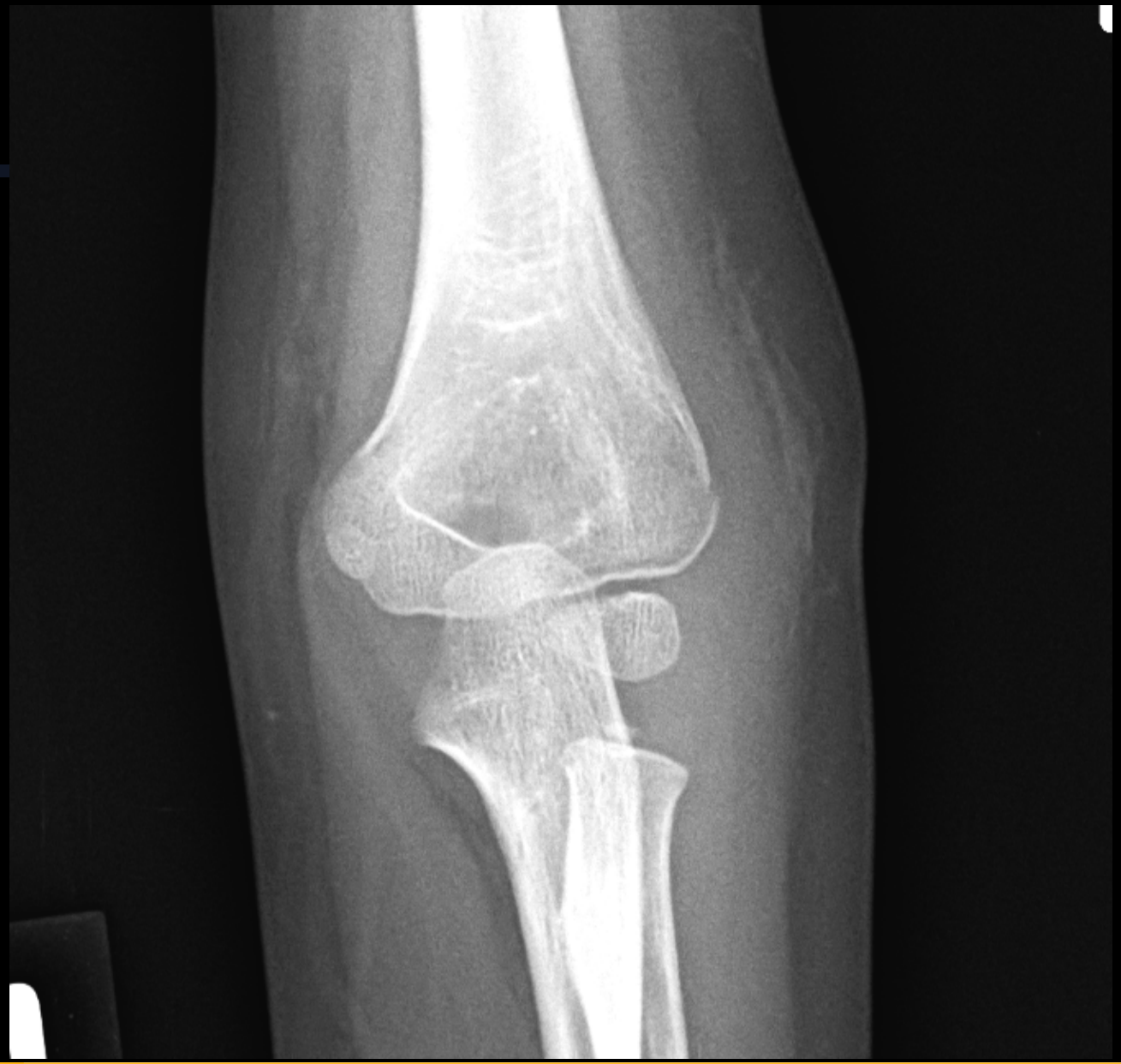
Distal radius buckle fracture

Subtle contour of the posterior cortex, best seen on the lateral view.

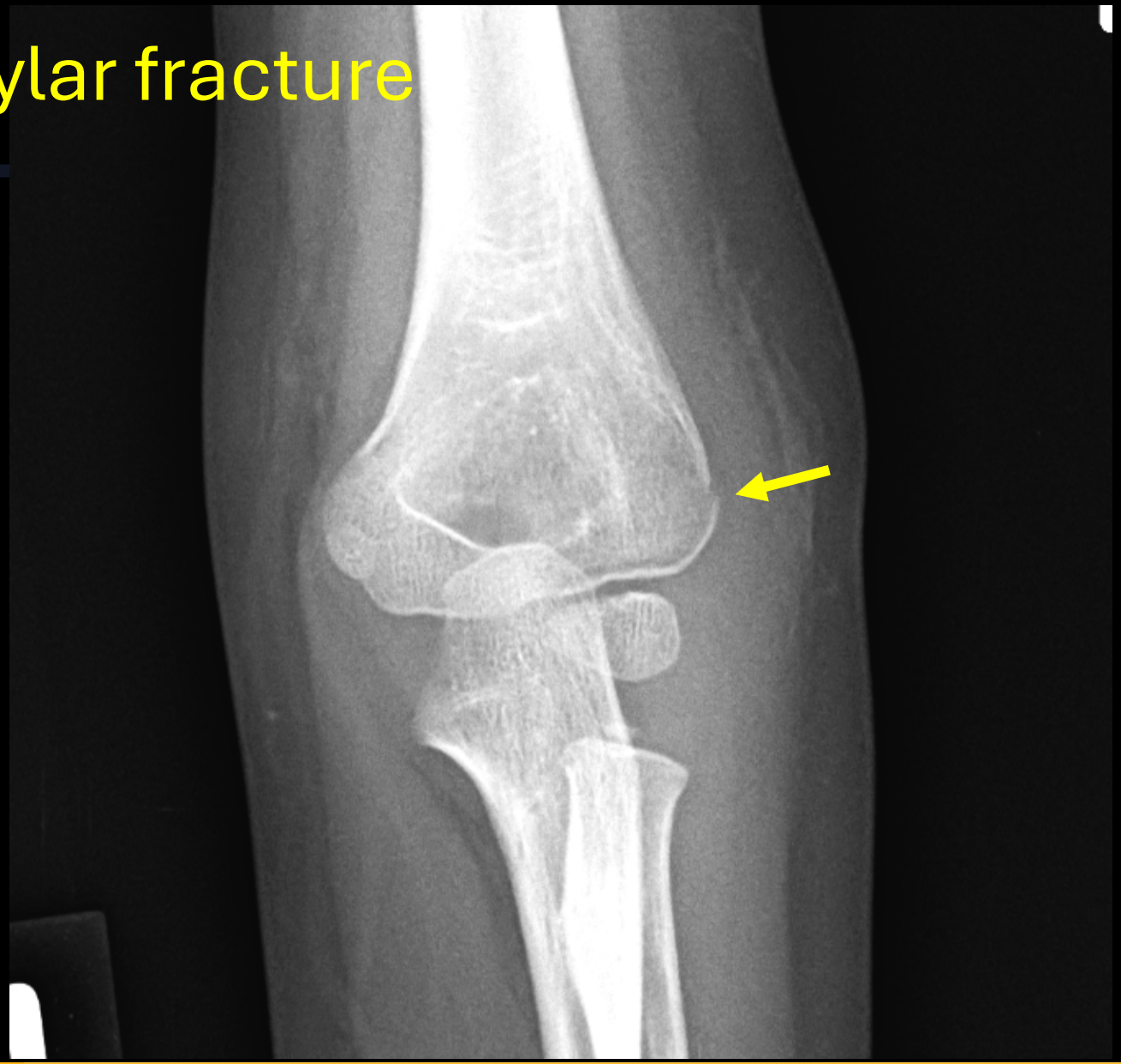
Must have a well-positioned lateral view without rotation.

Always pay close attention to this location b/c it's the most common site of fx.

5 yo s/p fall

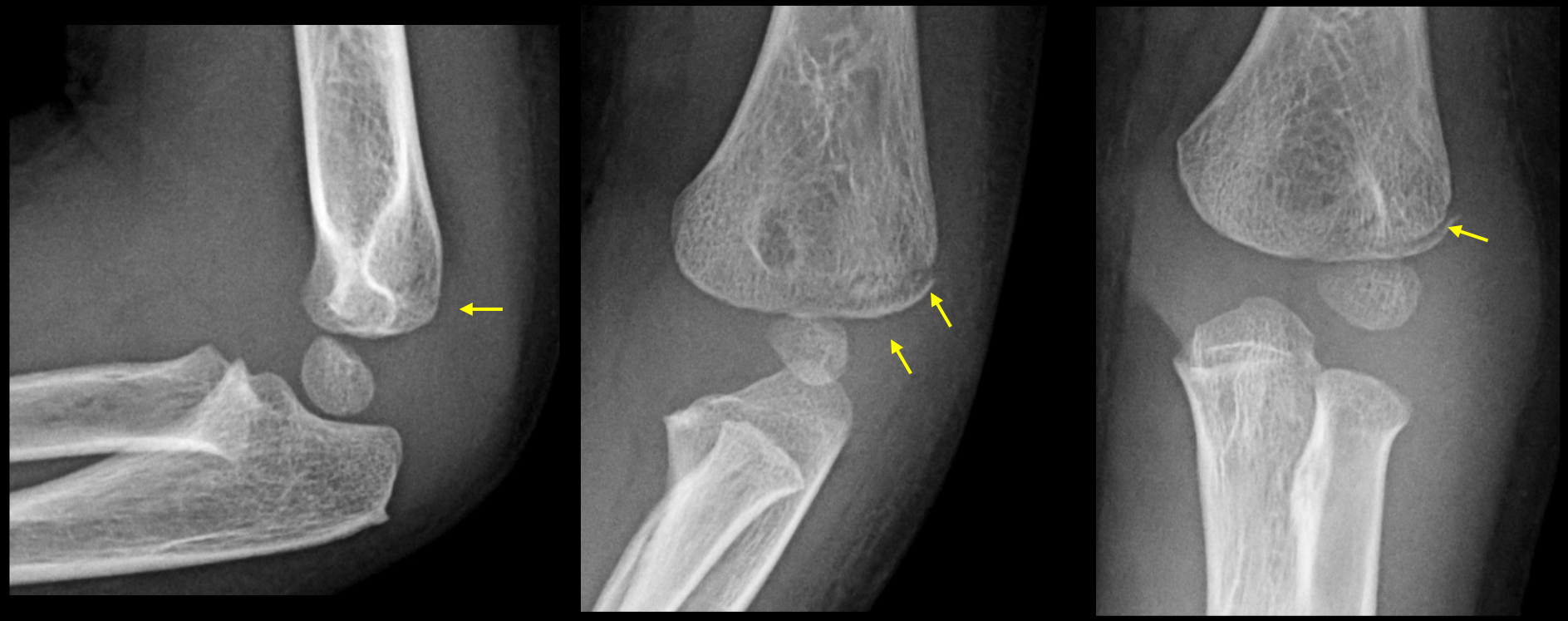


Lateral condylar fracture



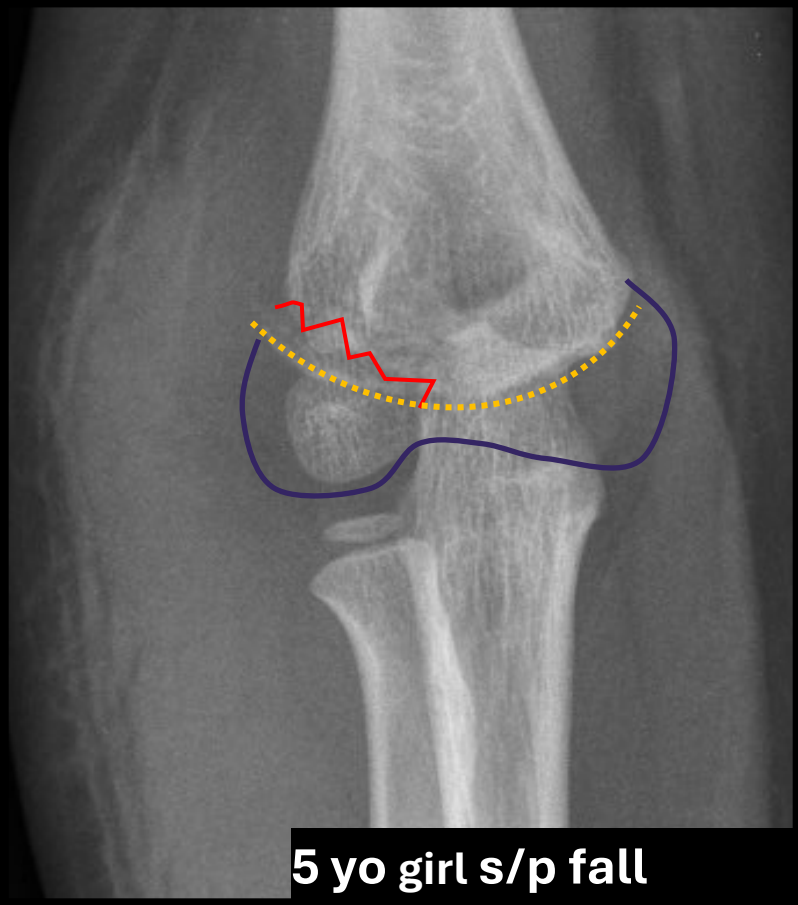
Lateral condylar fracture

Tip: Internal oblique view demonstrates maximal displacement



Lateral condylar fracture

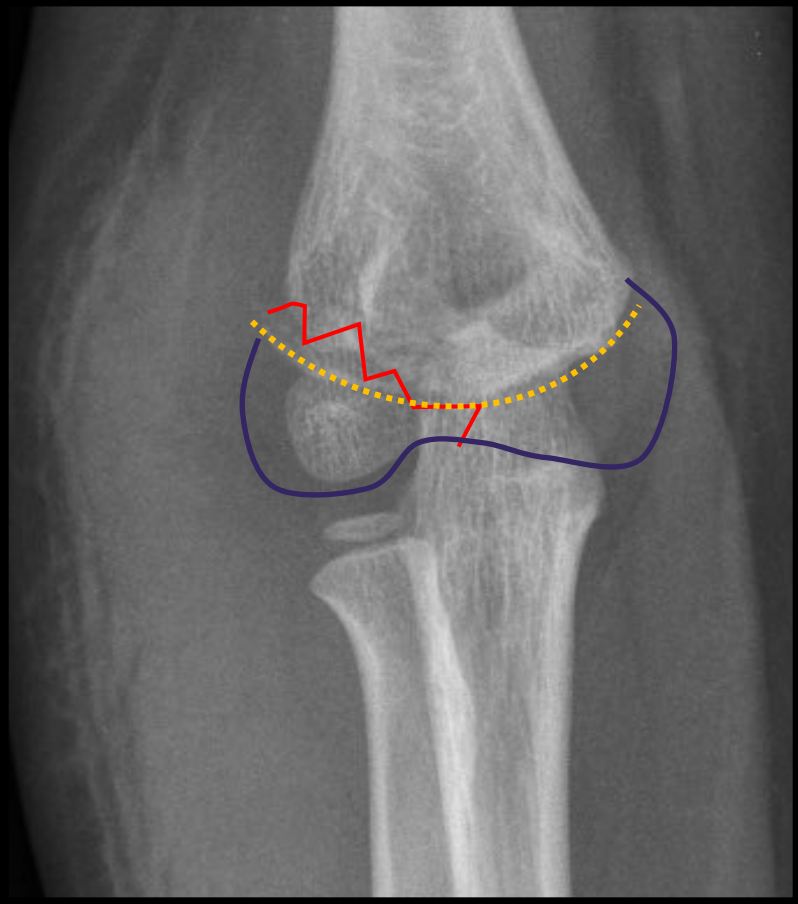
- 2nd most common pediatric elbow fracture
  - 10-20% of all pediatric elbow fractures
- Varus force
- Up to 50% missed in ER
- Most are Salter Harris II



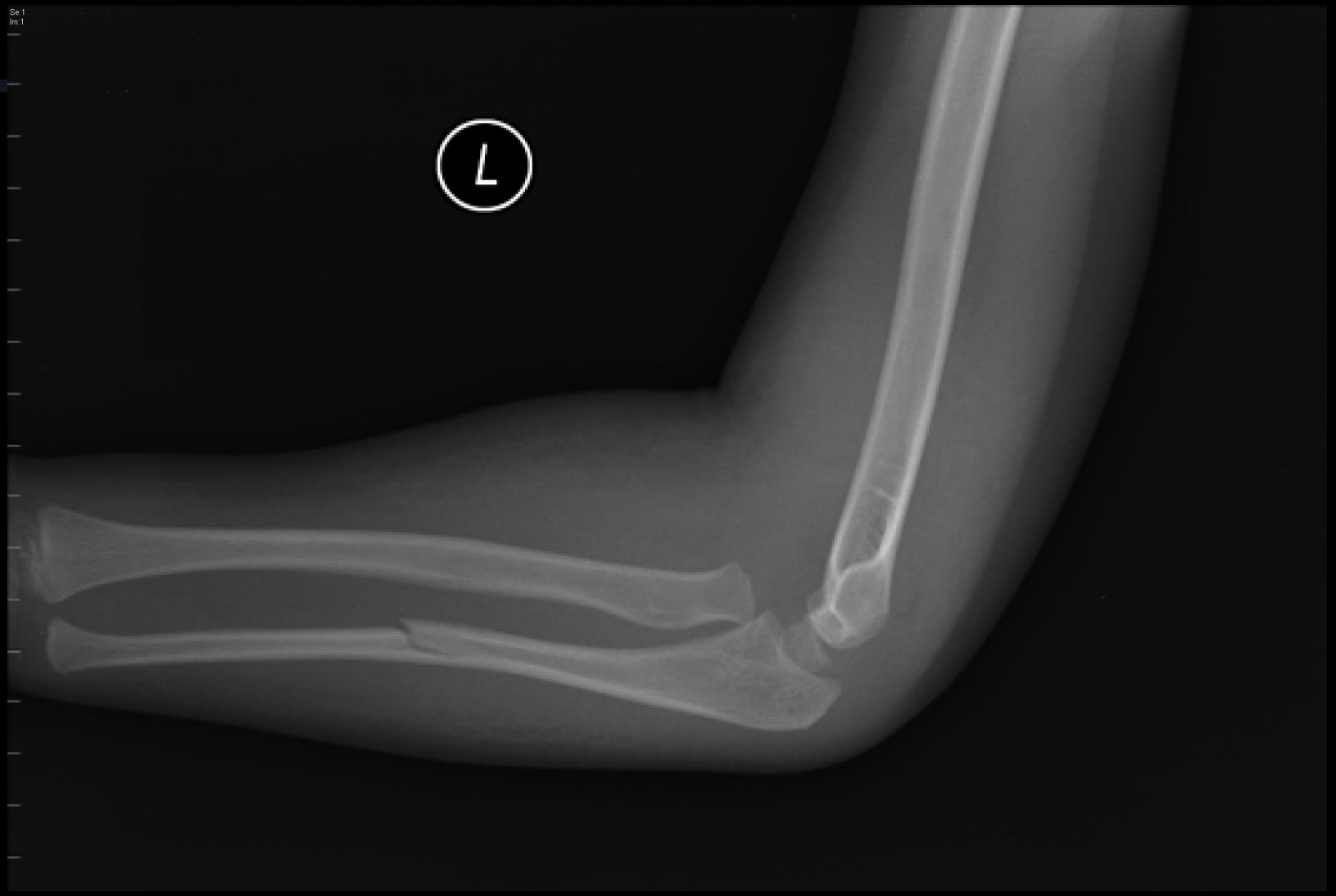
5 yo girl s/p fall

Lateral condylar fracture

- Can be Salter Harris IV
  - Unstable due to intra-articular extension



5 yo s/p fall



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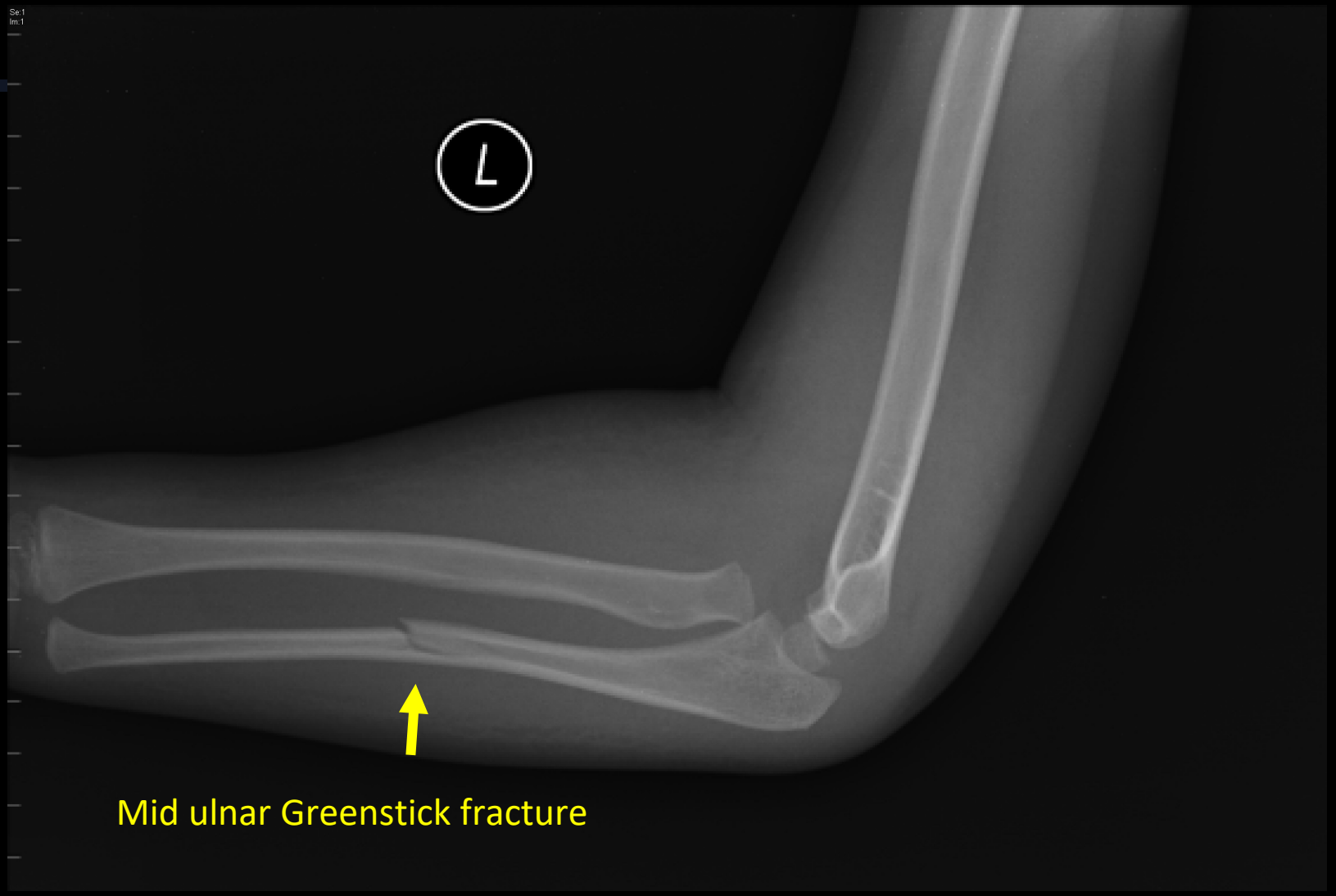
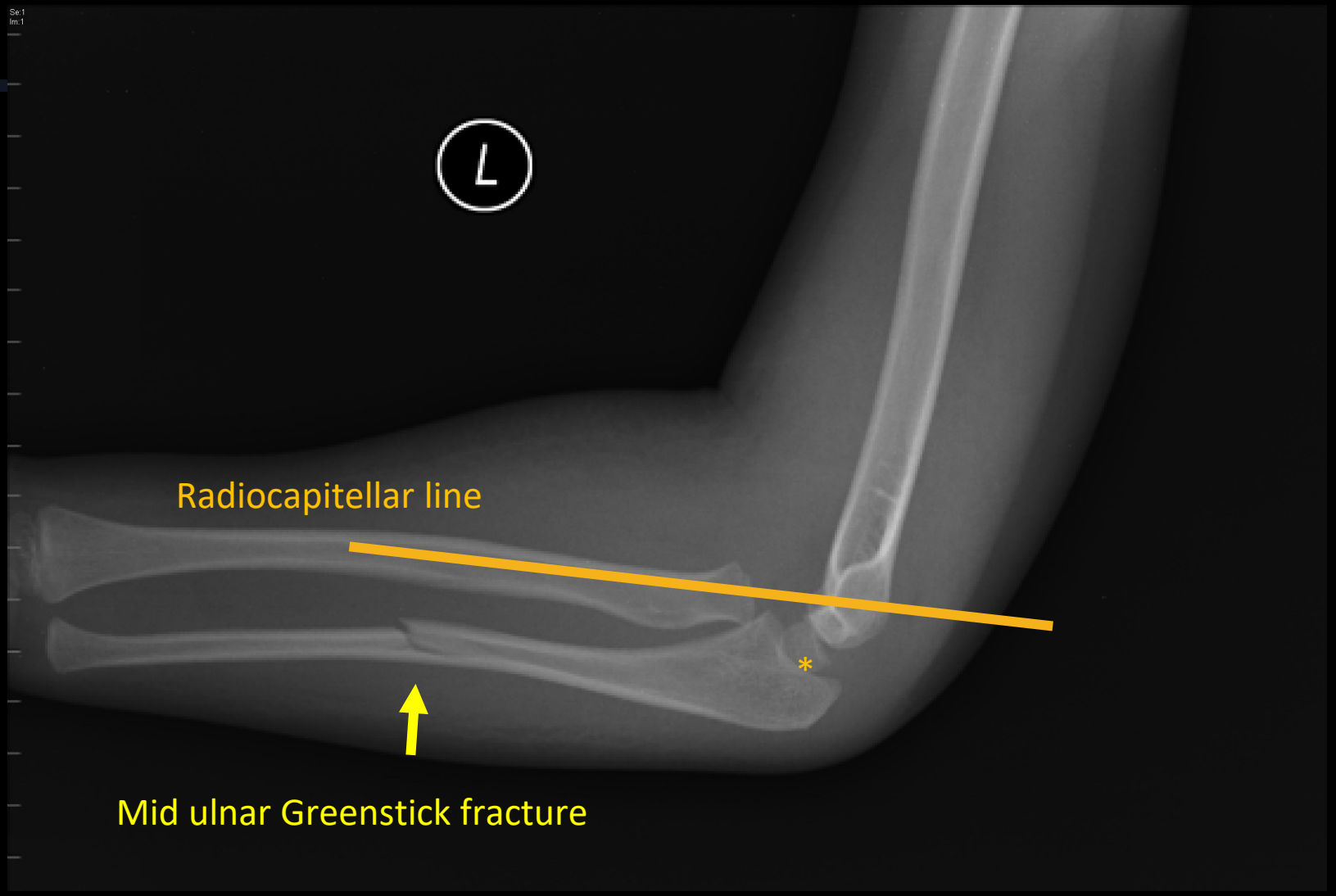
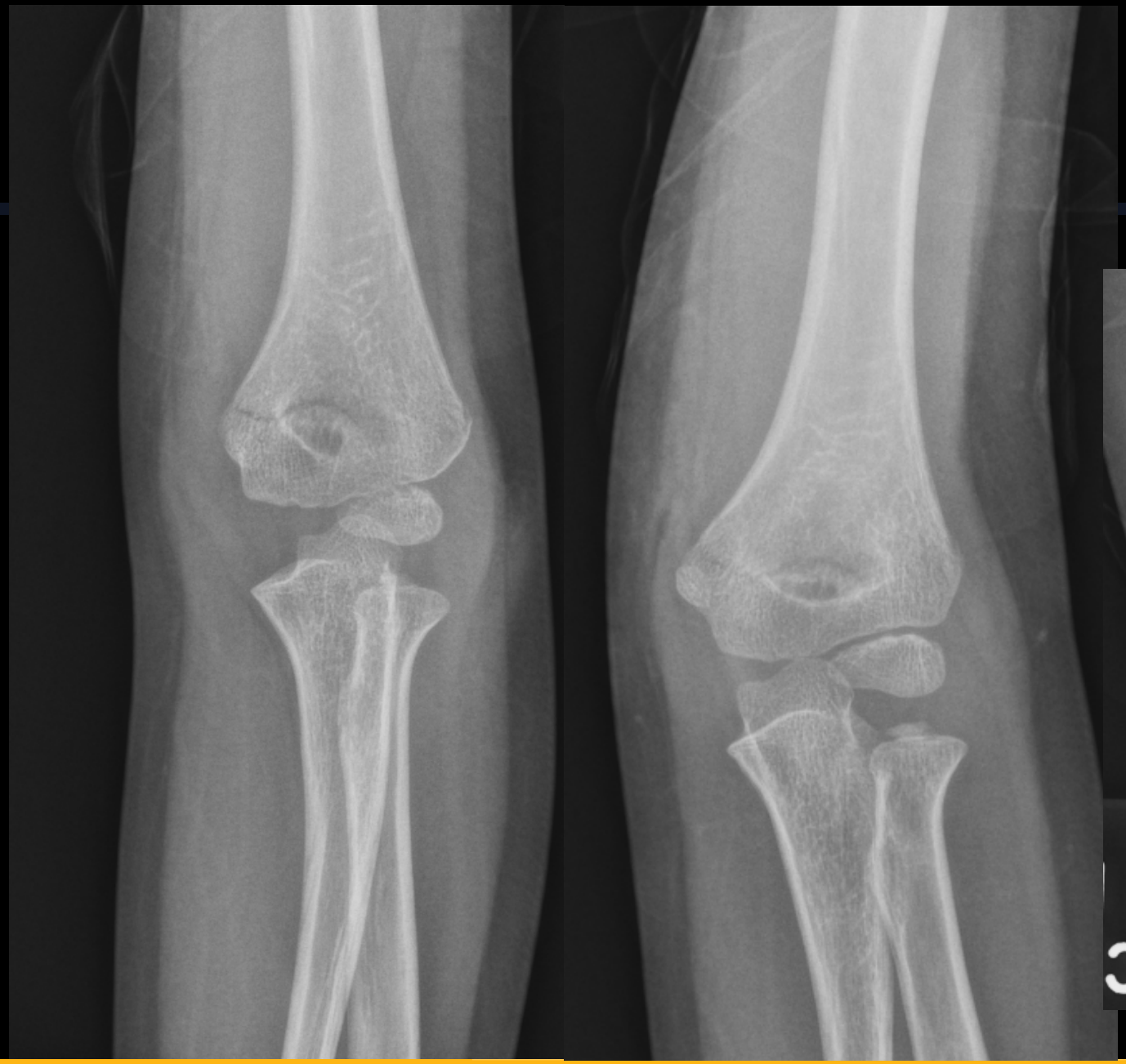


5 yo s/p fall

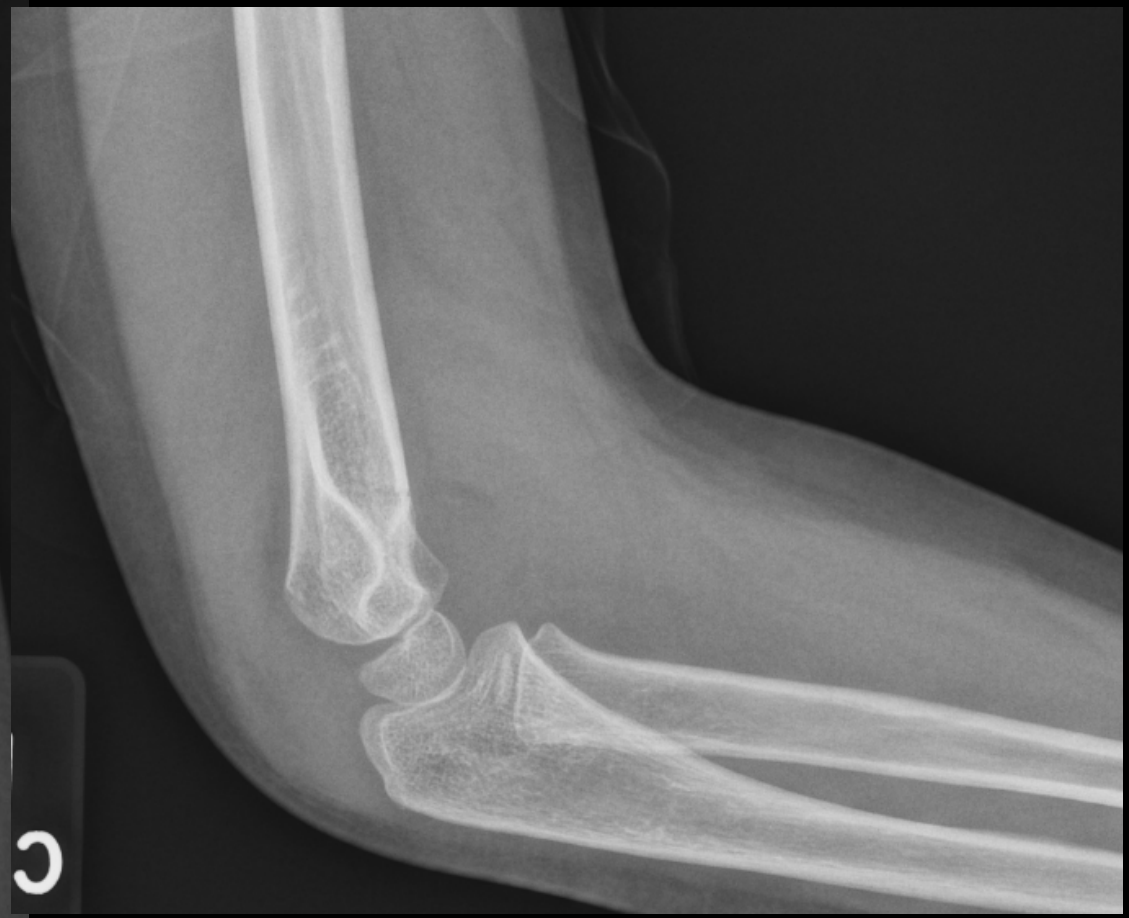


Monteggia Fracture-Dislocation

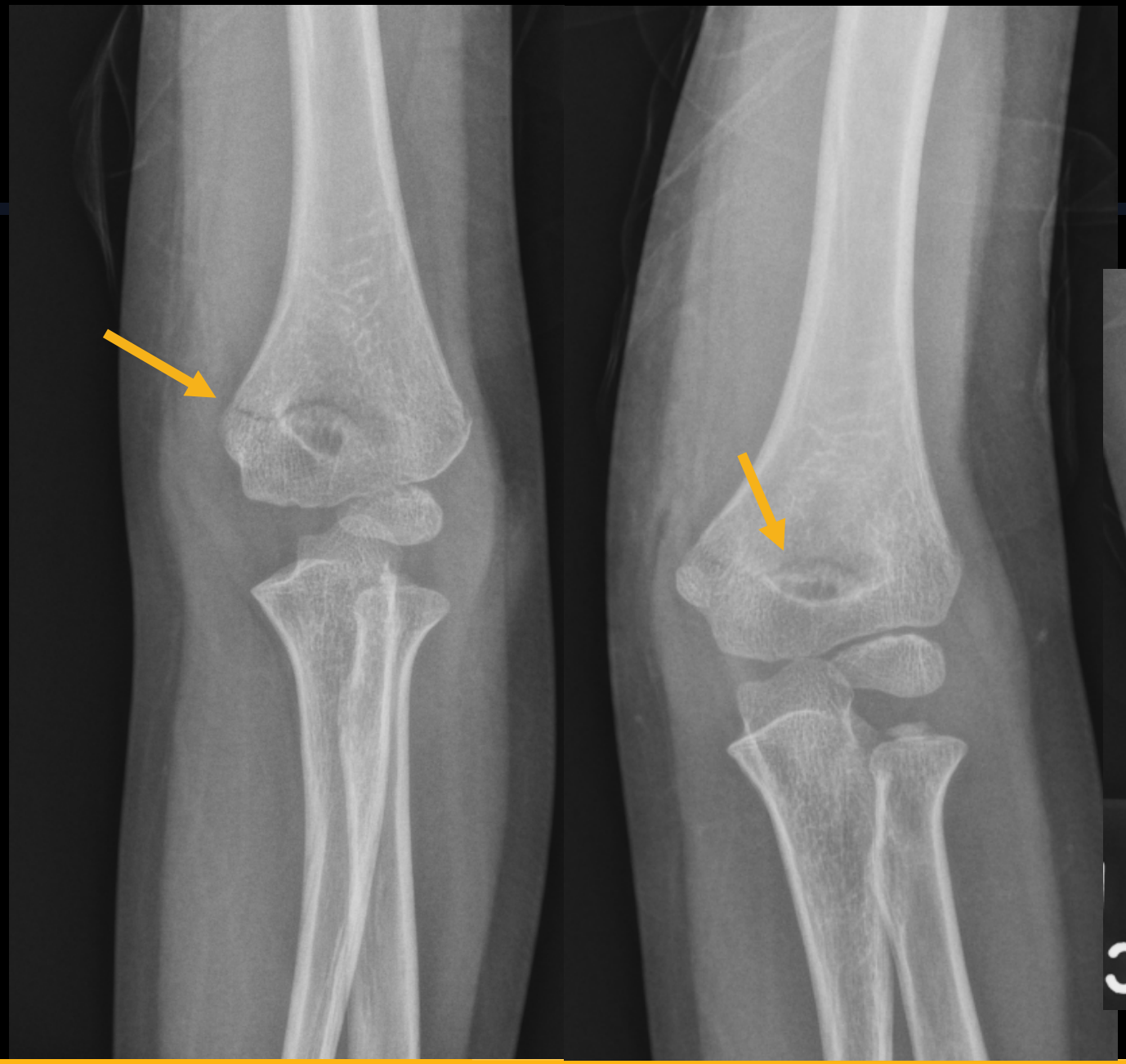
- **Lesion:** Fracture of the proximal third of the ulna with radial head dislocation
  - mneumonic MUGR – **M**onteggia/**U**lnar fx; **G**aleazzi, **R**adial fx
- **Radiocapitellar Line:** Must pass through the capitellum; if not, dislocation exists.
- **Bado Types:** I—anterior; II—posterior; III—lateral; IV—both ulna and radius fractures with dislocation.
- **Plastic Deformity:** Ulna may bend without breaking, causing dislocation in children.
- **Treatment:** Pediatric cases often use closed reduction and casting.

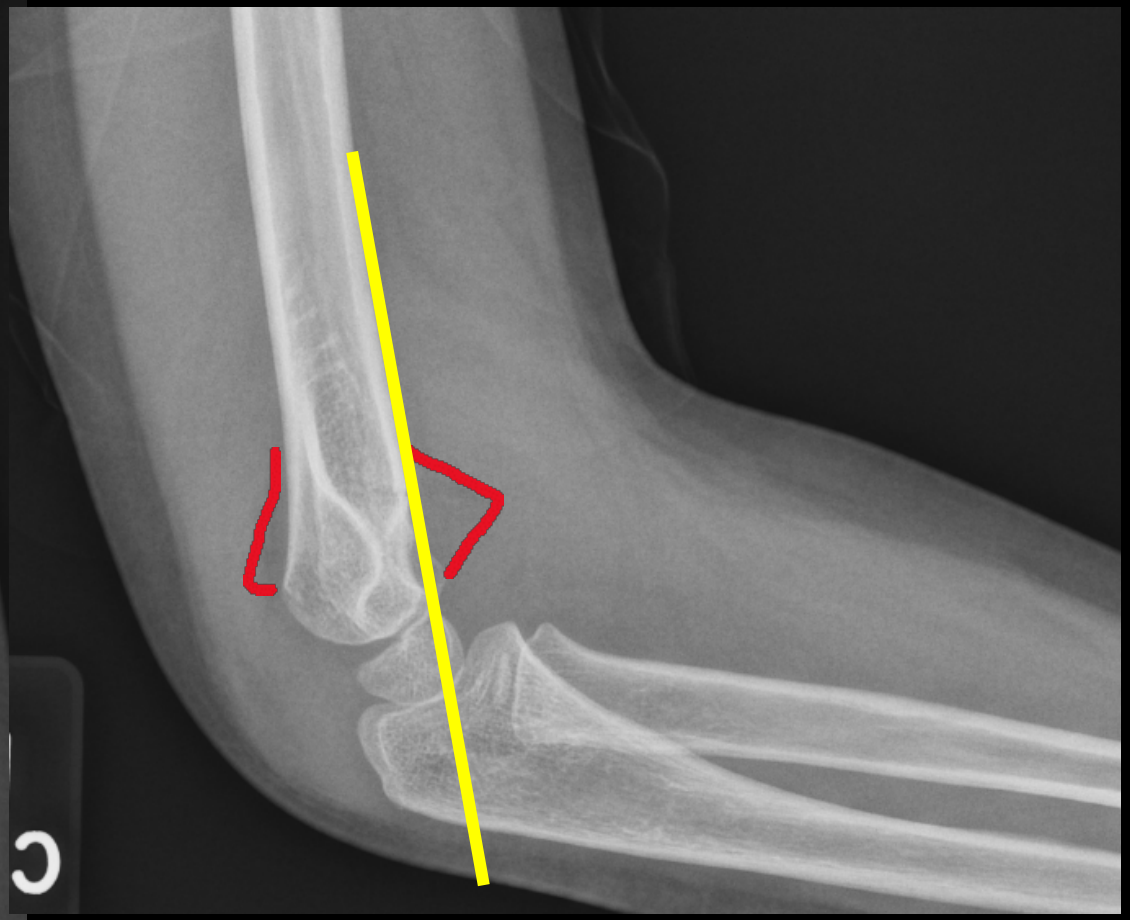


s/p fall



Supracondylar fracture

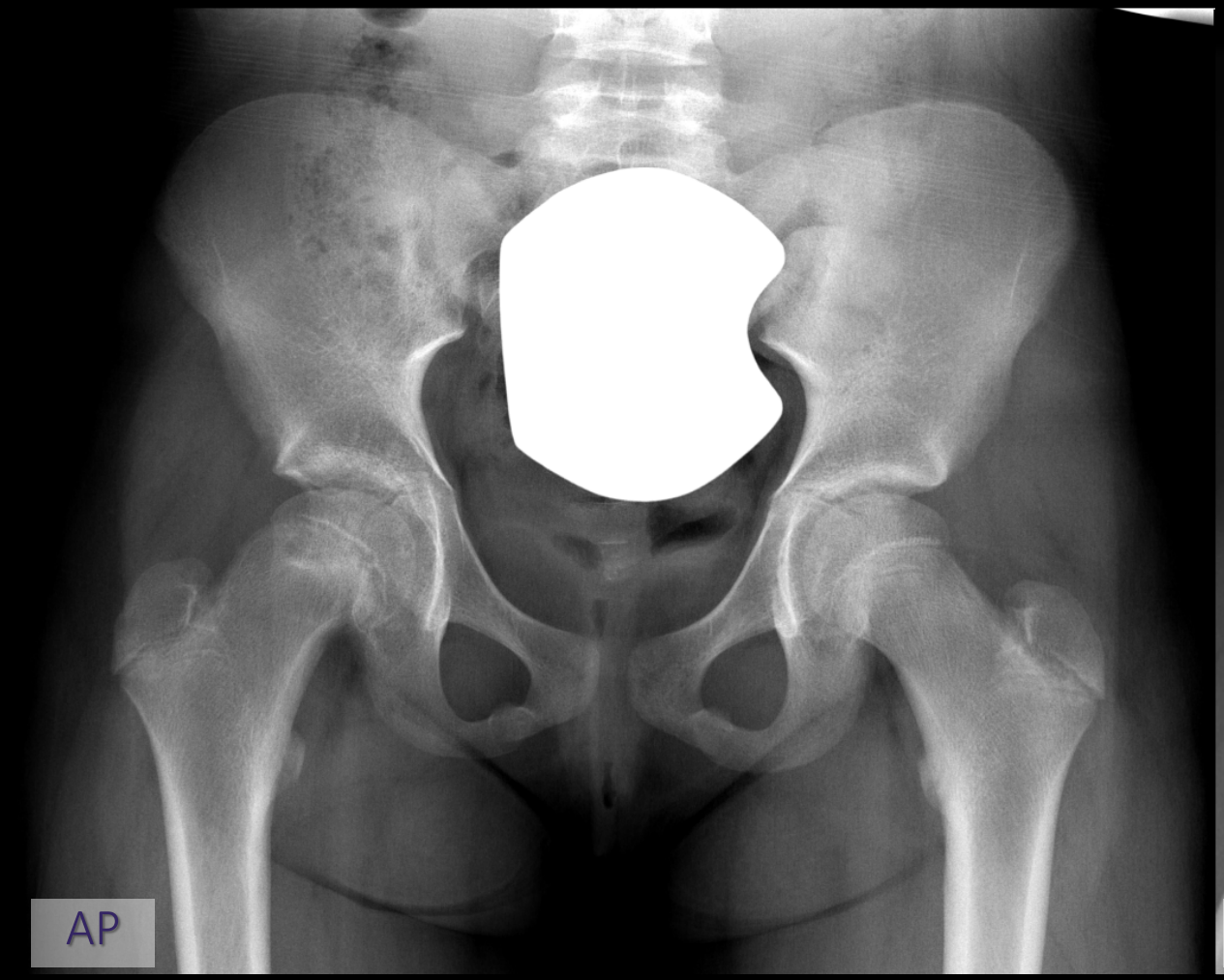


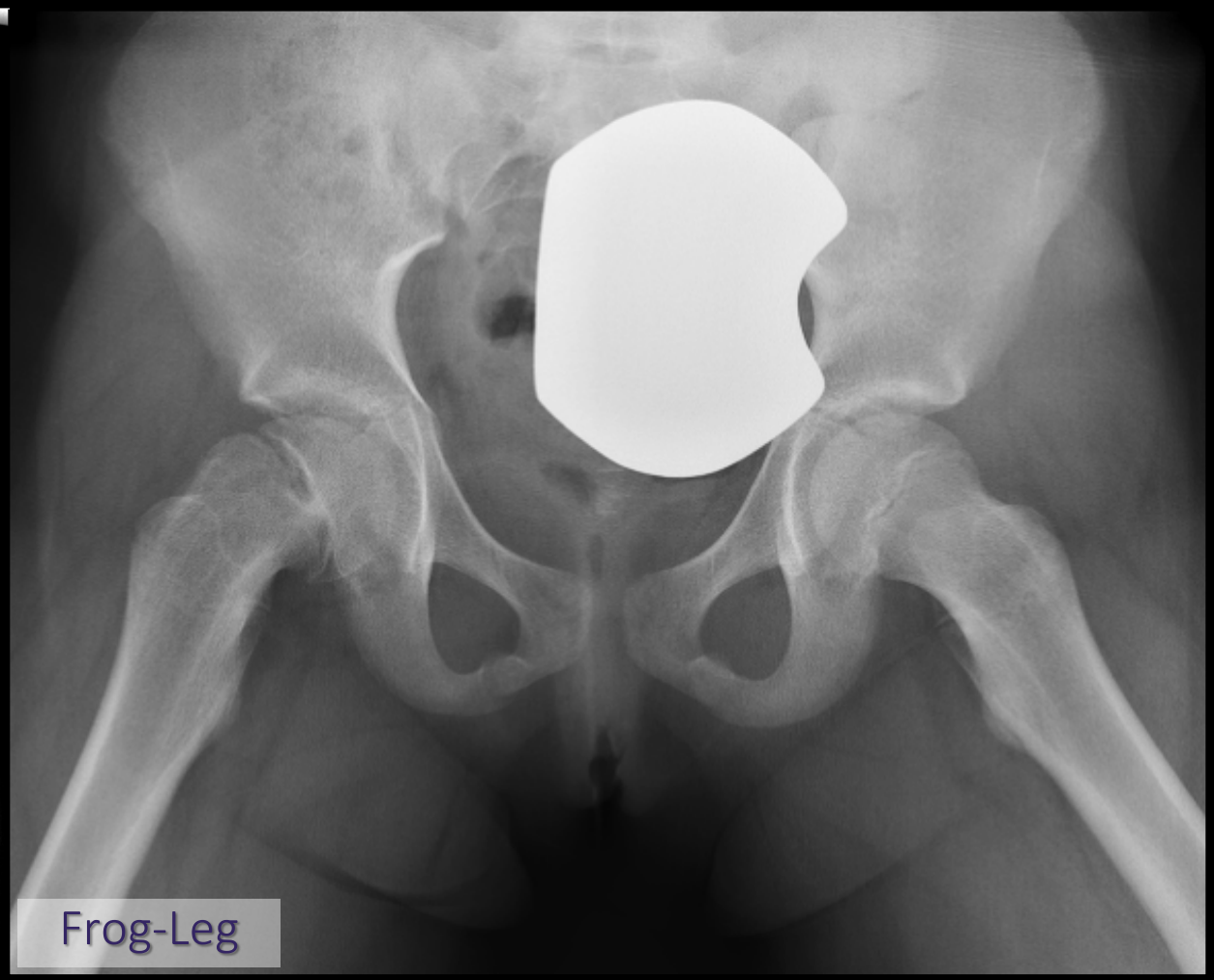


Supracondylar fracture

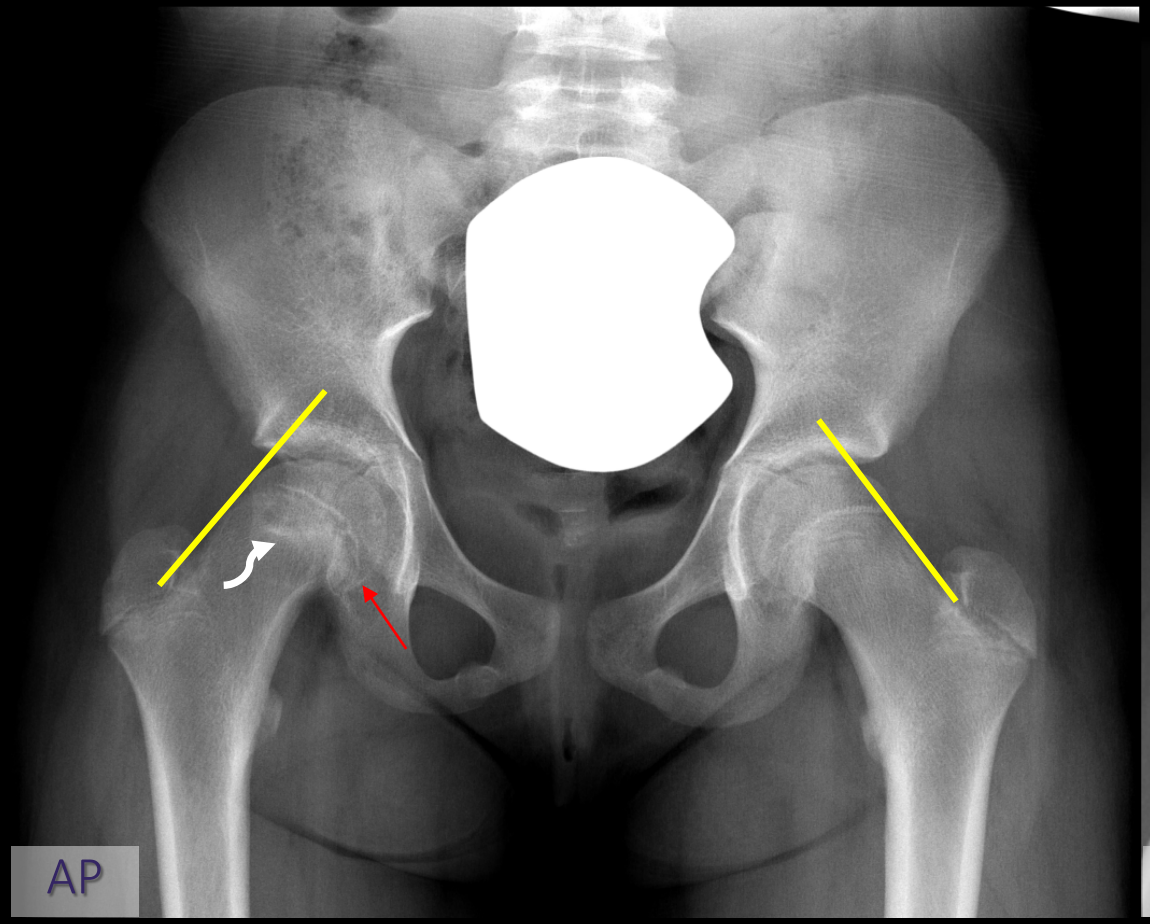
- ***For Interpretation:***
- Most common elbow fracture in pediatric patients
- Evaluate the anterior humeral line- should intersect middle 1/3 of capitellum
- Look for fat pads
  - Displaced anterior fat pad
  - Visible posterior fat pad always abnormal
- Gartland classification
- ***For Treatment:***
  - *Posterior elbow splint, f/u ortho*

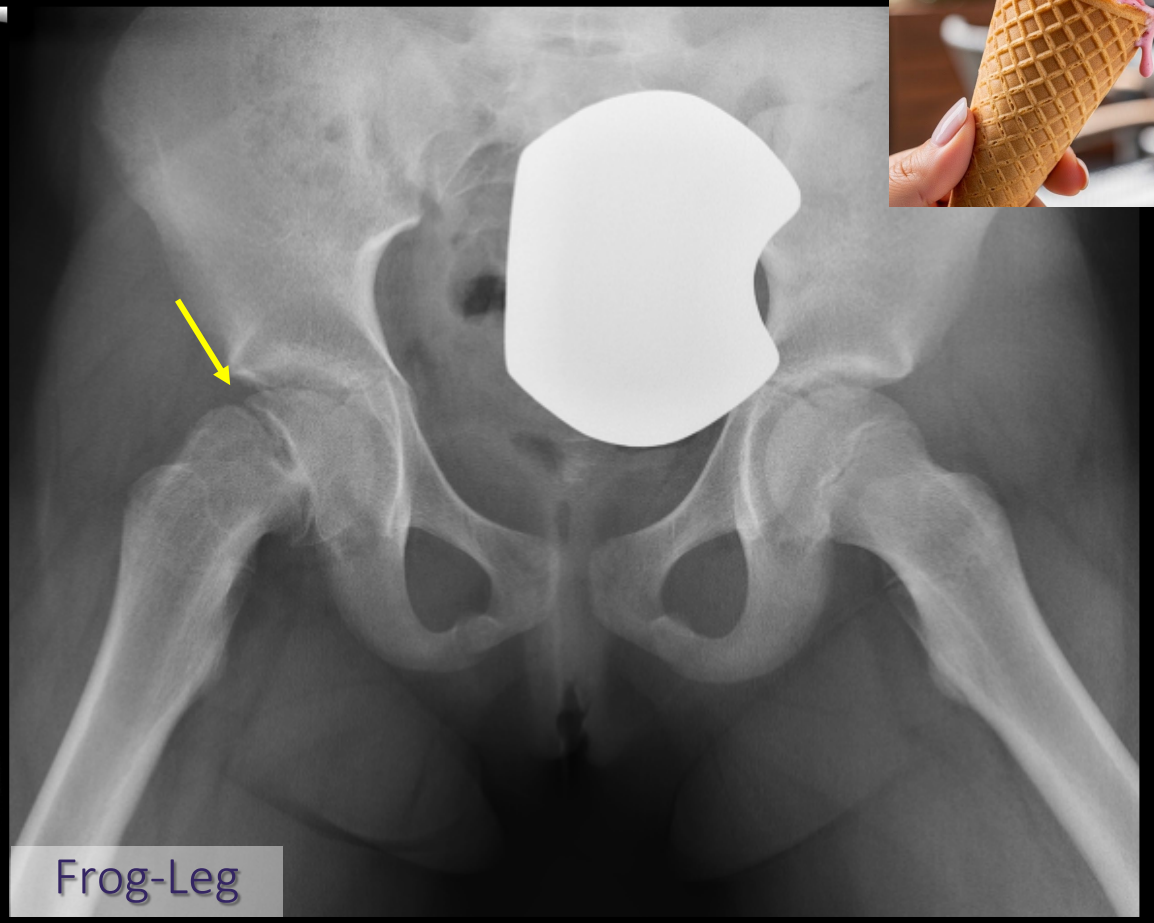
Right hip pain, 12 yo





Right slipped Capital Femoral Epiphysis





Slipped Capital Femoral Epiphysis

Displacement of epiphysis
posterior > medial

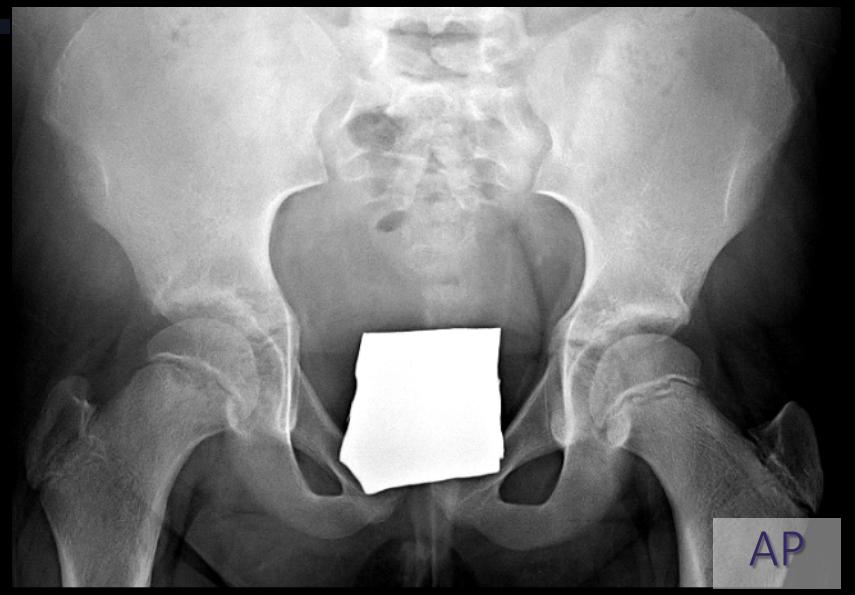
Etiology

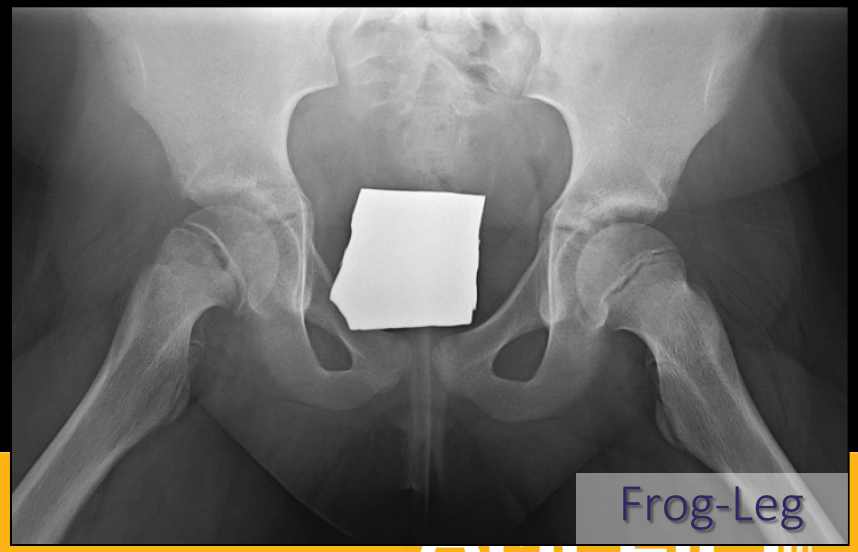
- Multifactorial
- Obesity

  Delayed skeletal maturity

  Hypothyroidism

  hypogonadism
- Rickets





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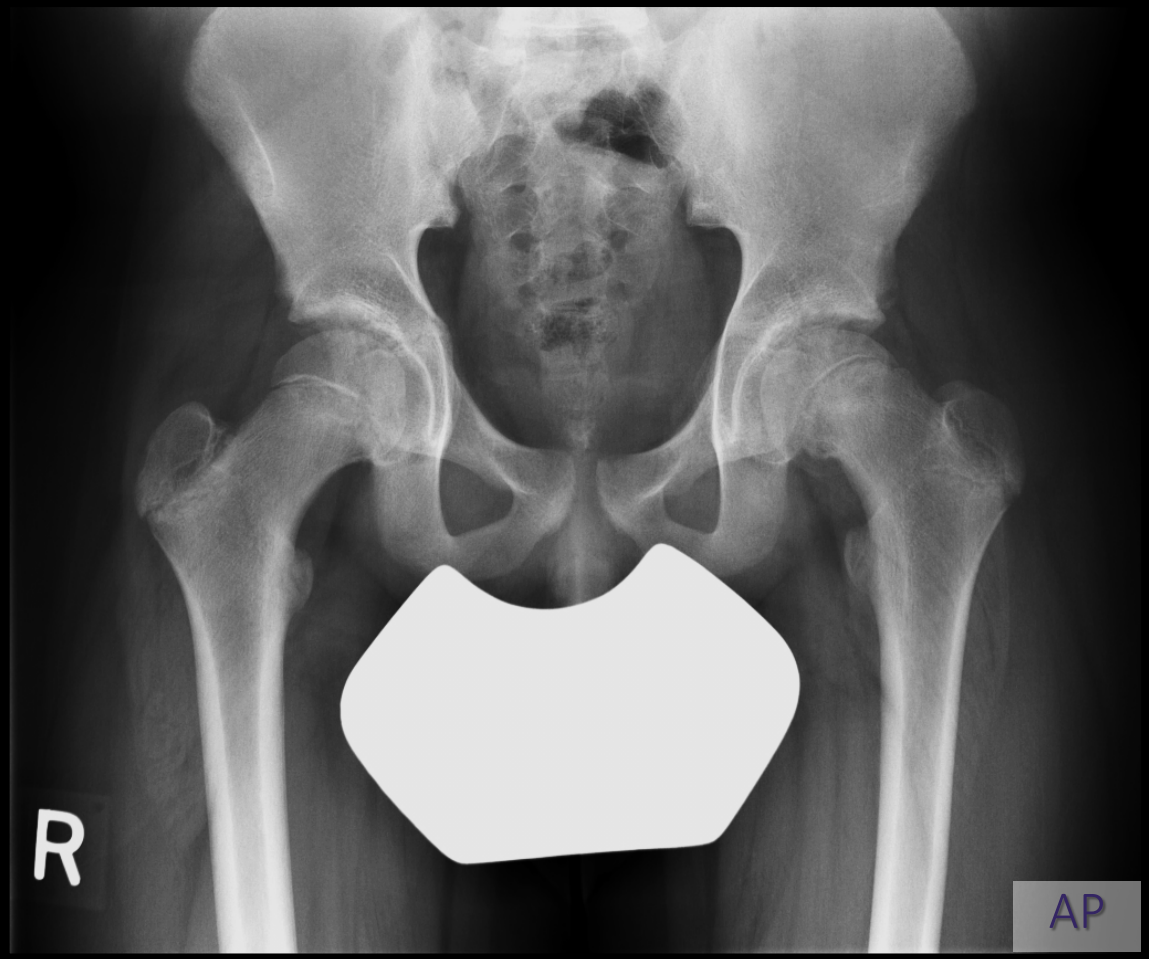
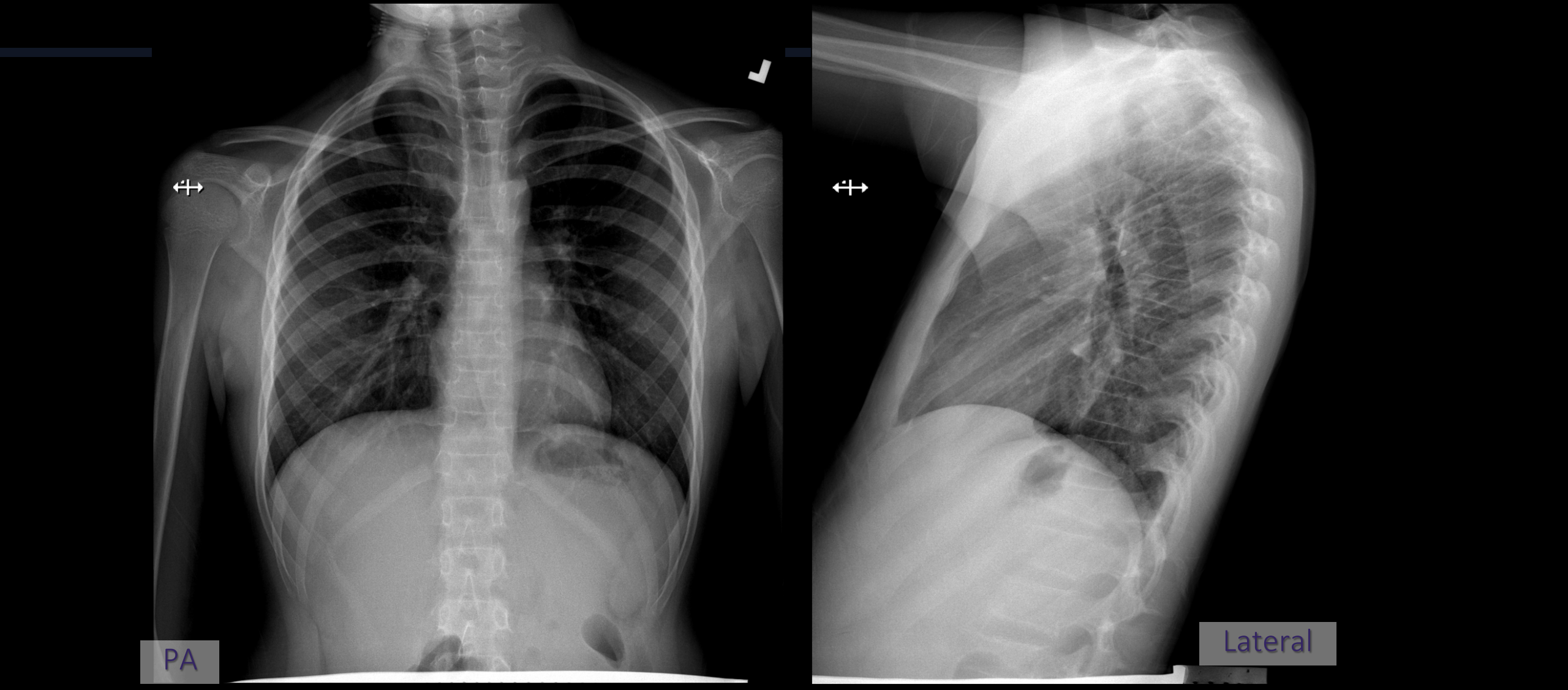


- Clinical
  - Poorly localized hip/groin pain may radiate to knee
  - Can be bilateral
    - 18-63%
    - Importance of AP/frog leg both hips and pelvis

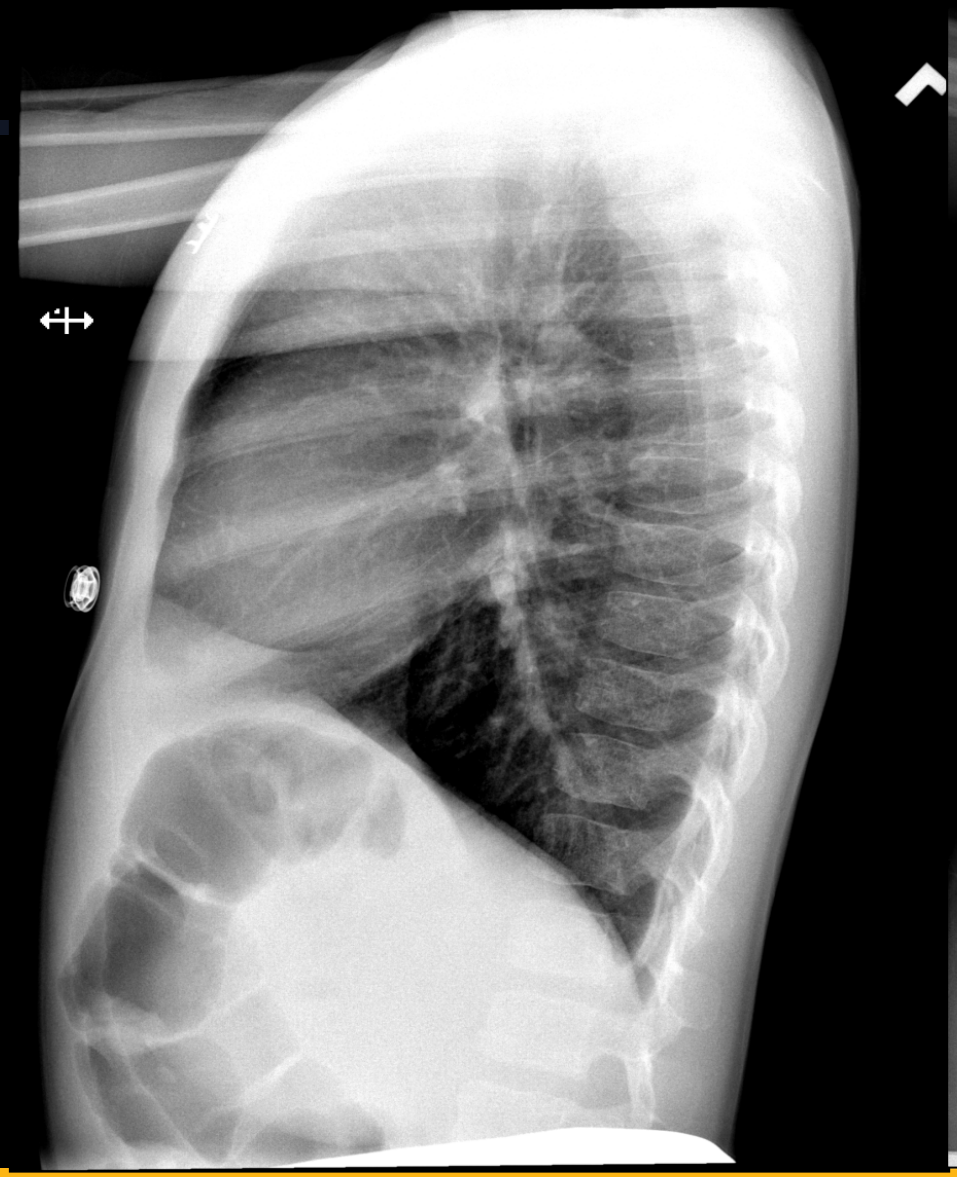
Radiographic Signs in SCFE

- **Frog-Leg View:** Use a frog-leg lateral X-ray to reveal subtle posterior slips often missed on standard AP views.
- **Klein's Line:** Normally intersects the femoral epiphysis; in SCFE, it passes above (Trethowan's Sign).
- **Physeal Widening:** Early SCFE may show growth plate widening or blurring without displacement.
- **Blanch Sign:** Increased density at the proximal metaphysis on AP view indicates a slipped epiphysis.
- MRI to assess for "pre-slip" with high suspicion and normal radiographs

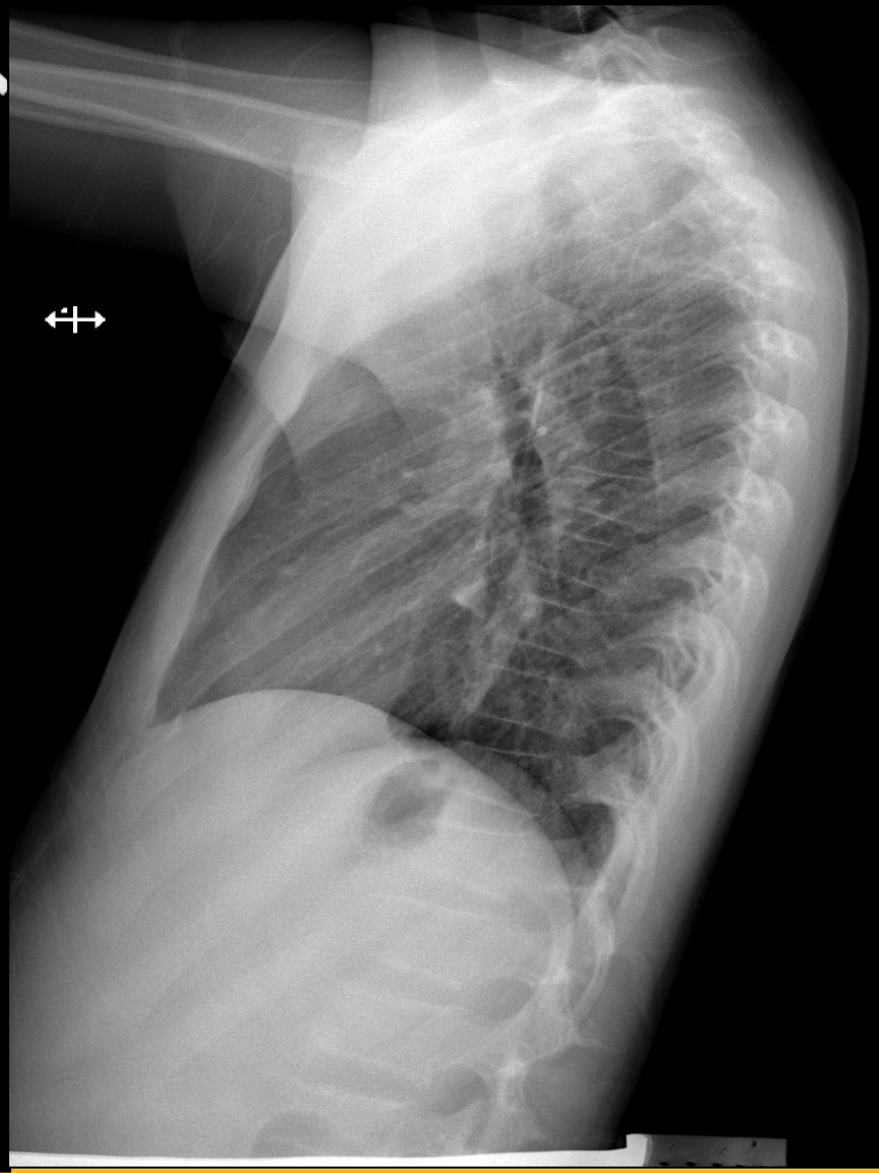
9 yo female with back pain for 2 weeks. Two months of left wrist pain and swelling.



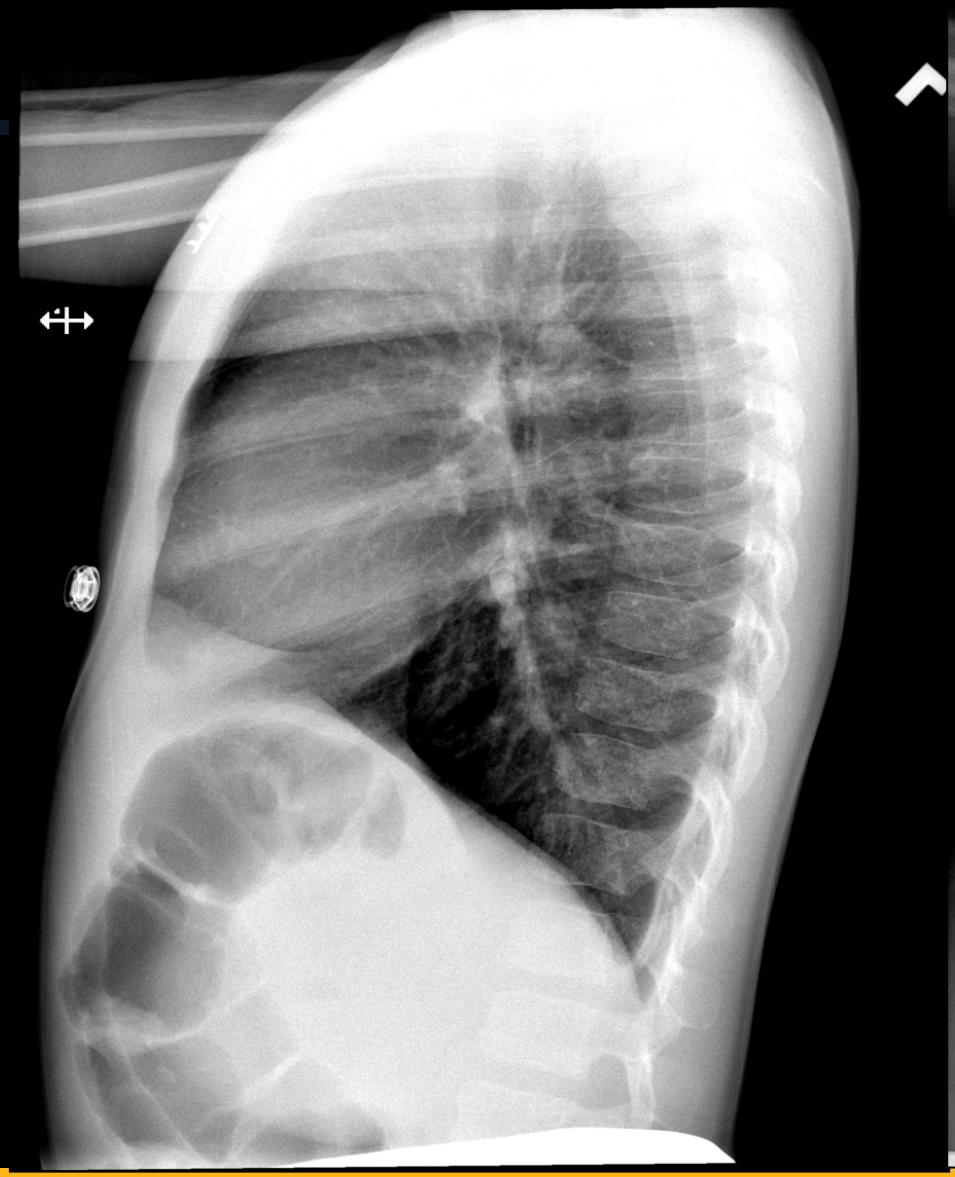
Normal



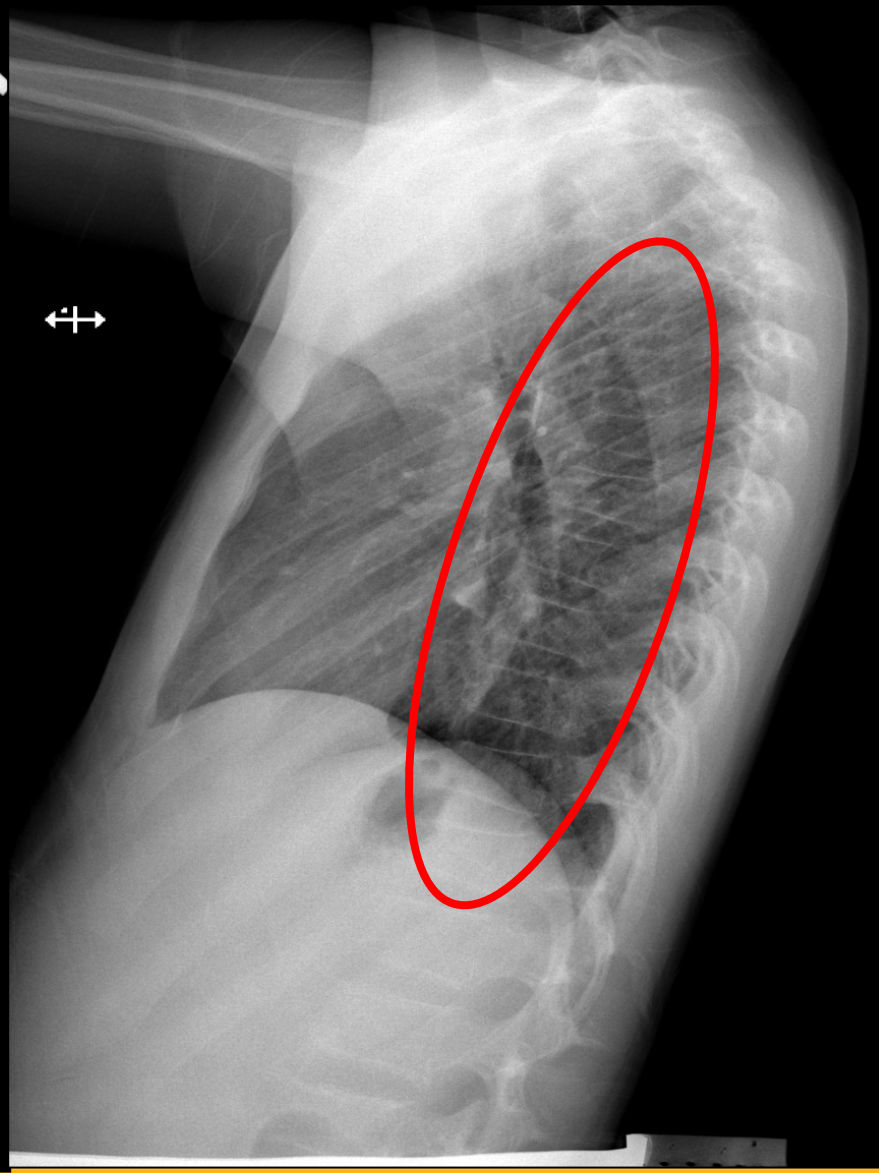
Demineralization



Normal



Demineralization + Multiple vertebral compression fractures



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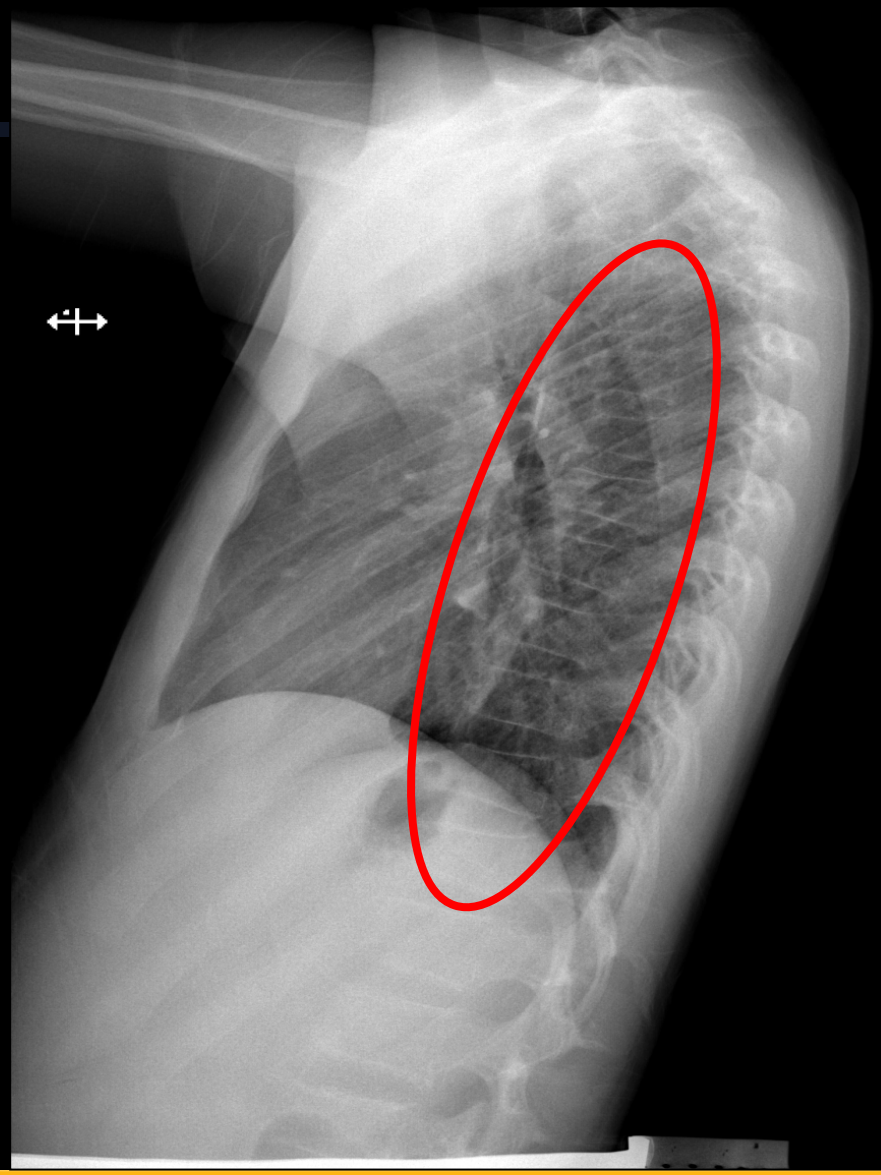
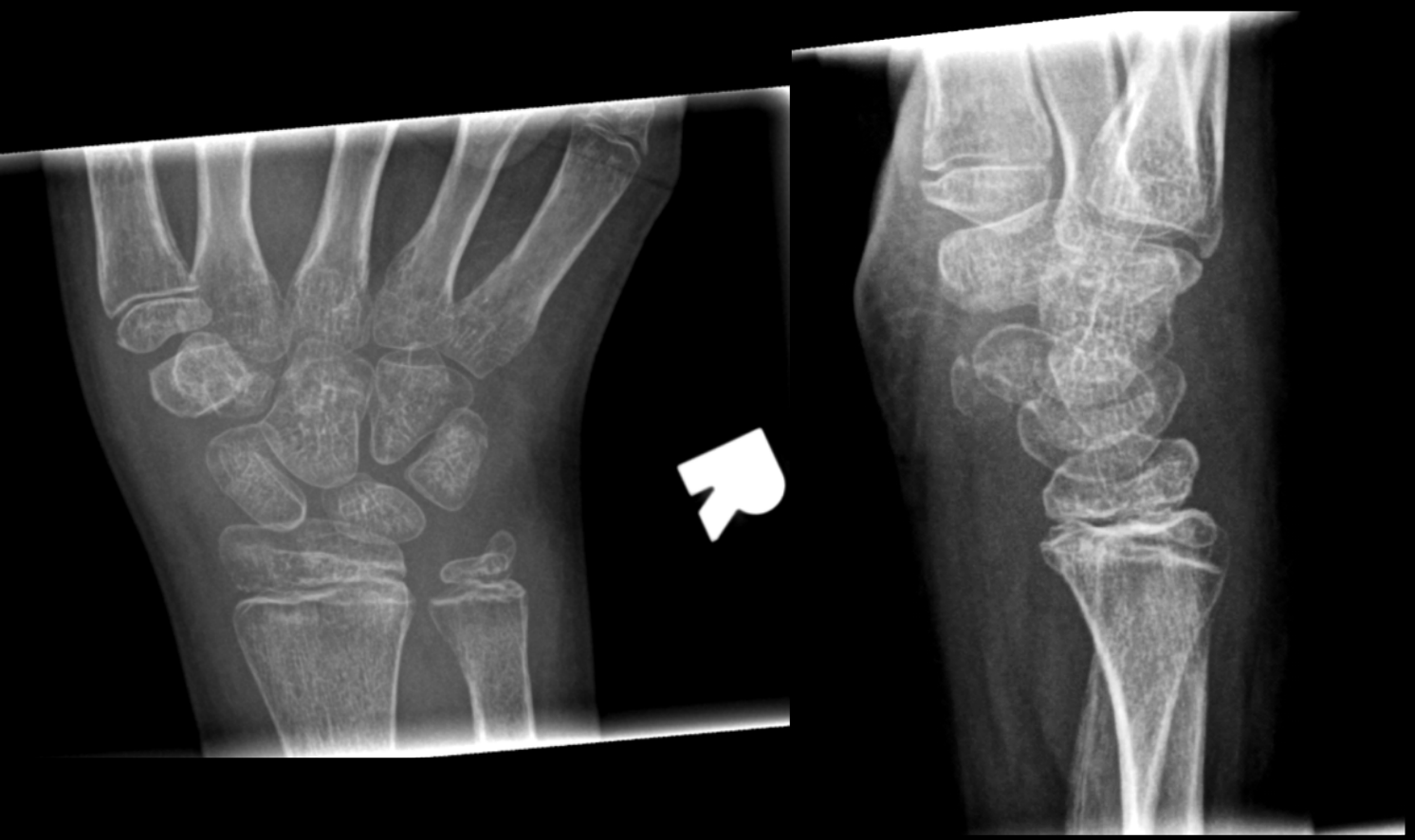


DDx:
Trauma
Steroids
Osteogenesis imperfecta
Leukemia/lymphoma
LCH
Metastasis

Her mom reports no history of an underlying medical condition. There is no history or trauma. She does not take any medications.

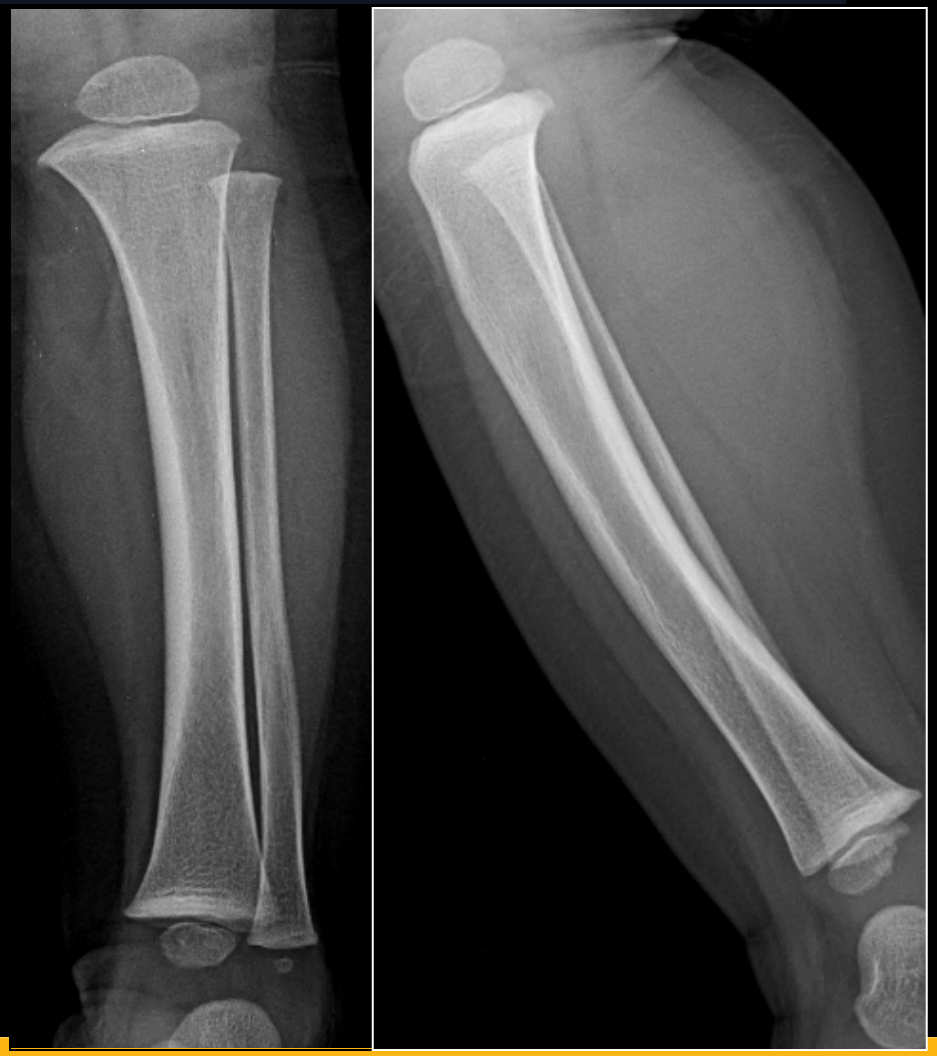
Red Flags: In children, compression fractures without high-energy trauma (e.g., fall from height) should immediately prompt screening for **Acute Lymphoblastic Leukemia (ALL)** or **osteoporosis**.

Leukemia



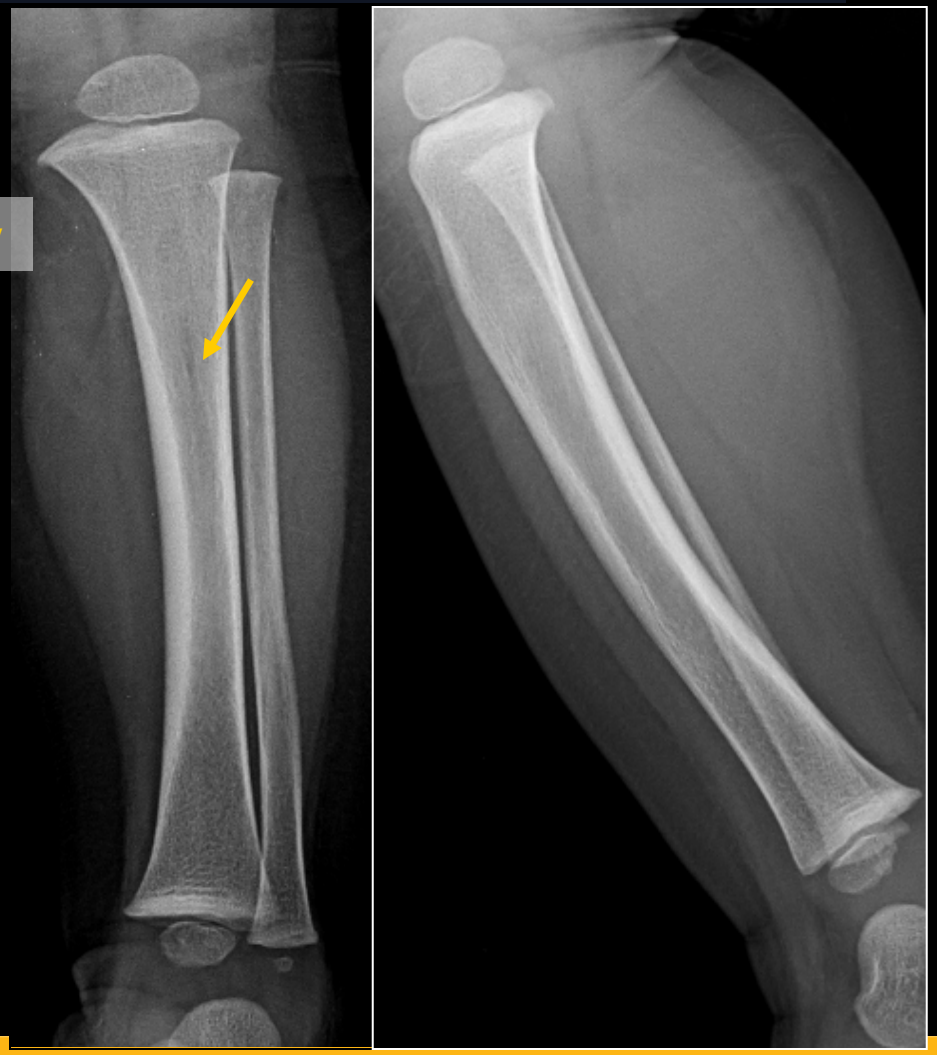
- Musculoskeletal symptoms
  - 20-50% pts
- Radiographic manifestations
  - Generalized osteopenia
  - Metaphyseal lucent band
  - Periosteal reaction
  - Osteosclerosis
  - Osteolysis
  - Pathologic fracture
  - Permeative bone lesion

r/o Toddler's Fracture

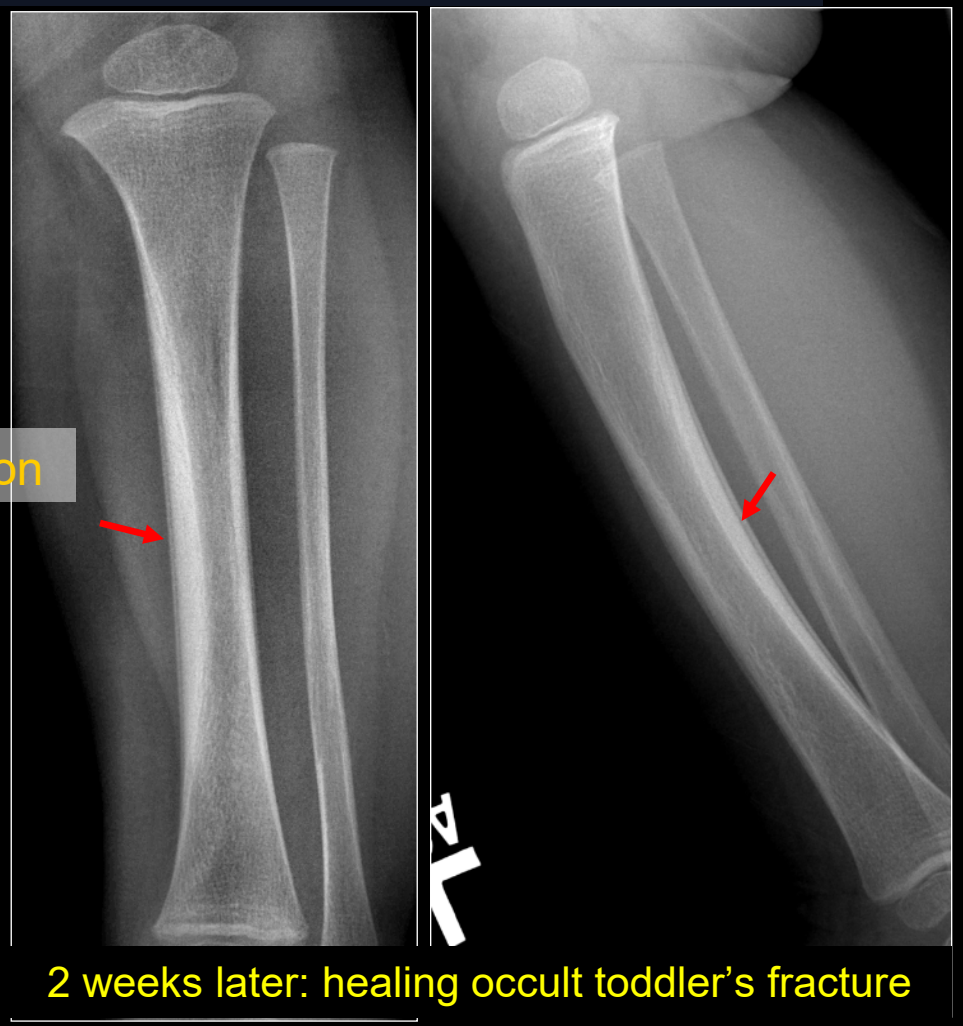


r/o Toddler's Fracture

Canal for nutrient artery

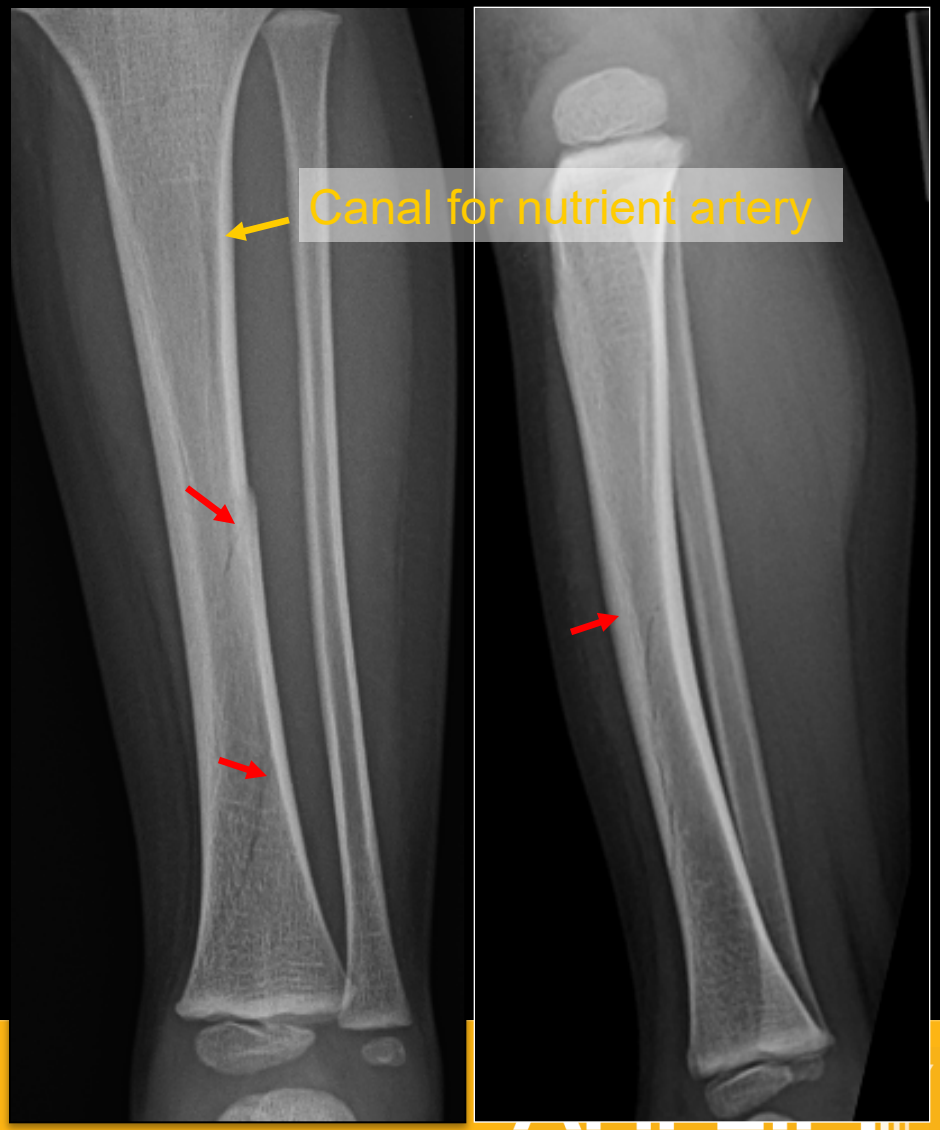


Healing occult Toddler's Fracture



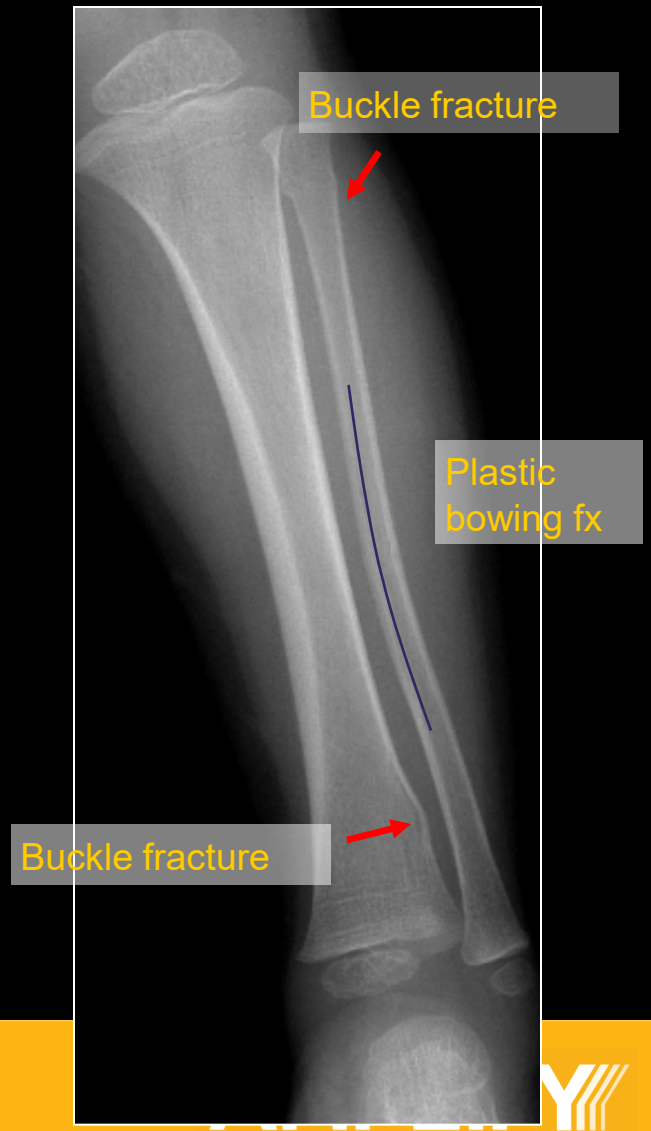
Toddler's Fracture

- Spiral fx distal 2/3 tibia
  - Stable fracture
  - Heals without treatment
- Not suspicious for abuse in an ambulatory child
- Often occult
  - Internal oblique radiograph may show fracture, follow-up XR
  - Treatment with long leg cast



Toddler Fracture Spectrum

- Includes variety of often subtle fractures
  - Fibula
  - Proximal and distal tibia
  - Cuboid
  - Calcaneus
  - Metatarsals



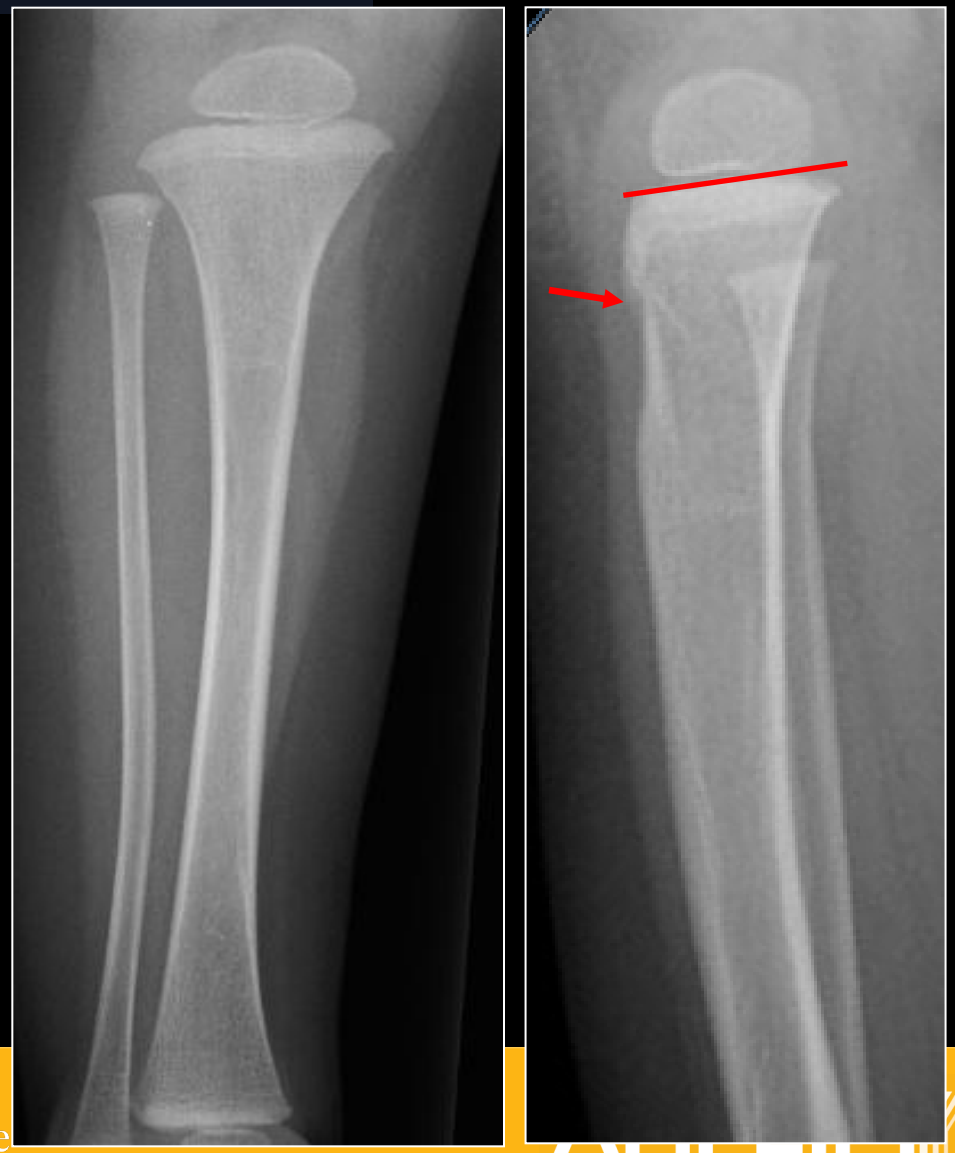
Expanding the Concept of the Toddler's Fracture[1]

Susan D. John, MD
Chetan S. Moorthy, MD
Leonard E. Swischuk, MD

RadioGraphics 1997; 17:367-376

Toddler Fracture Spectrum

- Proximal Tibial Fx:
  - Hyperextension force
  - Buckle fx anterior tibia
  - Anterior tilting physis
  - Increased “scooping” of tubercular notch



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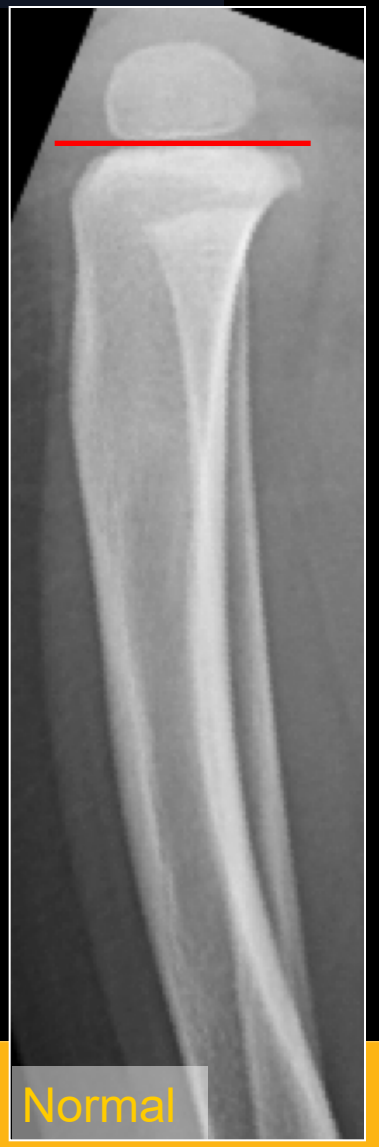
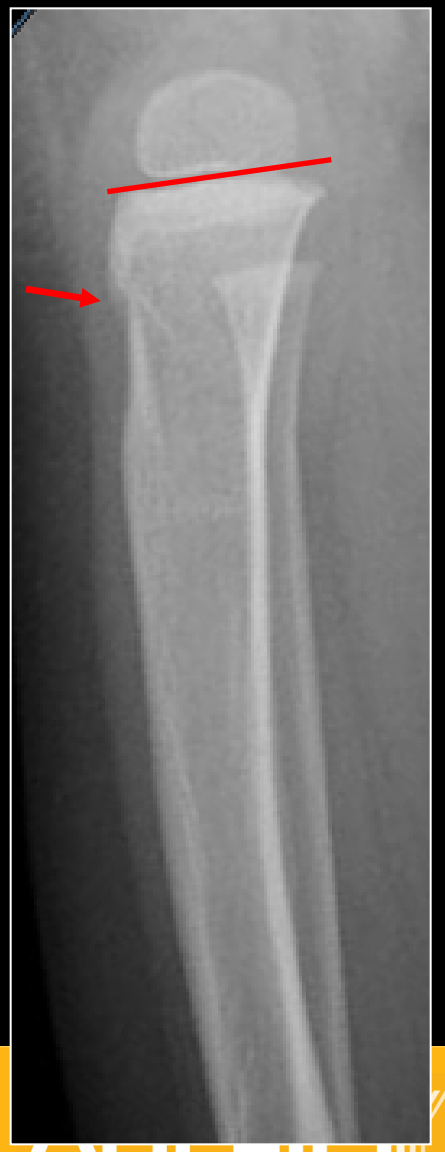
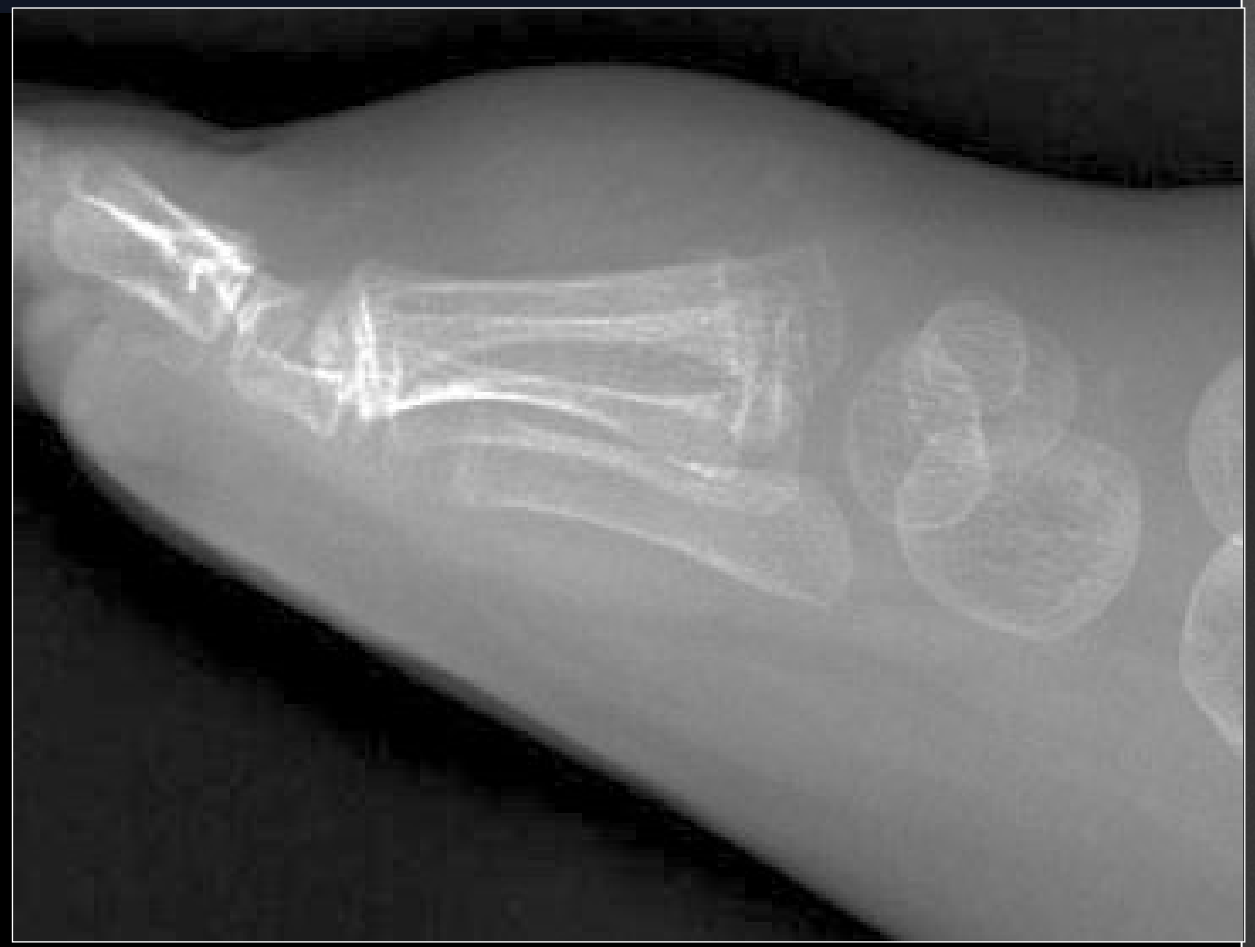


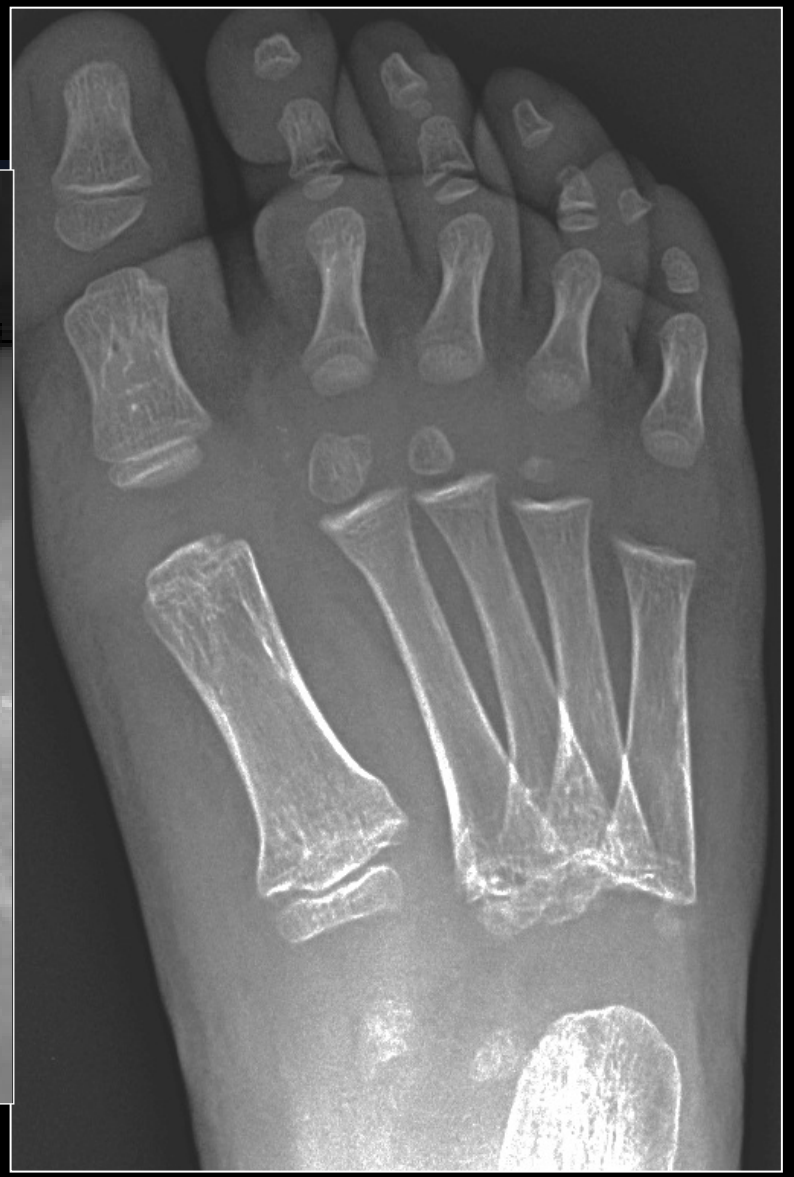


Normal

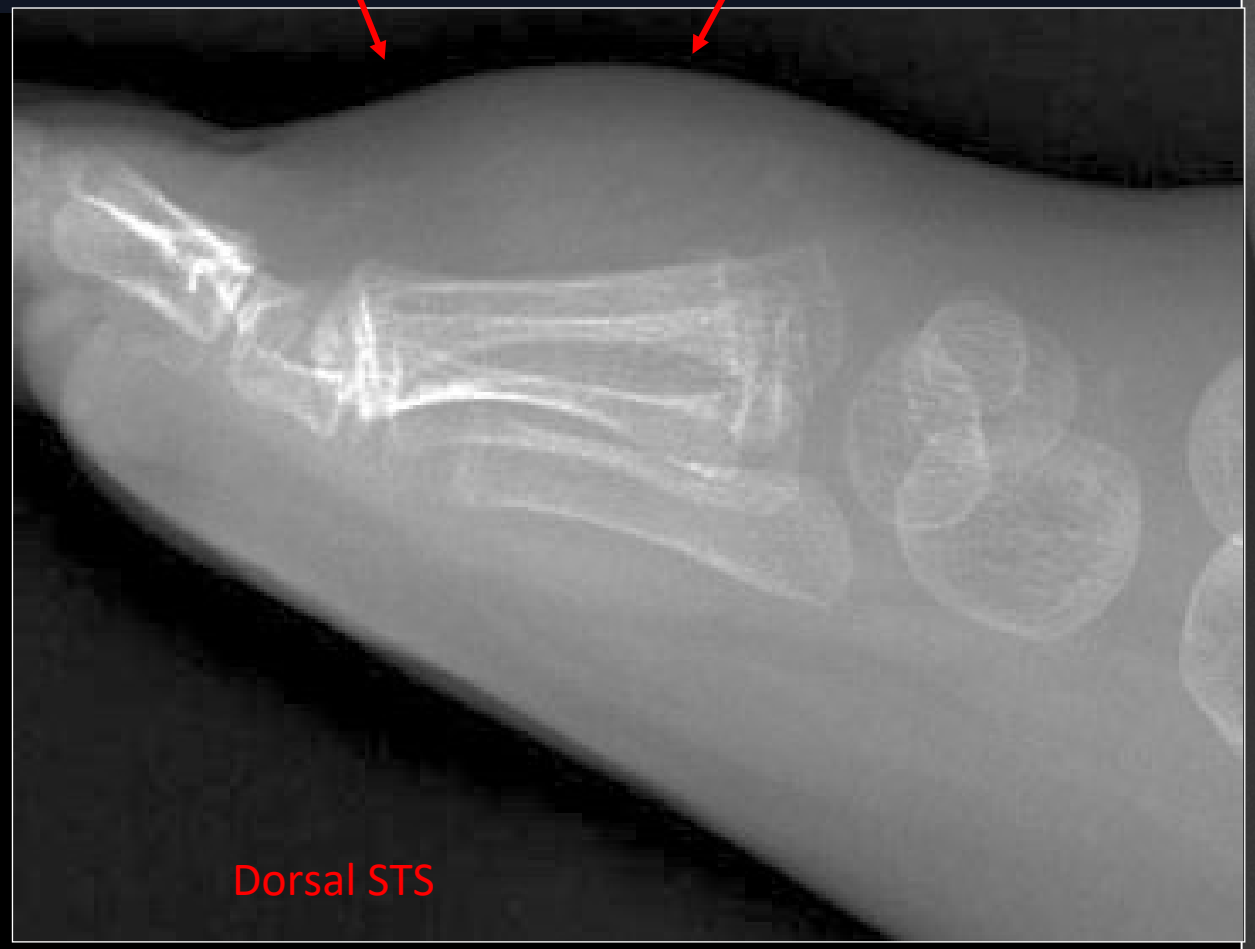
The Toddler Fracture: Take Home points

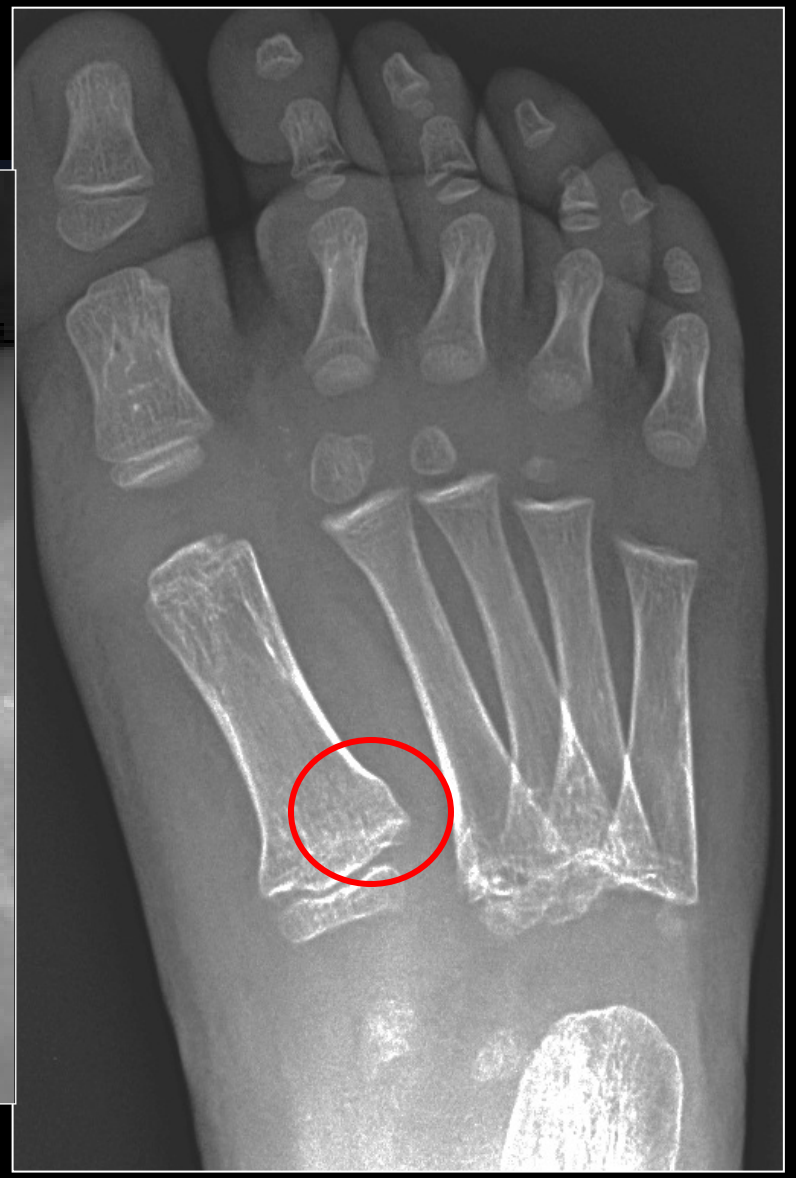
- **Definition:** A subtle spiral or oblique fracture of the distal tibial shaft in young children (ages 1–4).
- **Cause:** Usually from low-energy twisting injuries.
- **X-rays:** Often appear normal initially in 40–60% of cases due to minimal displacement.
- **Best View:** Internal oblique X-ray is most effective if standard views are negative.
- **Diagnosis:** Follow-up X-rays after 7–14 days may reveal signs like periosteal reaction or sclerosis.





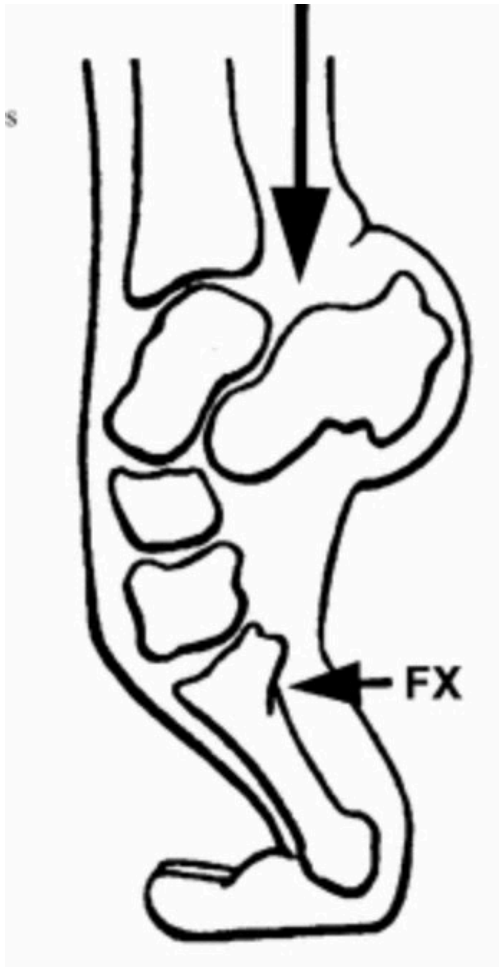
1st Metatarsal Buckle Fx

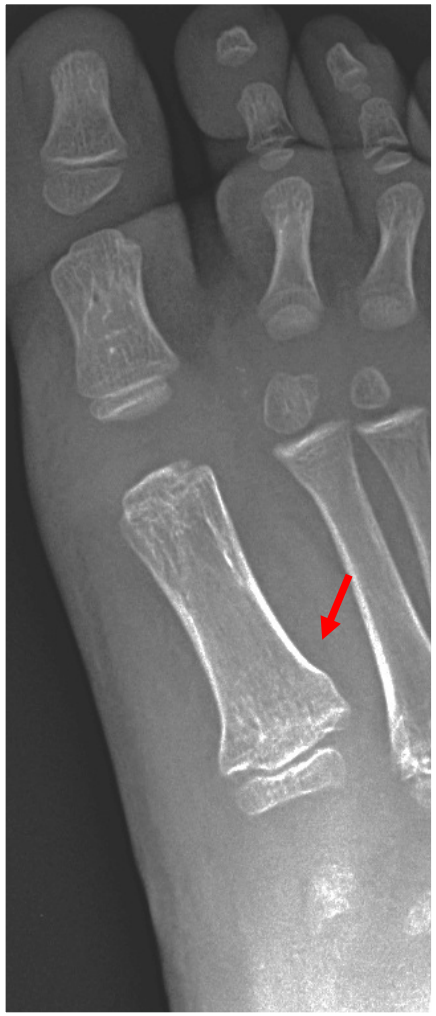




1st Metatarsal Fracture

- Compressive axial loading
- “Bunk bed” fracture
- Undulation of cortex





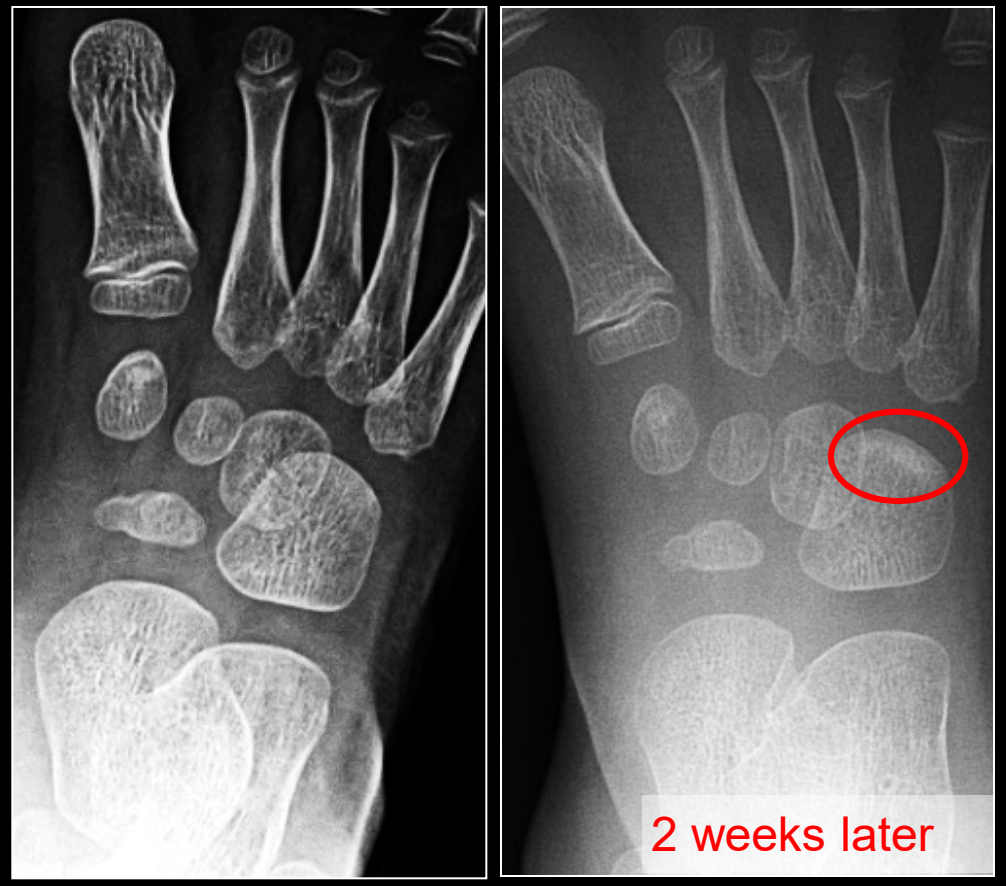
RadioGraphics 1997; 17:367-376

1st Metatarsal Buckle Fracture: The "Bunk Bed" Injury

- **Epidemiology:** Most frequent metatarsal fracture in children under 5, shifting to the 5th metatarsal as they grow.
- **Cause:** Usually from axial loading, like jumping or falling onto a planted foot.
- **X-ray Sign:** Cortical bulge at the metaphysis without a full break.
- **Physis Confusion:** Must differentiate from the normal proximal physis of the 1st metatarsal.
- **Treatment:** Stable fracture with excellent outlook, managed with 3–4 weeks in a walking boot or cast.

Cuboid Fracture

- Second “bunk bed” fx
  - Same mechanism
  - Impaction injury of cuboid
  - Band of sclerosis confirms healing occult fracture



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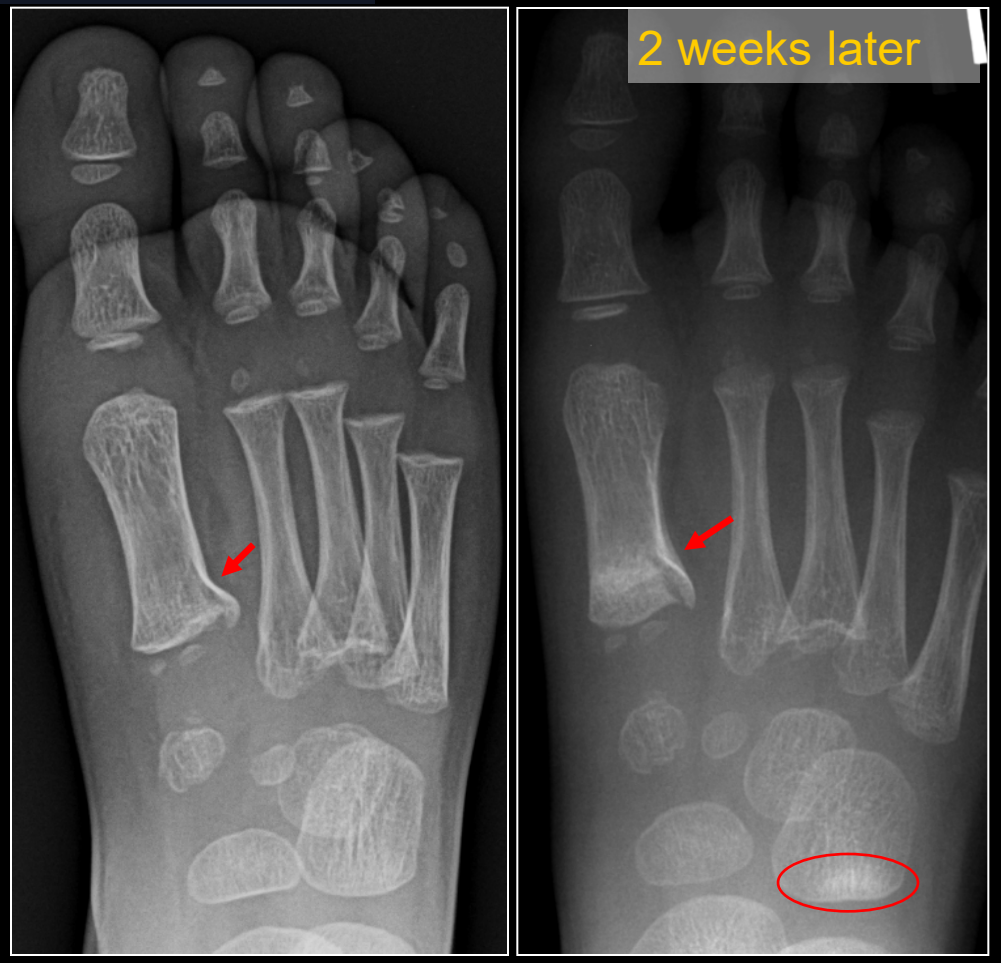
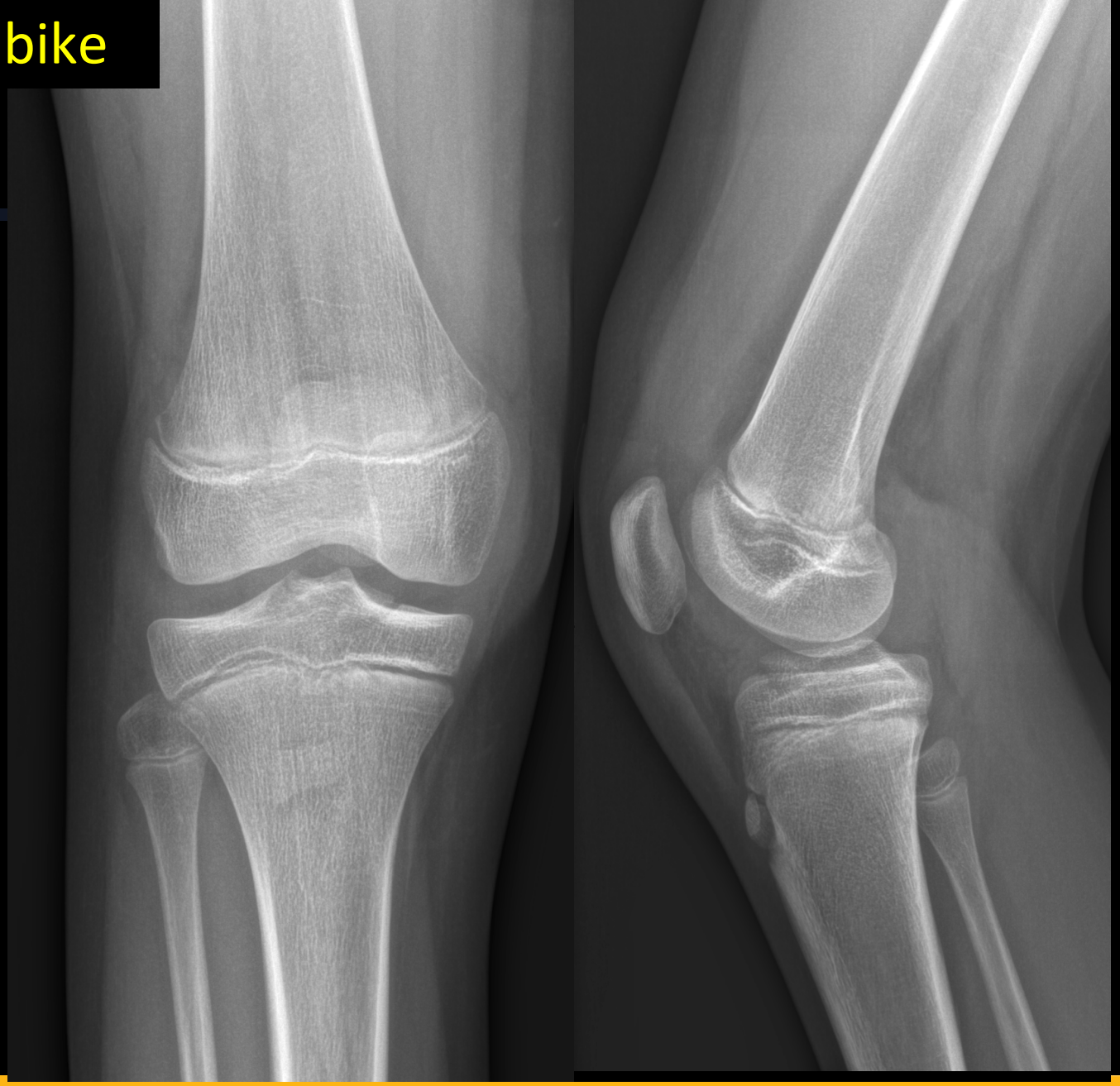
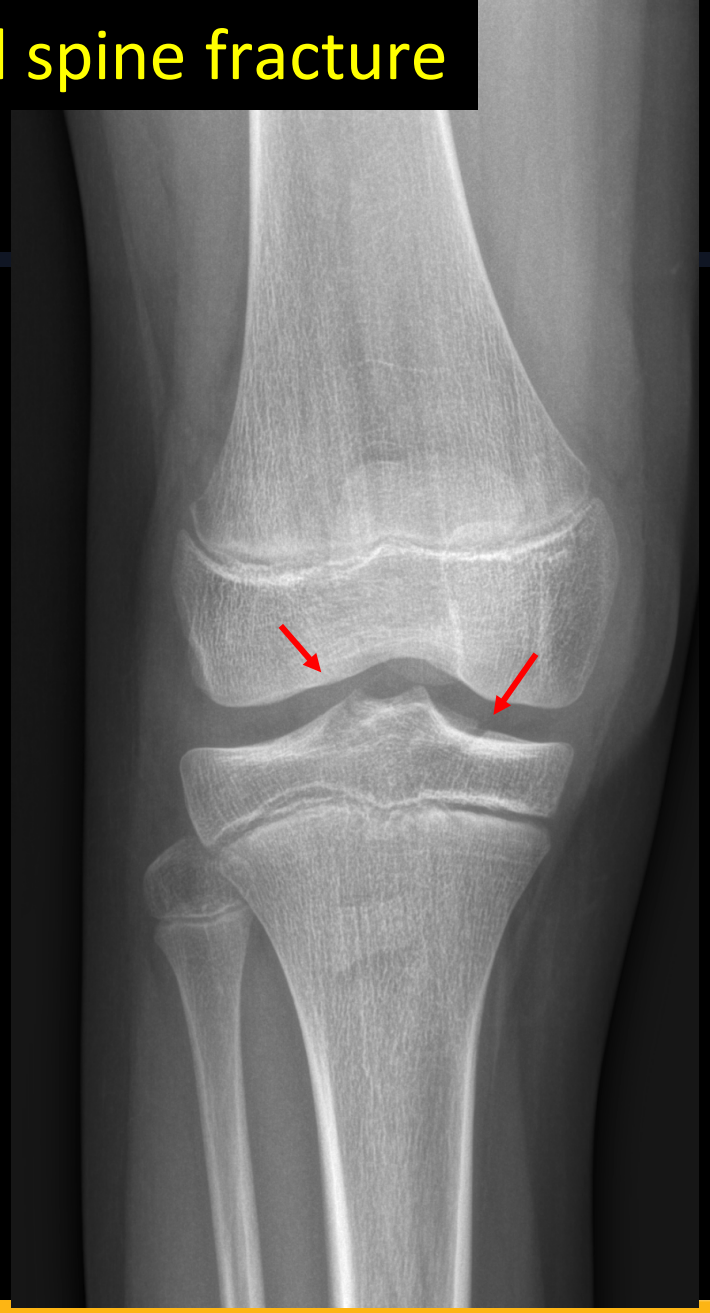
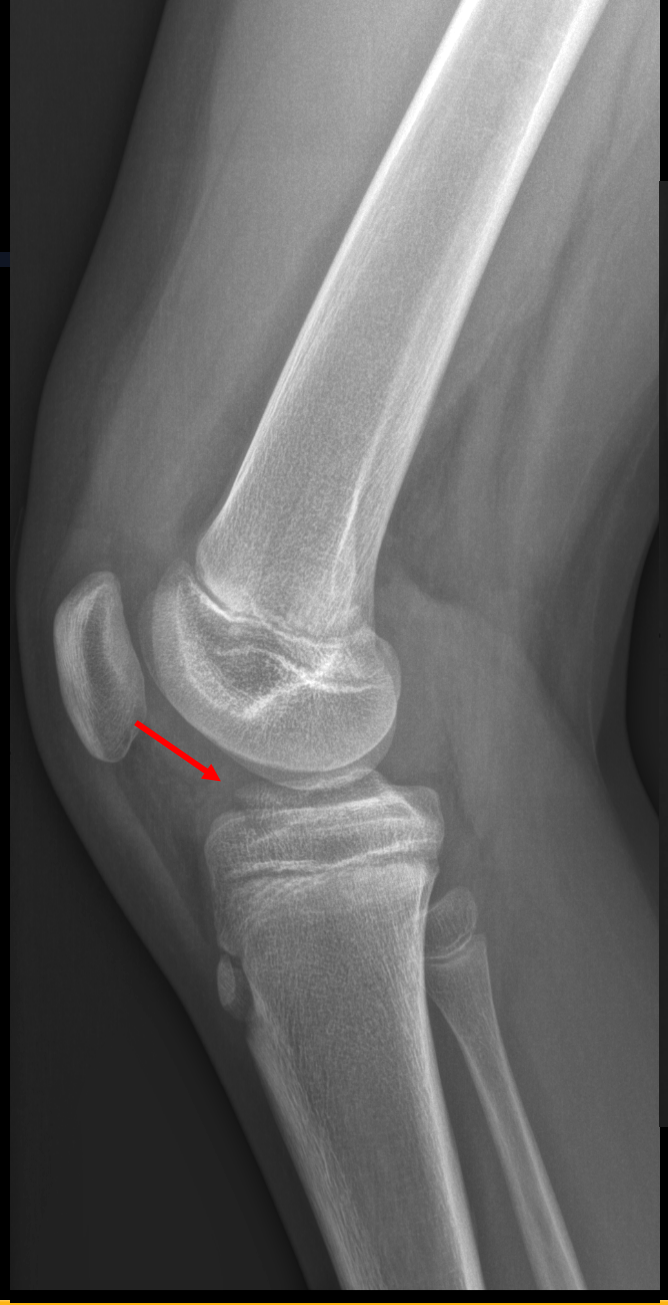


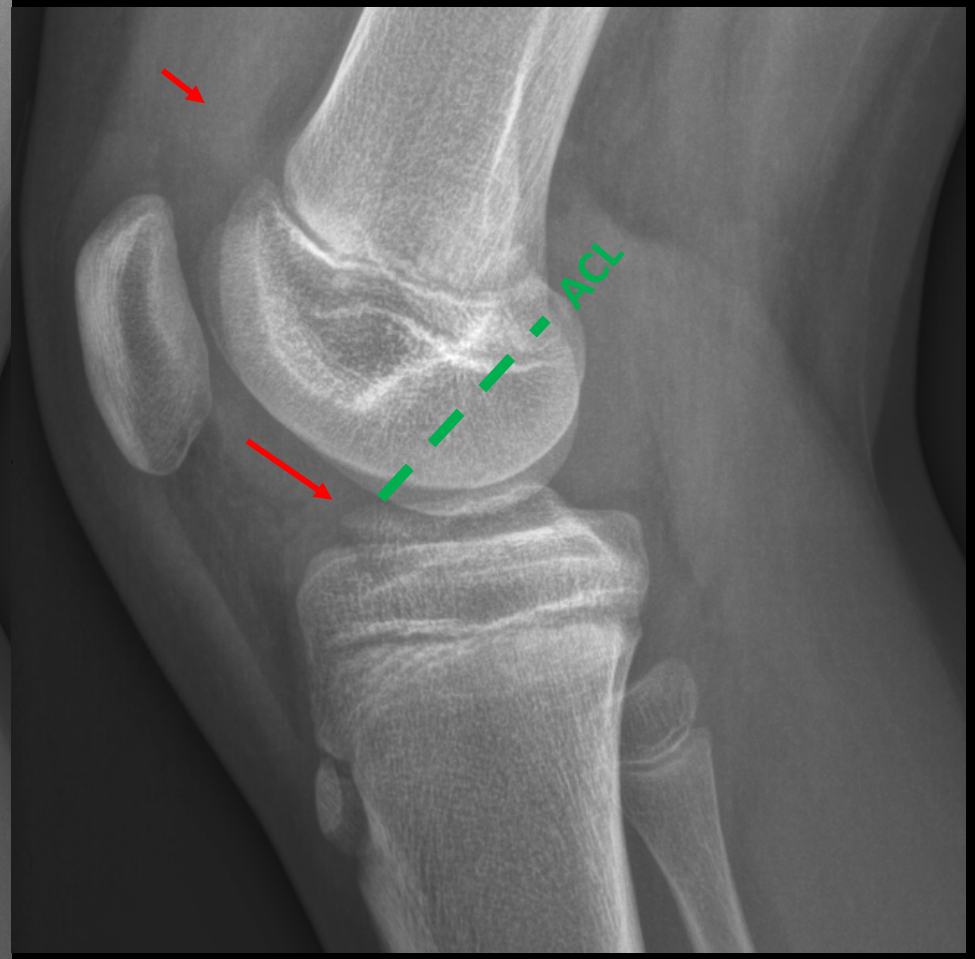
11 yo s/p fall from bike



Tibial spine fracture

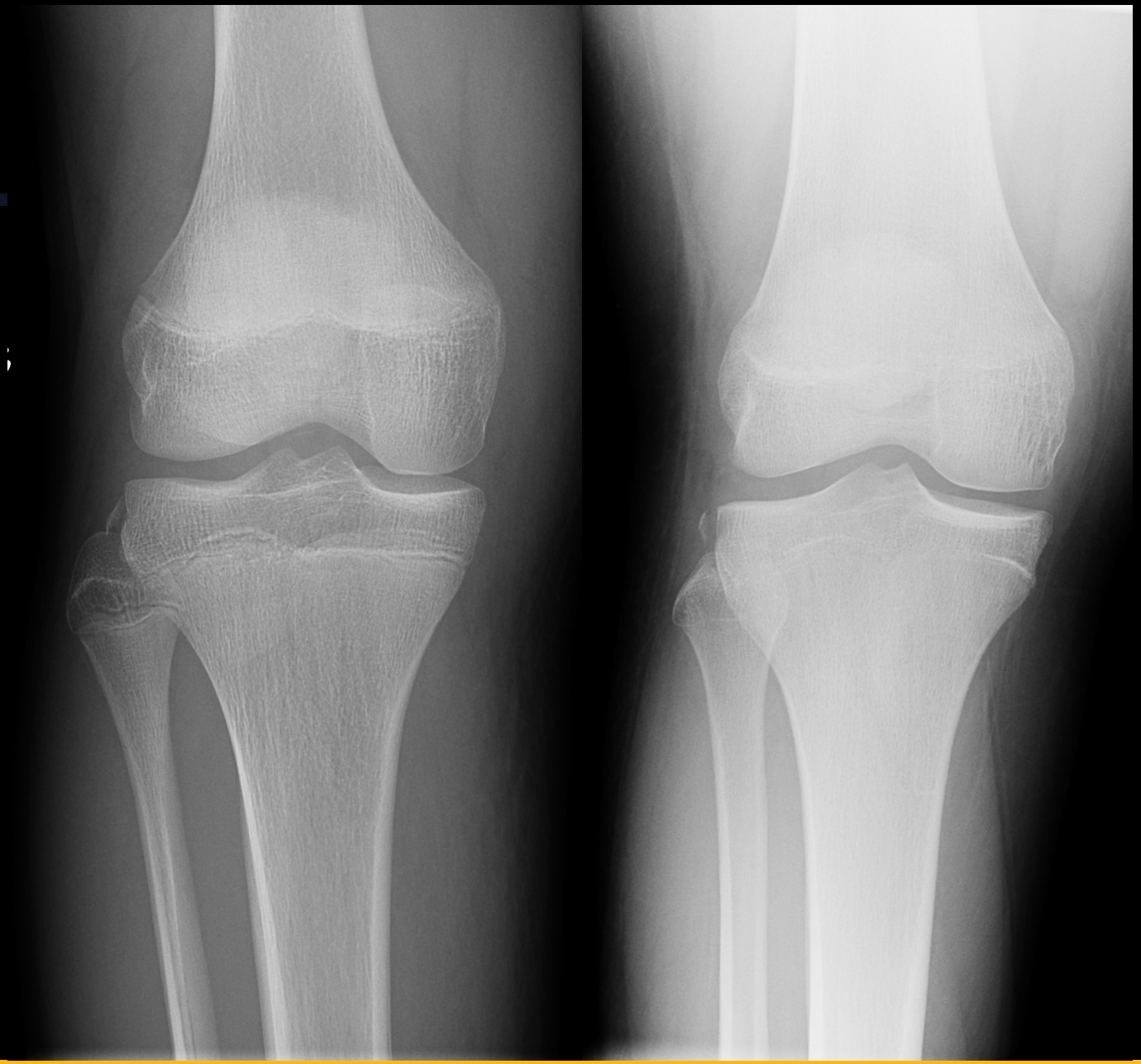






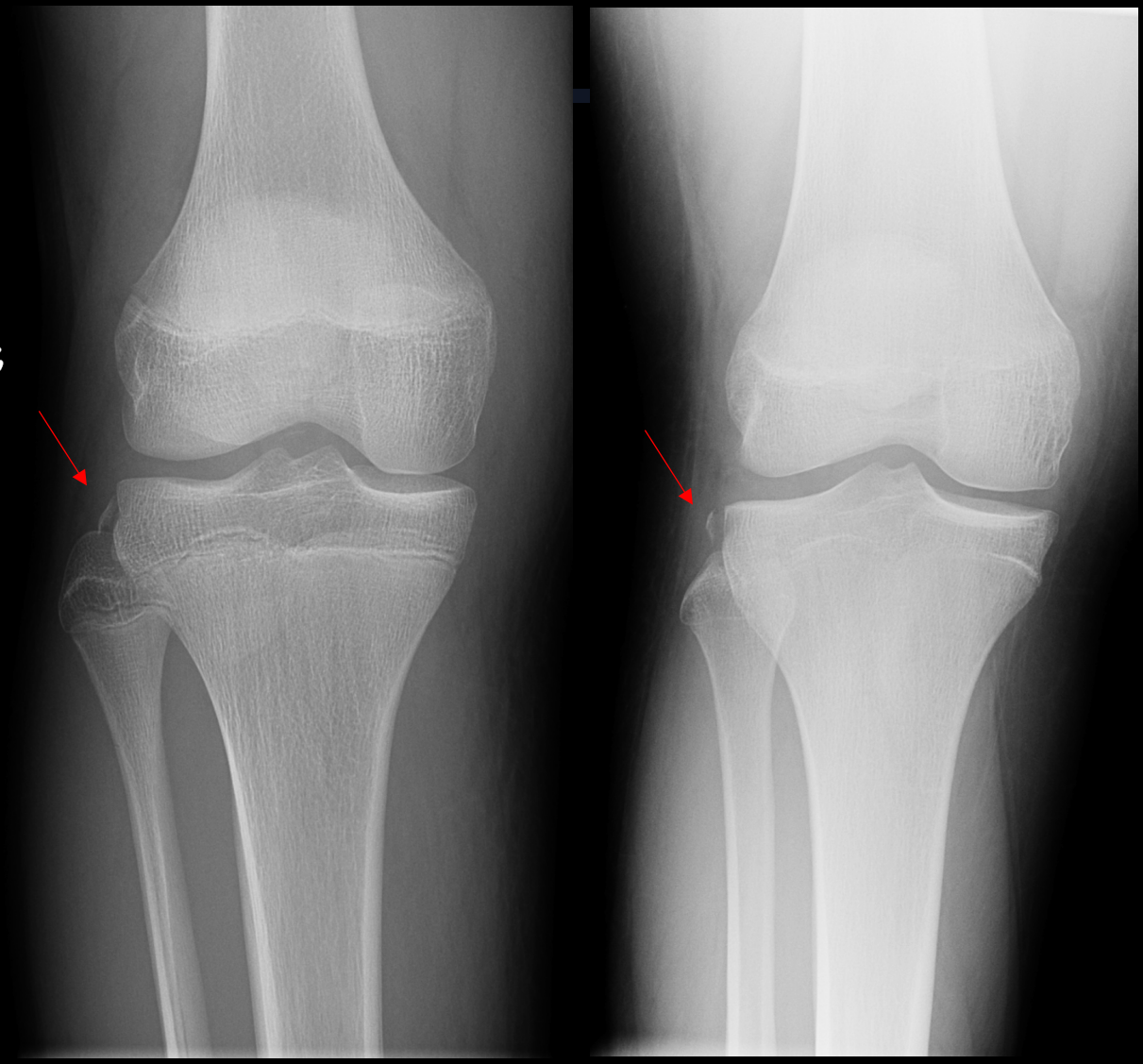
Tibial Eminence Avulsion: The Pediatric ACL "Equivalent"

- **Age Predilection:** Most common in children ages **8–14**; the immature intercondylar eminence is weaker than the ACL fibers themselves.
- **Mechanism of Injury:** Typically a forceful **hyperextension** or rotation (e.g., a fall from a bicycle or a skiing accident).
- **Meyers & McKeever Classification:**
  - **Type I:** Non-displaced or minimally displaced.
  - **Type II:** Partially displaced with an intact **posterior hinge**.
  - **Type III/IV:** Completely displaced (III) or comminuted (IV).
- **Radiographic Key:** Best visualized on the **lateral knee X-ray**; look for the "lifted" bone fragment in the intercondylar notch.

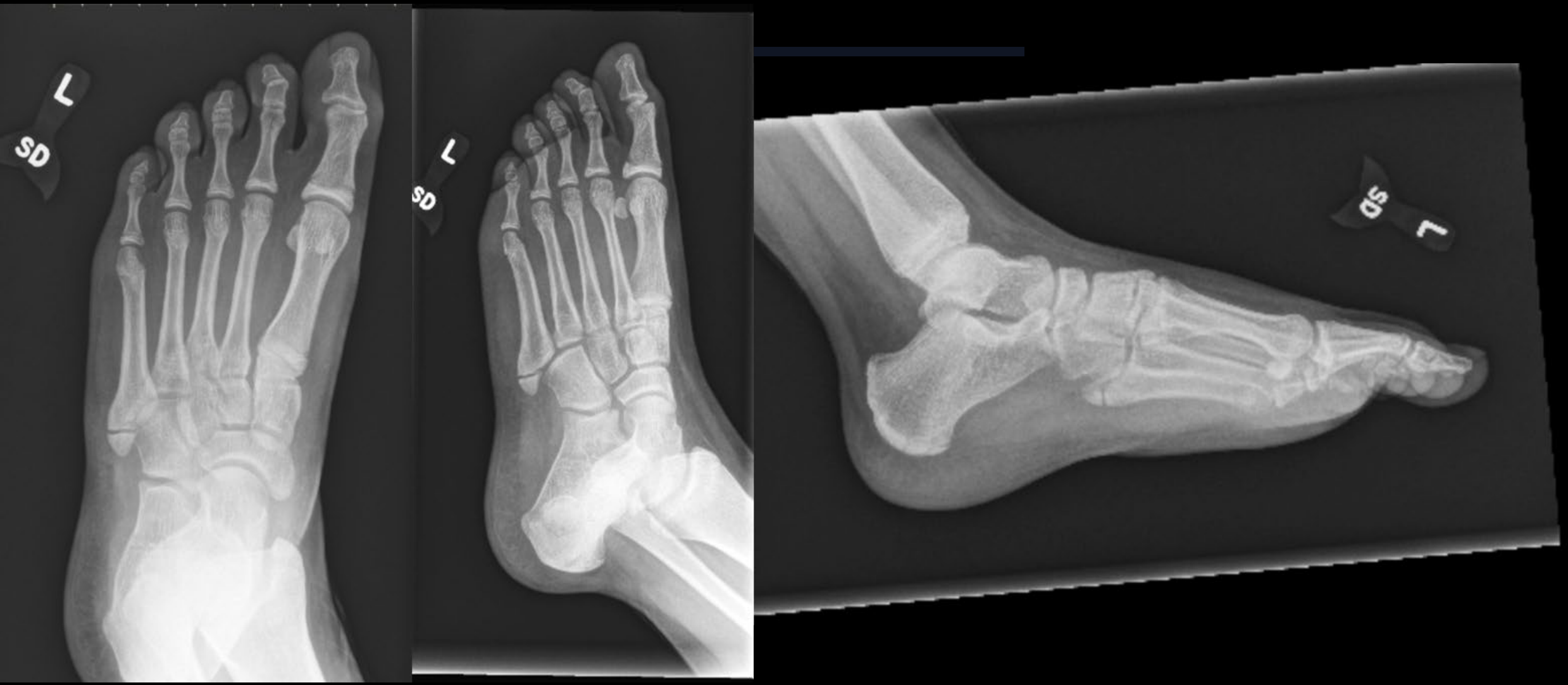


Segond fracture

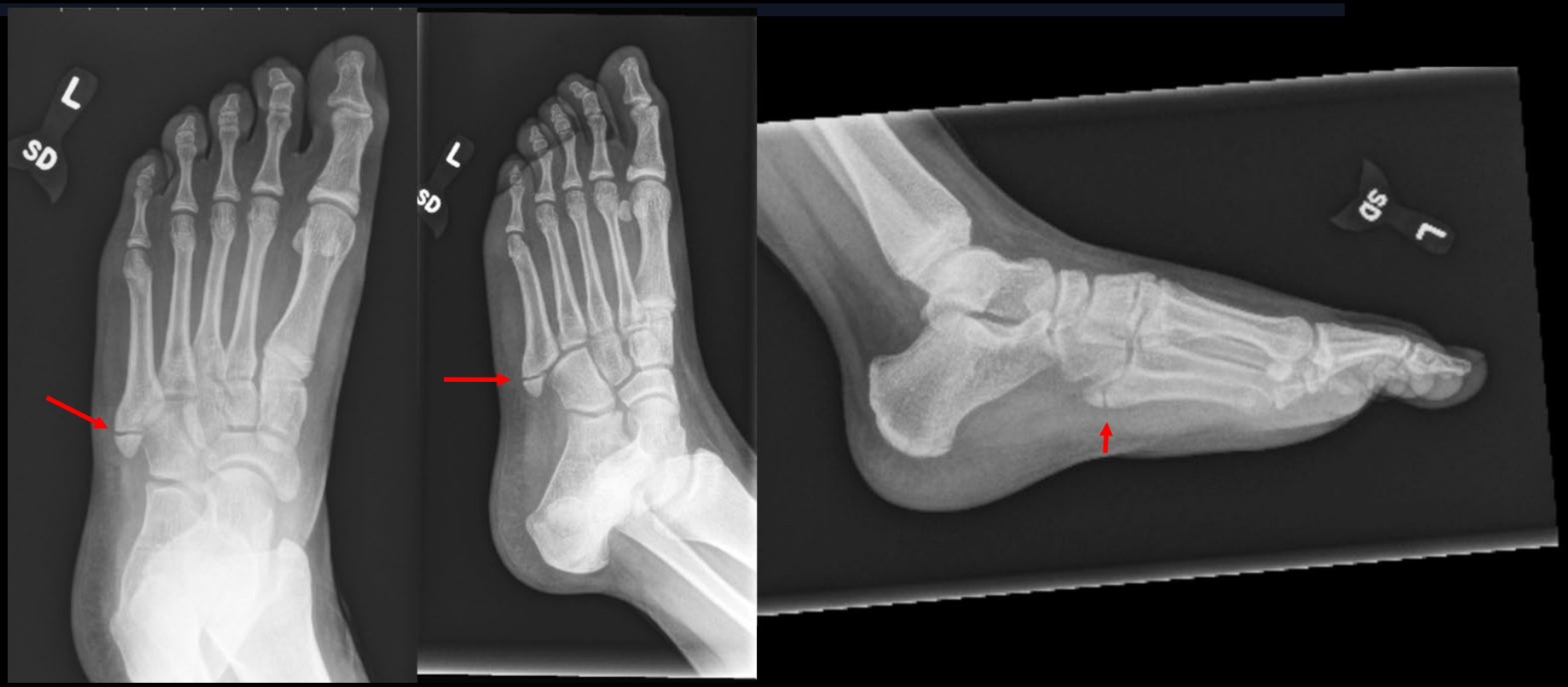
- **Location:** Lateral aspect of the tibia plateau, just below the knee joint line.
- **Cause:** Forced internal rotation and varus stress (twisting inward with force).
- **Associated Injuries:** Highly associated with ACL tears, lateral meniscus tears, and capsular ligament injuries.



Twisted foot, lateral pain



Avulsion fx @ base of 5th metatarsal



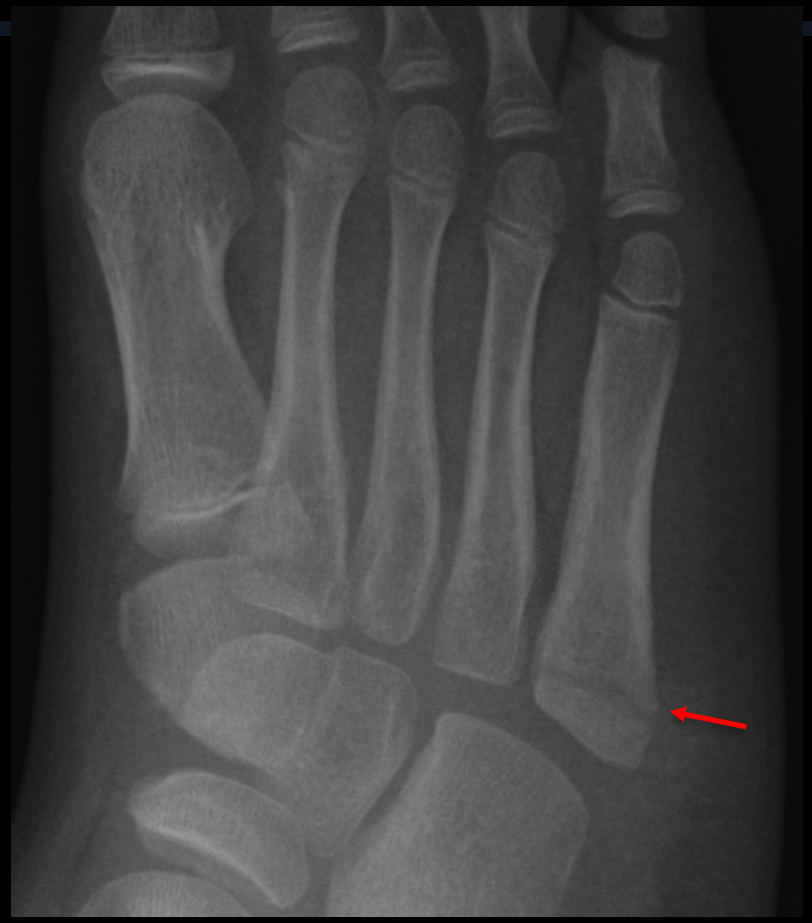
Tips:

- Transverse fx at base of the 5th MT.
- Perpendicular to the long axis of the bone
- Apophysis growth plate runs parallel to long axis

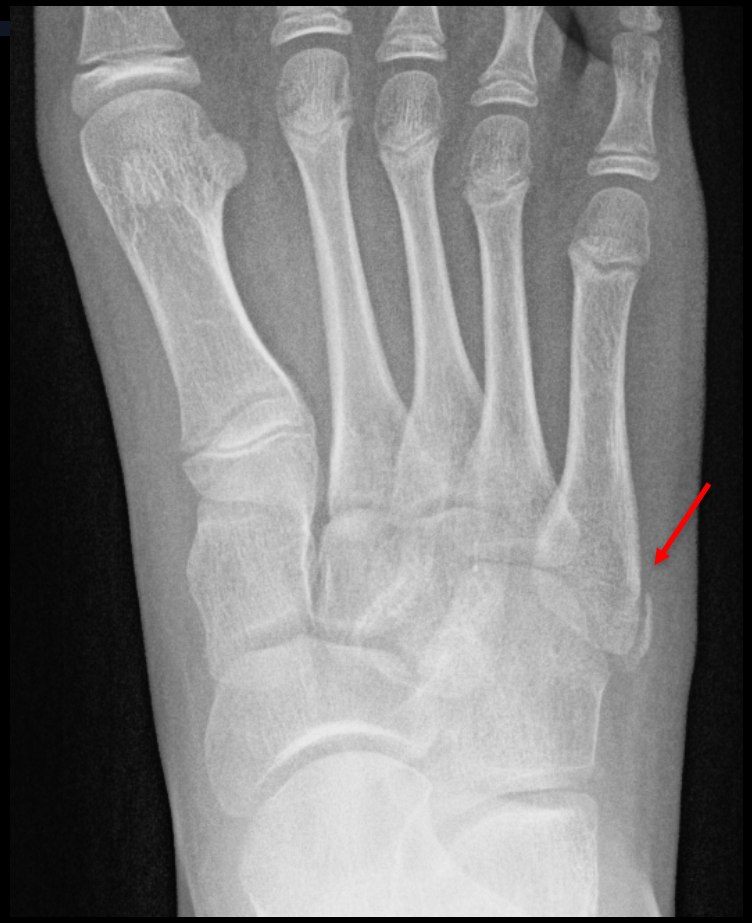
- Avulsion from peroneus brevis tendon, lateral cord of plantar fascia

- Aka Pseudo Jones fracture. Jones fx occur more distally

Proximal 5th metatarsal fracture versus normal apophysis

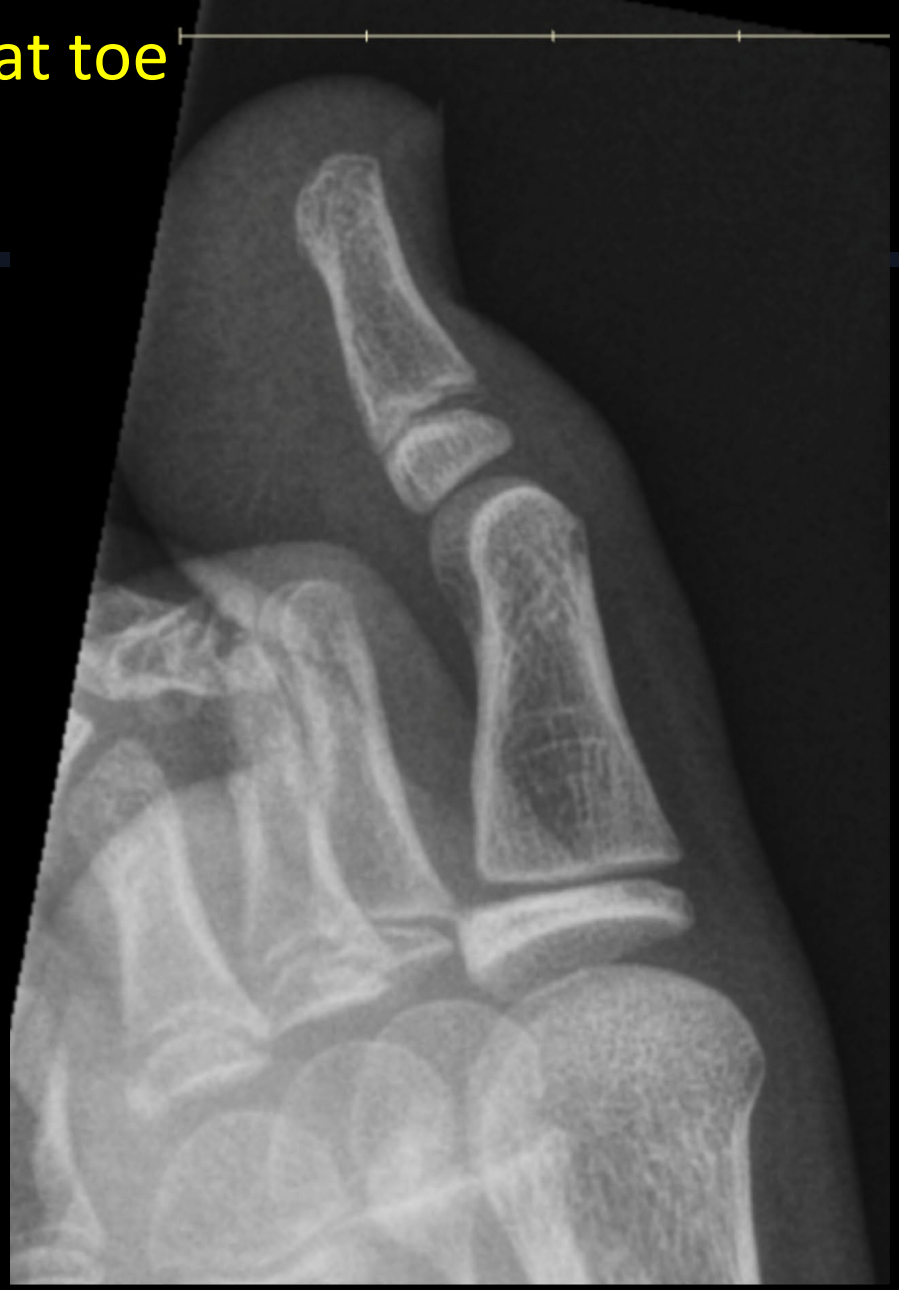


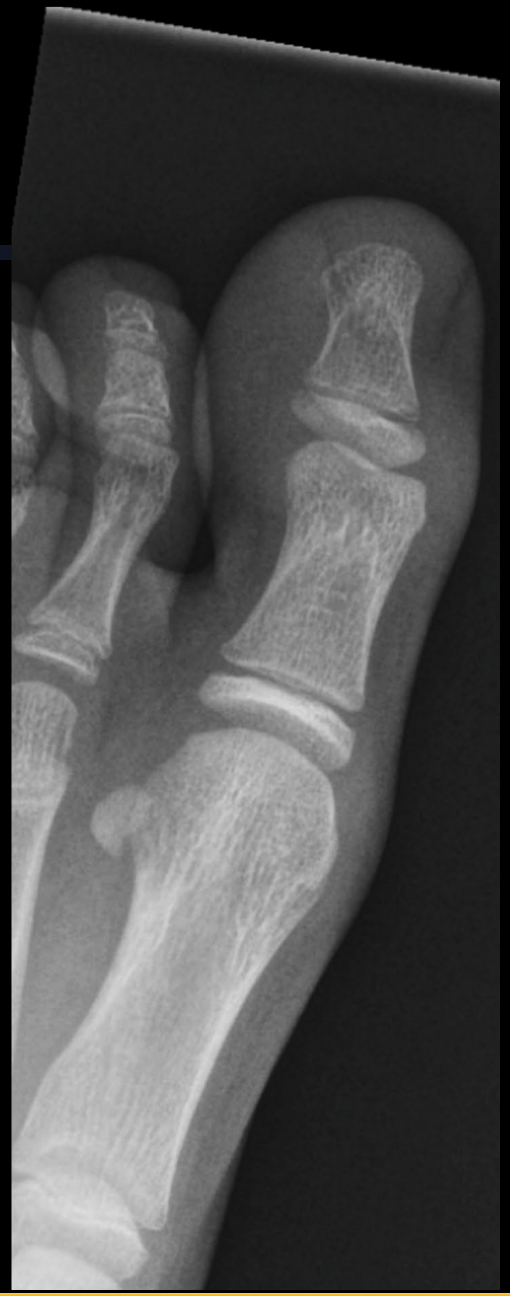
+ fracture – fracture line perpendicular to long axis



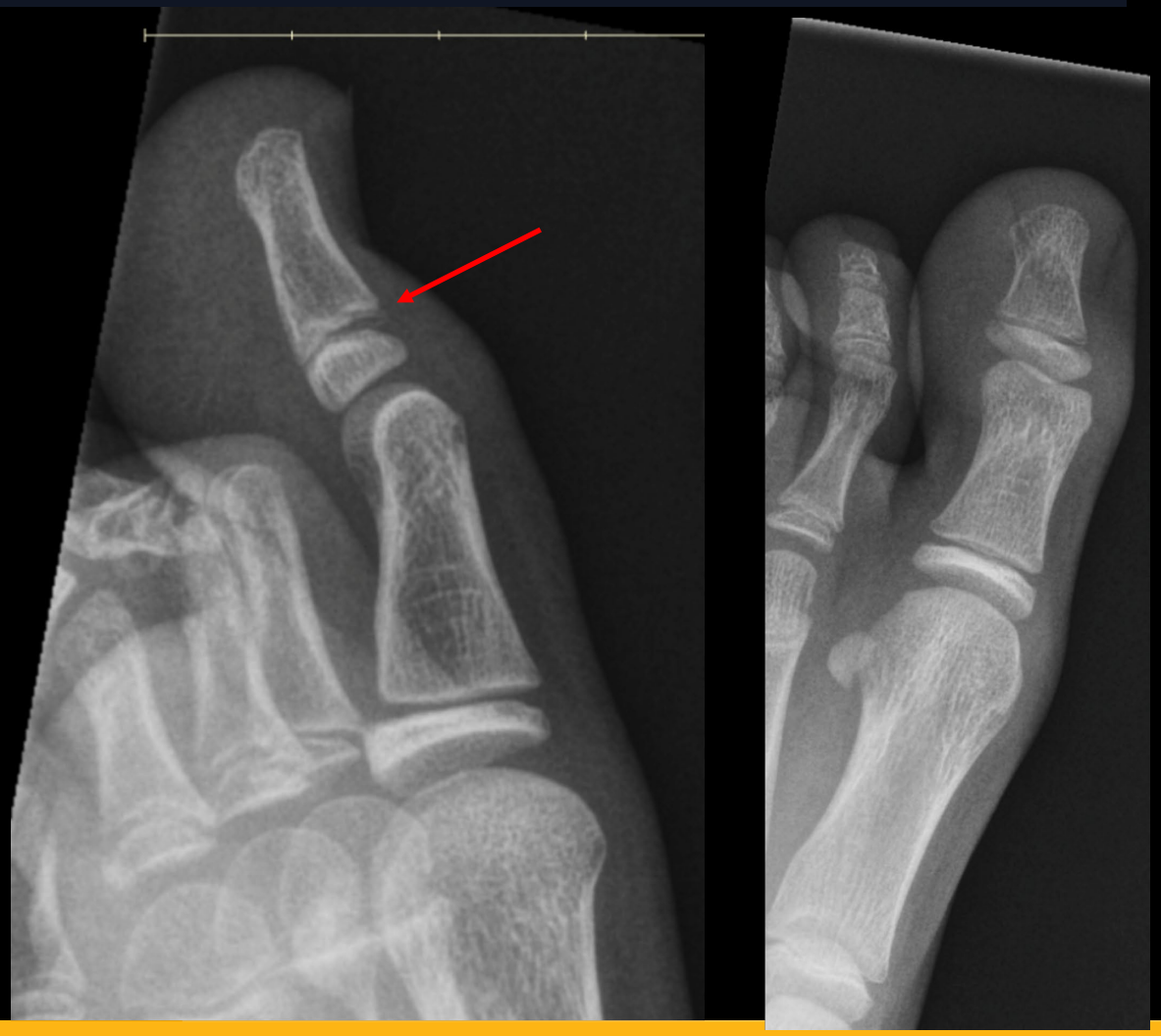
No fracture – physis line is parallel to long axis

Stubbed great toe





Fracture of the 1st distal phalanx dorsal metaphysis adjacent to the growth plate (SH II)



Tips:

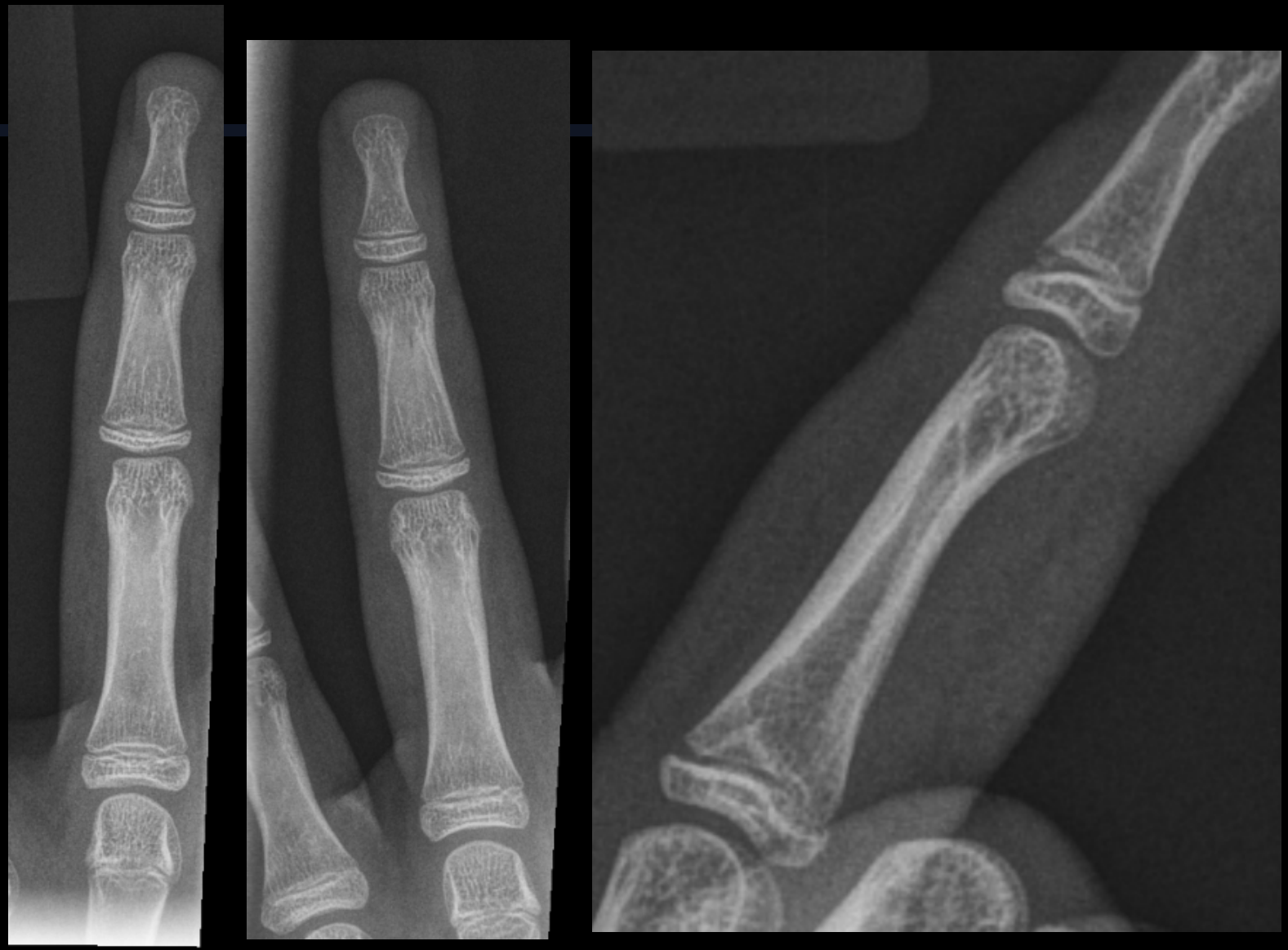
- SH2 fx.

- Lateral view most helpful, so important to have a well-positioned true lateral view without rotation/obliquity

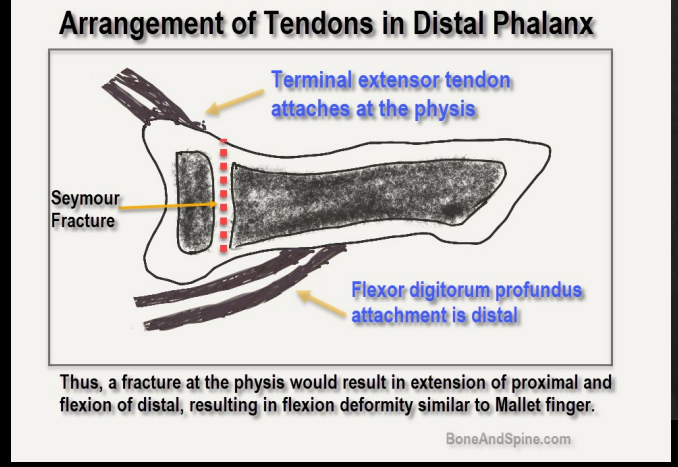
- Follow the STS

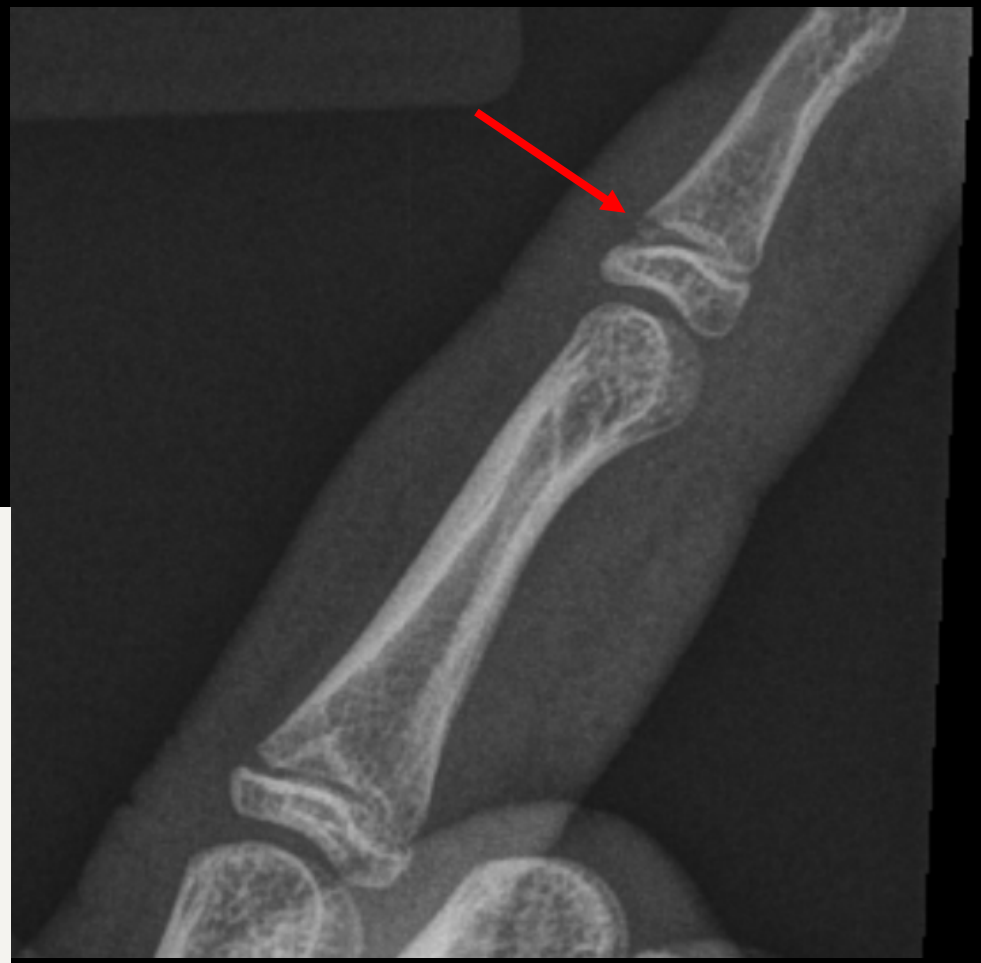
- Use tools, like magnification, zoom.

HX: 12yo F, injury catching football, tender at DIP joint, + bleeding/bruising at base of nail, nail appears elevated at base



Seymour Fracture



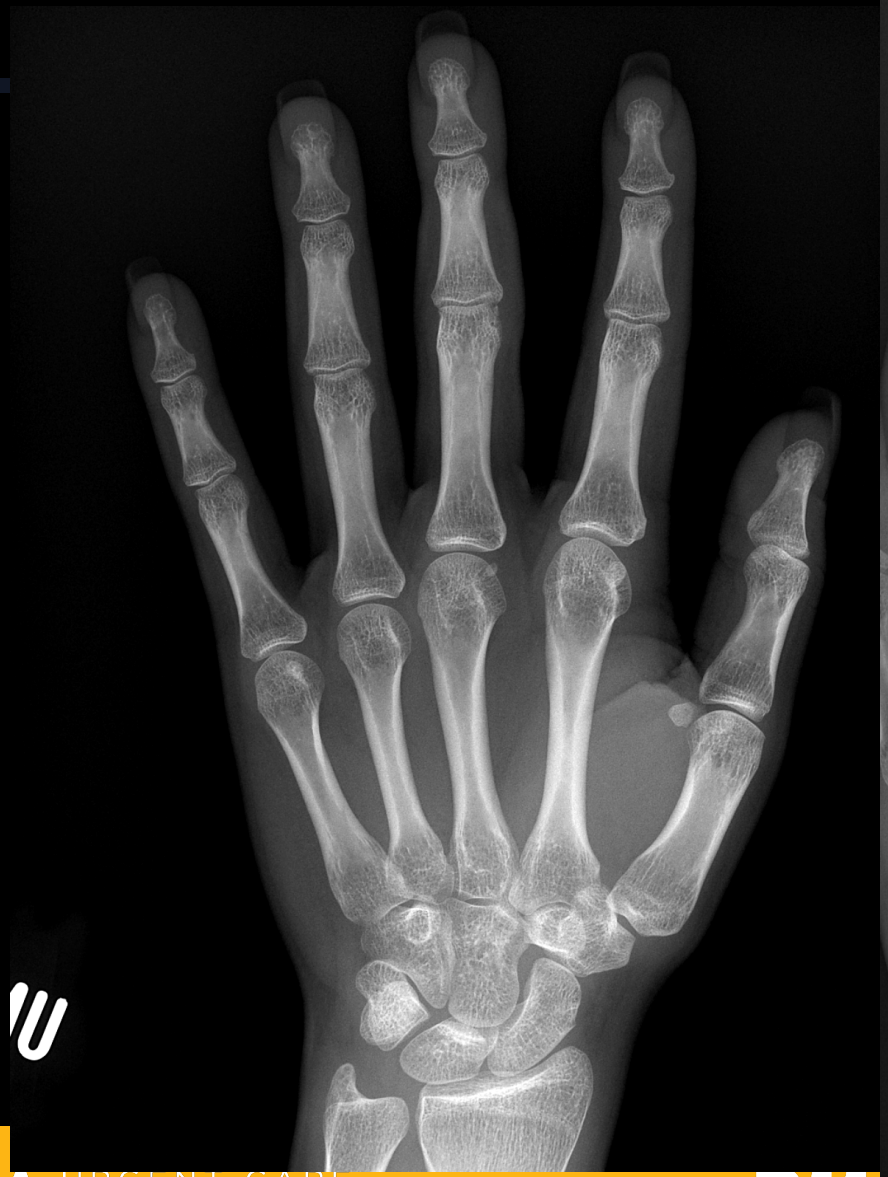


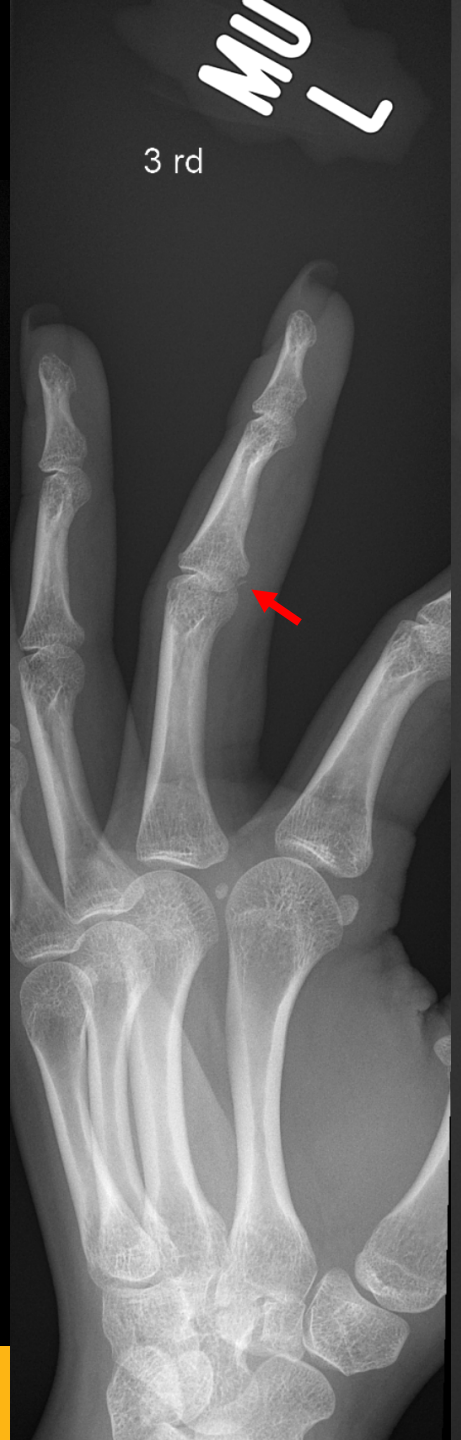
Tips

- Salter 2 fracture at the dorsal aspect of the distal phalanx.
- Need to assess for nail bed injury as these can be considered an **open fracture** with an increased risk of osteomyelitis.
- Tx: Transfer to the ER for ortho eval and Abx

Salter-Harris II Distal Phalanx: Seymour Fracture Alert

- **Definition:** A fracture through the physis that exits through the metaphysis; characterized by the **Thurston-Holland fragment** (a triangular metaphyseal piece).
- **The Seymour Fracture (Open Fracture):** A displaced SH II of the distal phalanx often associated with a nail bed laceration or proximal nail plate avulsion.
- **Clinical Trap:** Often misdiagnosed as a simple "mallet finger" or "bony mallet"; however, the deformity occurs at the **physis**, not the DIP joint.
- **Radiographic Hallmark:** Look for **flexion deformity** and dorsal apex angulation on the lateral view; the AP view may appear deceptively normal.
- **Emergency Management:**
  - **Antibiotics:** Mandatory for Seymour variants (open fractures) to prevent osteomyelitis.
  - **Reduction:** Requires thorough irrigation, nail bed repair, and often K-wire fixation to maintain stability.

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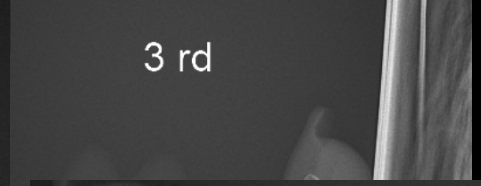
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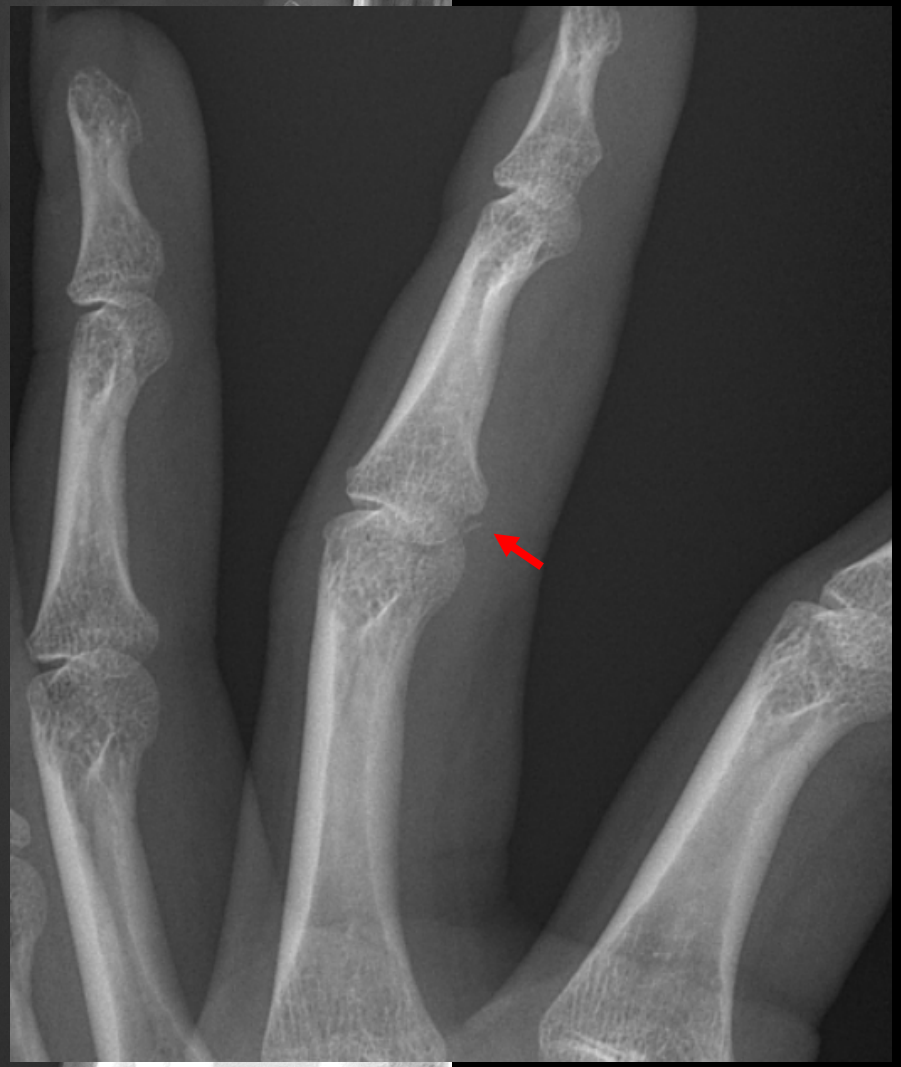
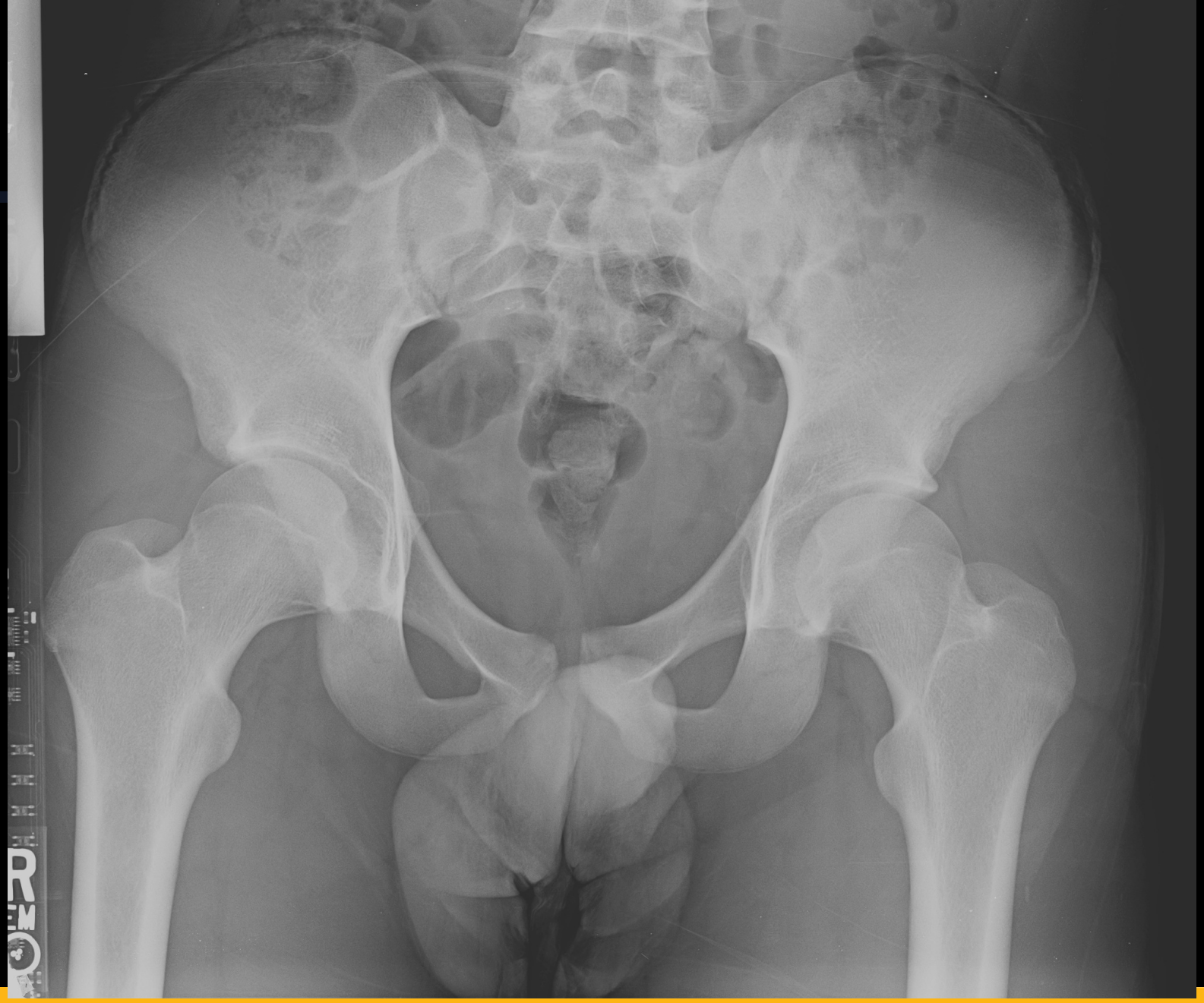
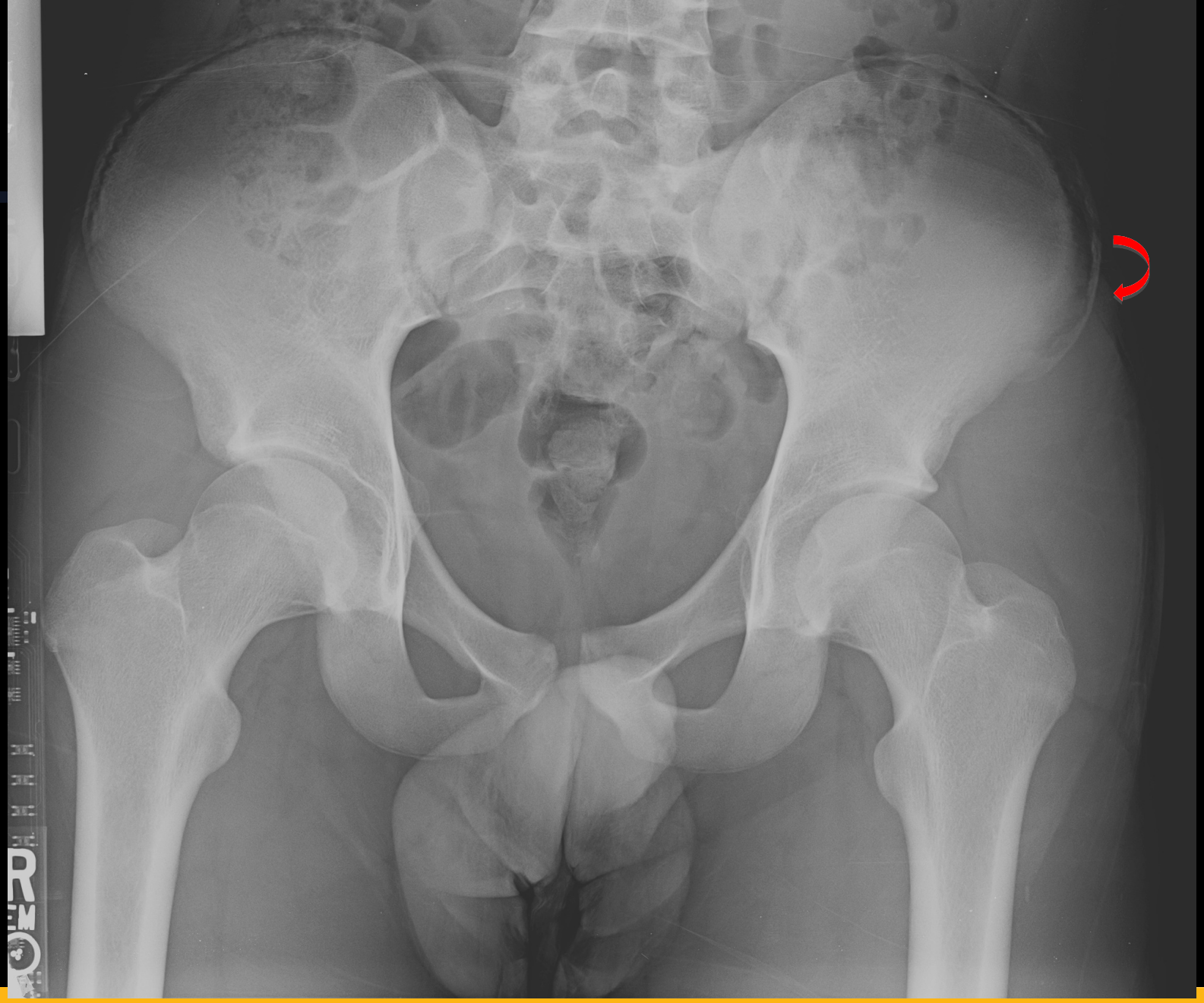
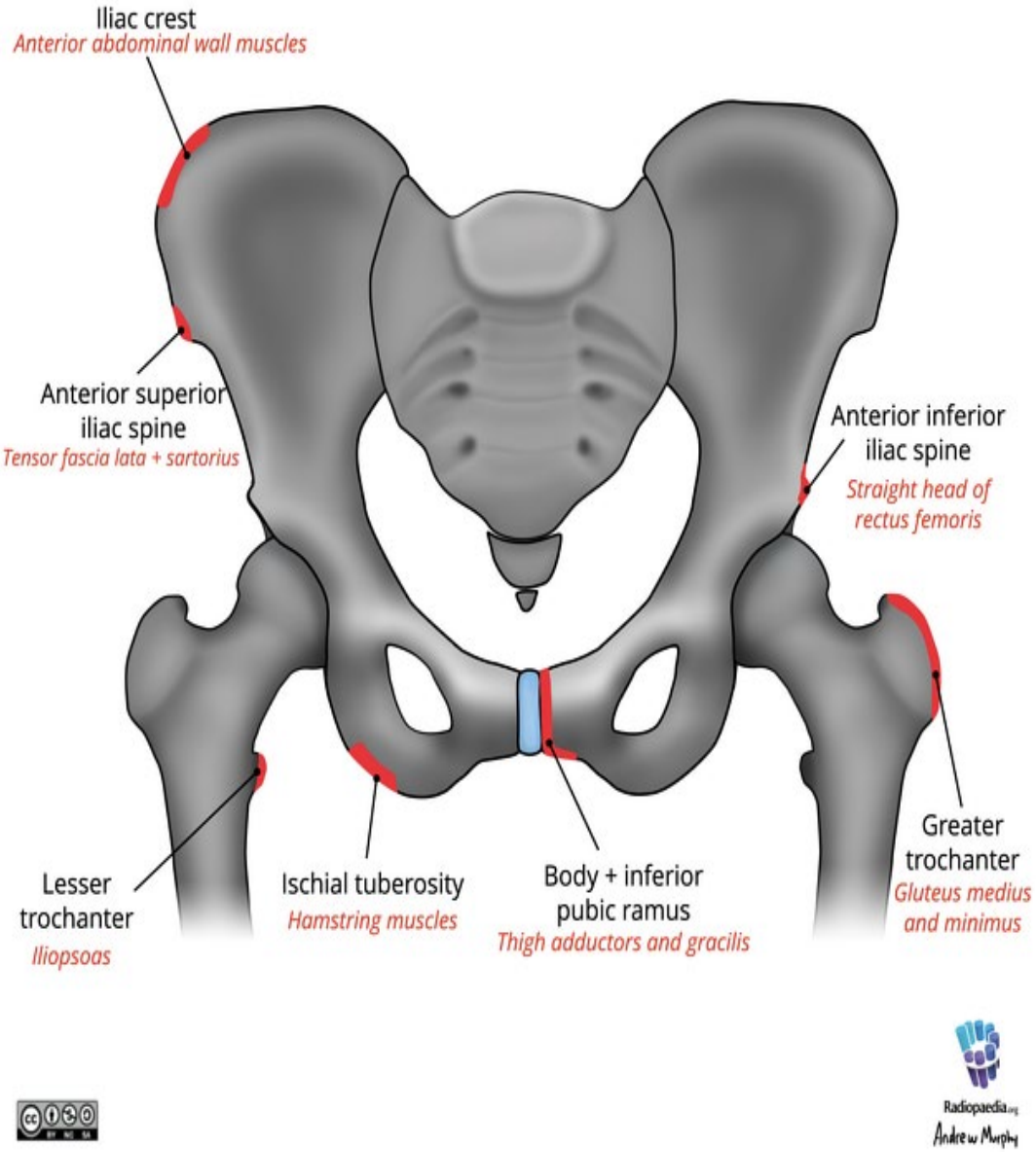


Volar Plate Avulsion: More Than a "Jammed Finger"

- **Mechanism of Injury:** Forceful **hyperextension** (often from a ball-handling sport) causes the thick fibrocartilaginous volar plate to pull a small bone fragment from the **volar base of the middle phalanx**.
- **The Diagnostic Trap:** Frontal (AP) X-rays are often normal; a **true lateral view** is mandatory to visualize the small, minimally displaced "fleck" of bone at the joint space.
- **Stability Assessment:**
  - **Stable:** Small fragment (<30-40% of the articular surface) with no dorsal subluxation of the middle phalanx.
  - **Unstable:** Large fragment (>40% of articular surface) or persistent dorsal displacement; these often require surgical fixation.
- **Conservative Management:** Stable injuries are treated with **buddy taping** or a dorsal blocking splint for 2–3 weeks, followed by early mobilization to prevent permanent stiffness.
- **Chronic Complication:** Untreated or mismanaged unstable fractures can lead to a **Swan-Neck Deformity** due to loss of the volar restraint.

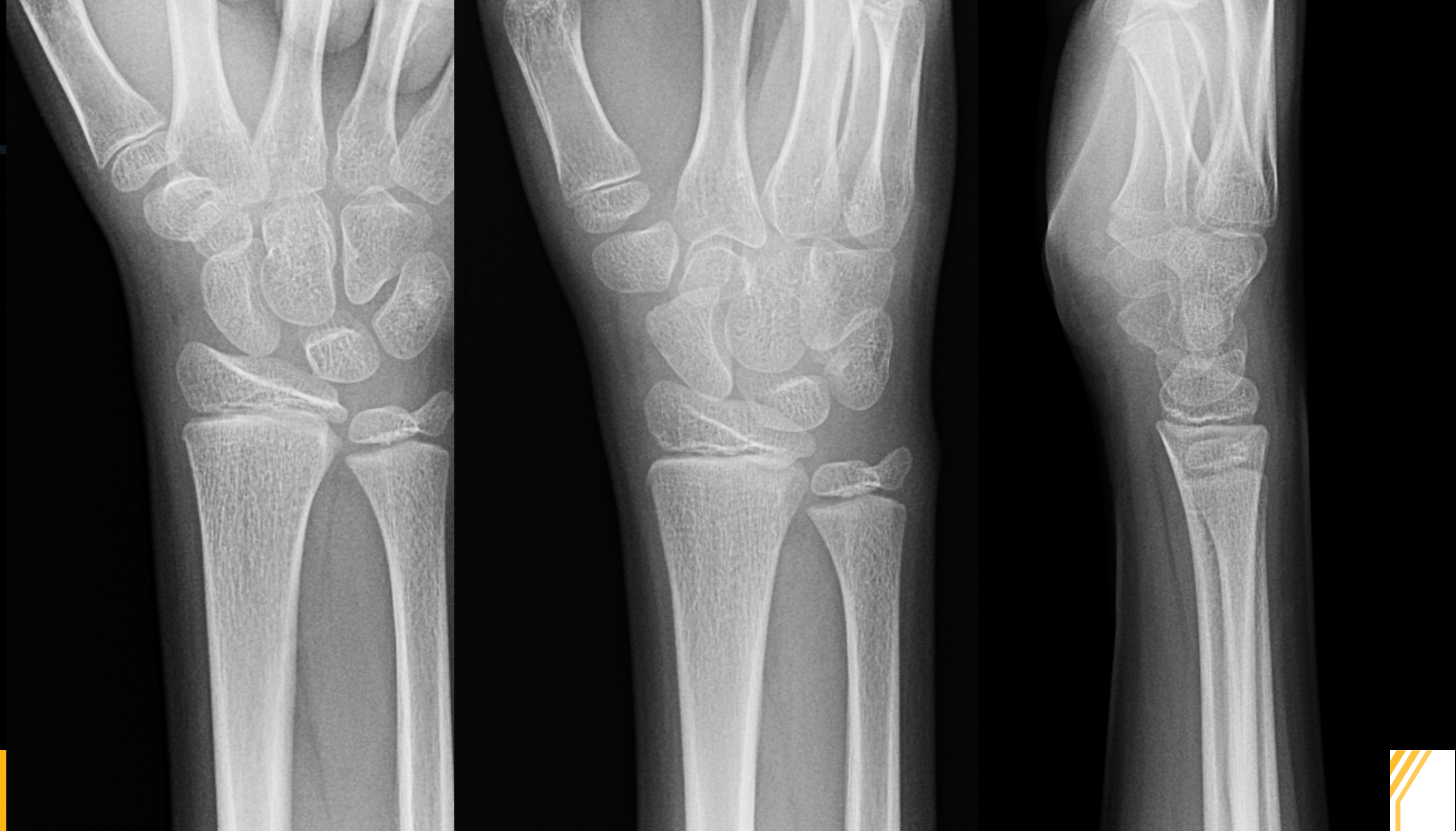


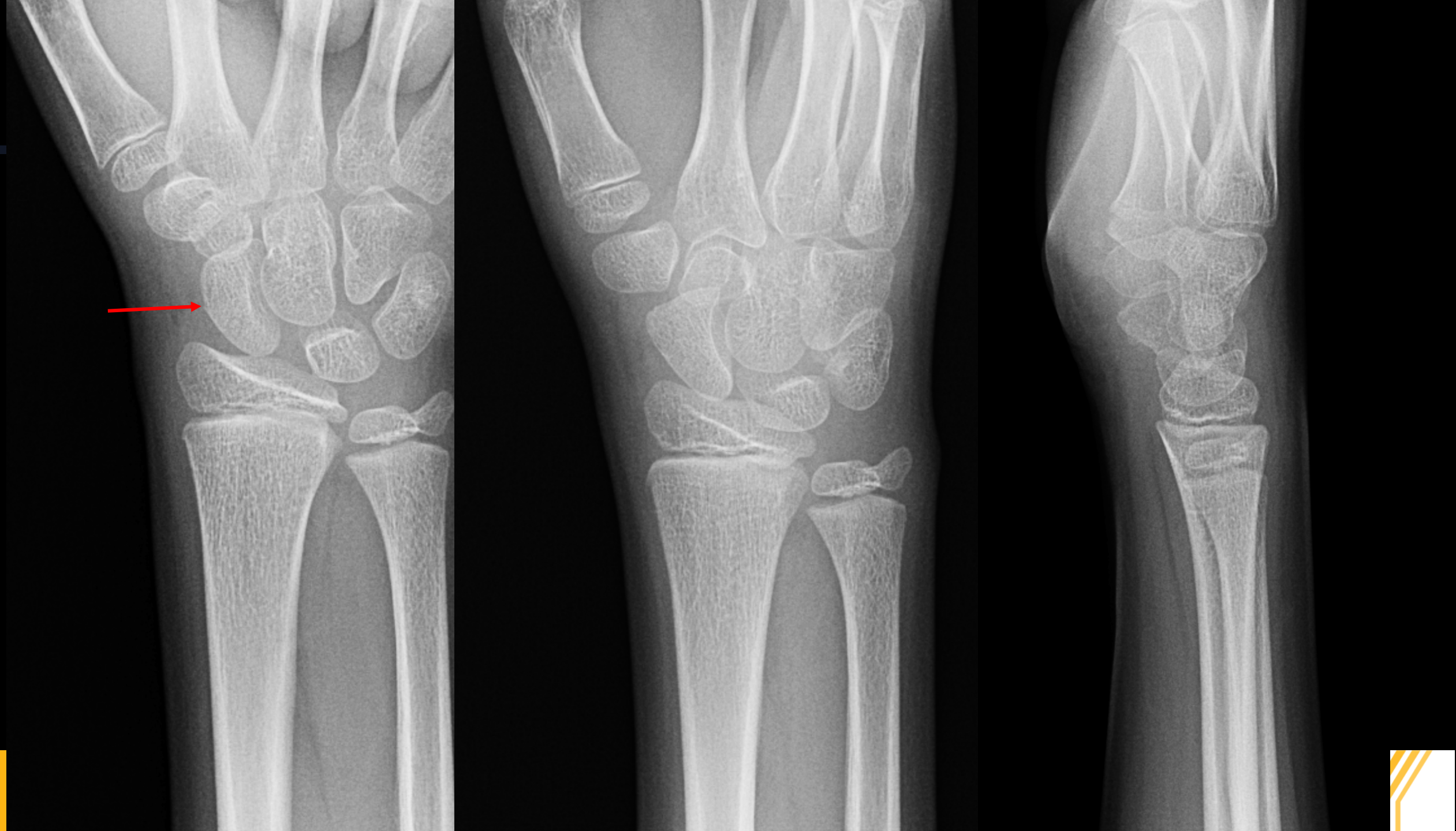




Key Aspects of Pelvic Avulsion Fractures

- **Epidemiology:** Primarily affect males (76% of cases) aged 10–18, usually during sports.
- **Mechanism:** Forced muscular contraction against a fixed or suddenly accelerating pelvis, common in soccer, running, and gymnastics.
- **Common Locations:**
  - **AIIS (49%):** Rectus femoris attachment (kicking).
  - **ASIS (30%):** Sartorius attachment (sprinting).
  - **Ischial Tuberosity (11%):** Hamstring attachment.
  - **Iliac Crest (10%):** Abdominal muscle attachment.
  - **Lesser Trochanter:** Iliopsoas attachment.
- **Diagnosis:**
  - **Symptoms:** Sudden pain, "cracking" sensation, local tenderness, and gait impairment.
  - **Imaging:** Plain radiographs are usually sufficient.
- **Treatment:**
  - **Conservative (Standard):** Rest, crutches, ice, and gradual rehabilitation.
  - **Surgical:** Indicated if the fragment is displaced by more than 2 cm





Scaphoid fracture

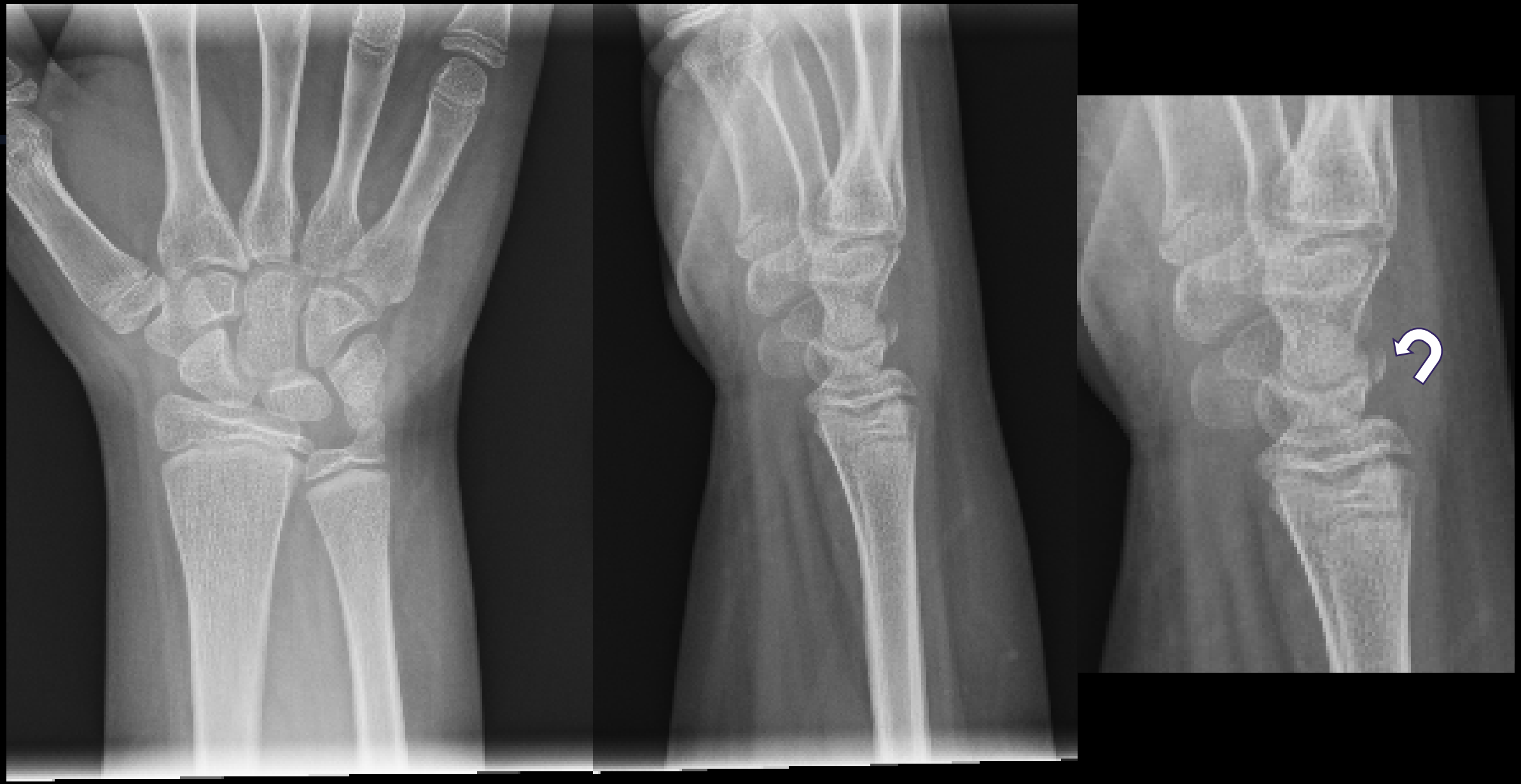
- Suspect scaphoid fx if snuff box tenderness on exam.

- Proximal (25%)
- Waist (65%)
- Distal pole (10%)

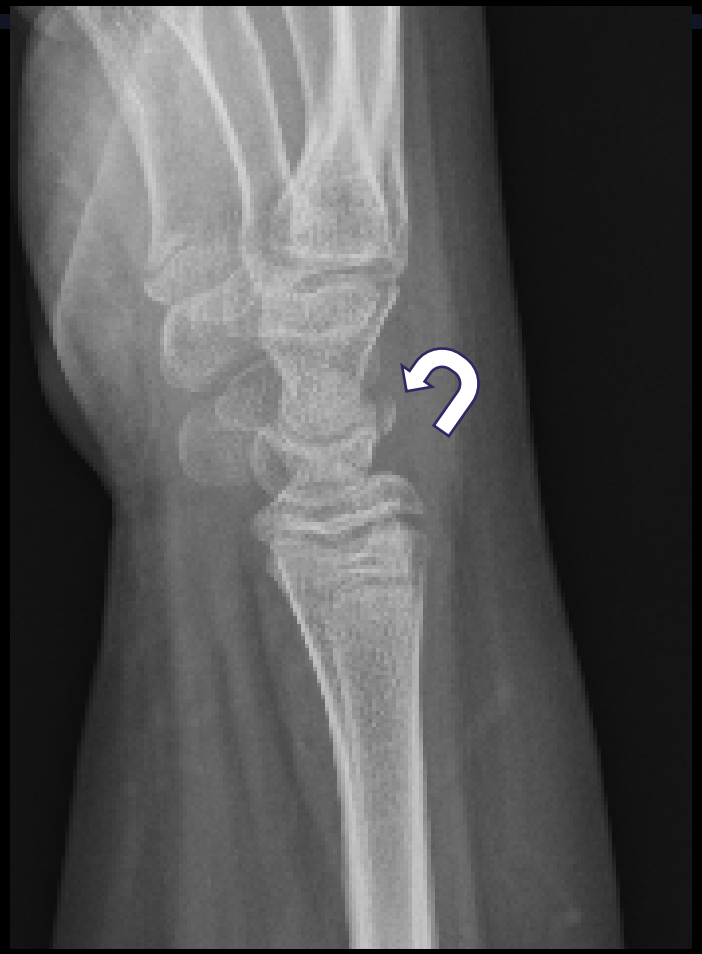
- Because of the blood supply (distal to proximal), risk of proximal pole AVN.

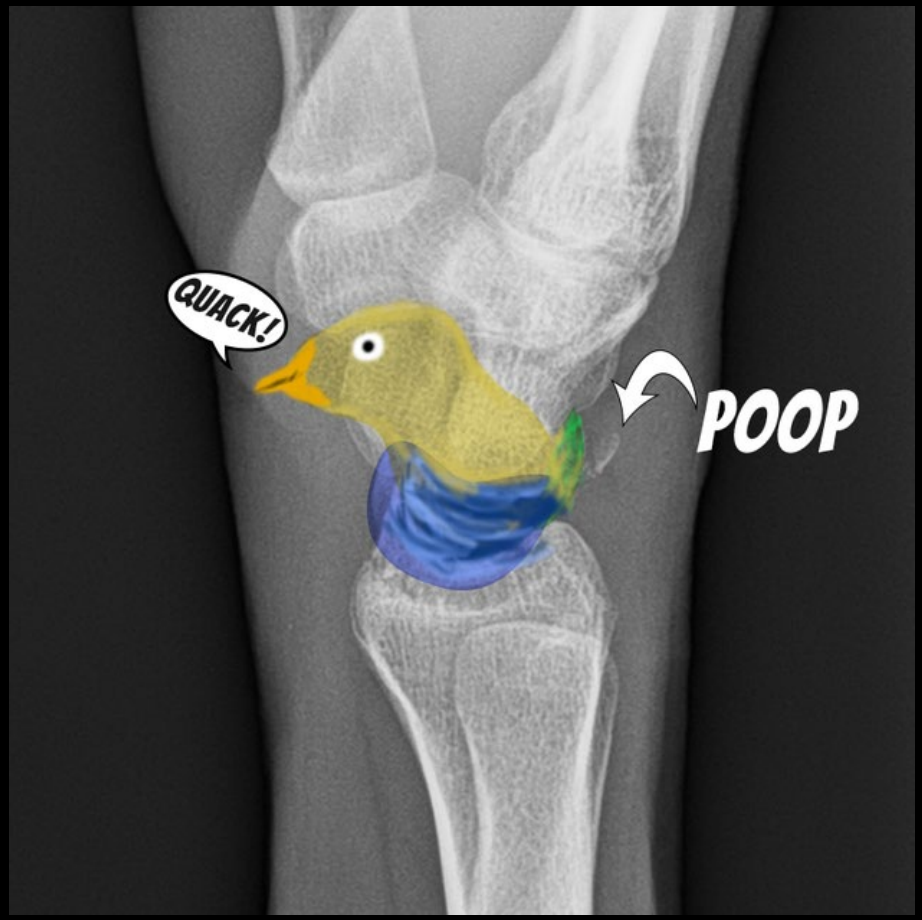
- The "Occult" Challenge: Up to 20–25% of fractures are invisible on initial X-rays; clinical suspicion warrants empiric immobilization and repeat imaging in 10–14 days.

- Tx: Thumb Spica



Triquetrum Fx.





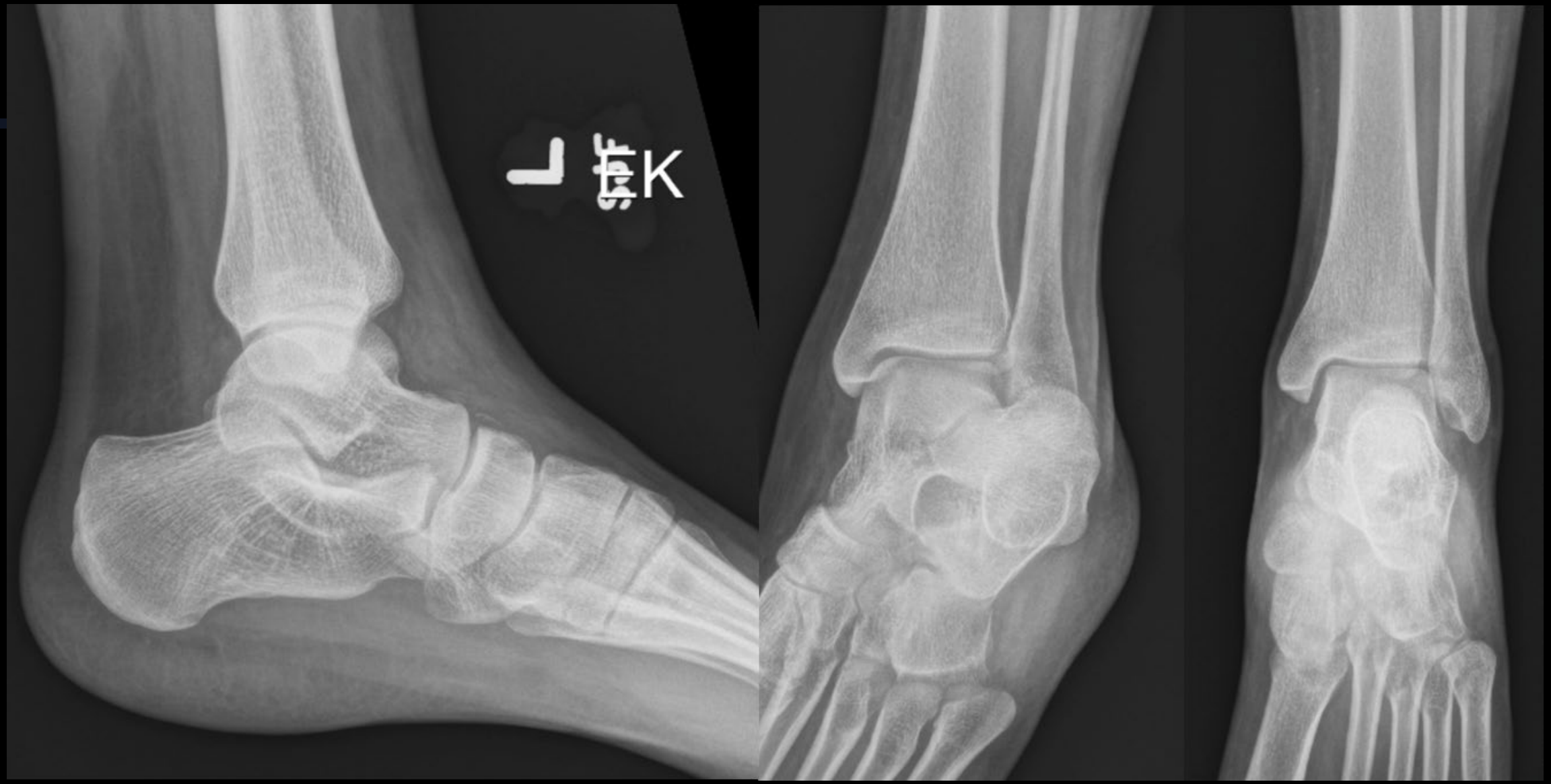
https://radiopaedia.org/cases/triquetral-fracture-pooping-duck-sign

Tips:

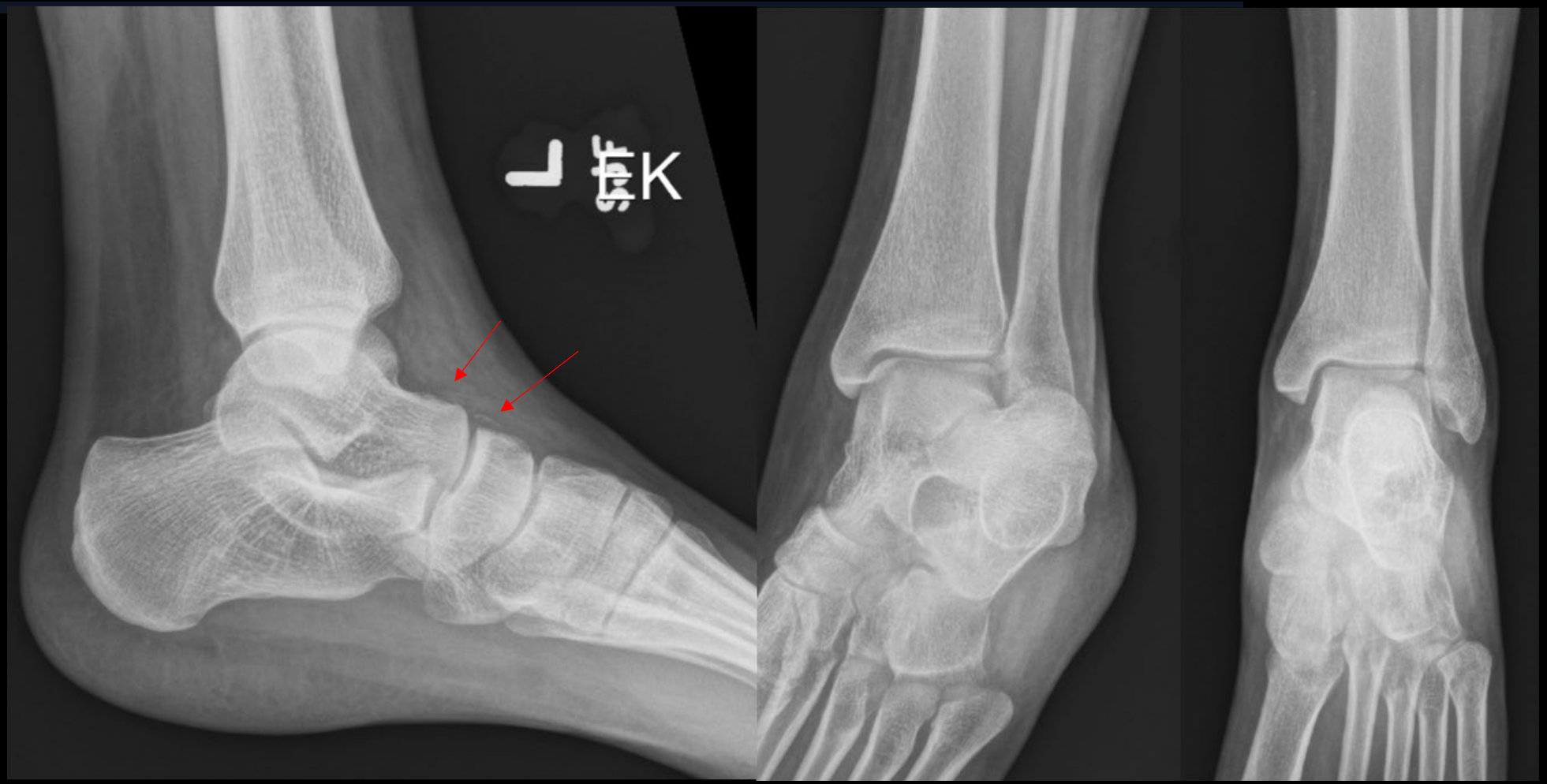
- Dorsal aspect of proximal carpal row.
- Ulnar sided pain and dorsal soft tissue swelling.
- 2nd most common carpal bone fracture after scaphoid.
- Ossific fleck on lateral view.
- Tx: Volar splint

Triquetral Fracture: The "Pooping Duck" Sign

- **Epidemiology:** The **second most common** carpal fracture (15–20% of cases). Often misdiagnosed as a simple wrist sprain due to subtle findings.
- **The "Pooping Duck" Hallmark:** On a **lateral X-ray**, the avulsed dorsal flake of bone sits just posterior to the triquetrum, resembling a "poop" behind a duck (the duck being the scaphoid/lunate/triquetrum complex).
- **Mechanism of Injury:** Typically a fall on an outstretched hand (FOOSH).
  - **Impaction:** The ulnar styloid acts as a "chisel" hitting the triquetrum during hyperextension and ulnar deviation.
  - **Avulsion:** Forceful wrist flexion pulls a flake of bone away via the dorsal radiotriquetral ligament.
- **Diagnostic Tip:** If AP and lateral views are negative, an **oblique view** (45° pronation) is often the most sensitive for unmasking the fracture line.
- **Management:** Highly favorable prognosis. Most are **stable chip fractures** treated with a short-arm splint or cast for 3–6 weeks.
- **Associated Injury:** Always screen for **Triangular Fibrocartilage Complex (TFCC)** tears or perilunate dislocations if the fracture involves the triquetral *body* rather than just the cortex.



Avulsion fx, dorsal talus and dorsal navicular

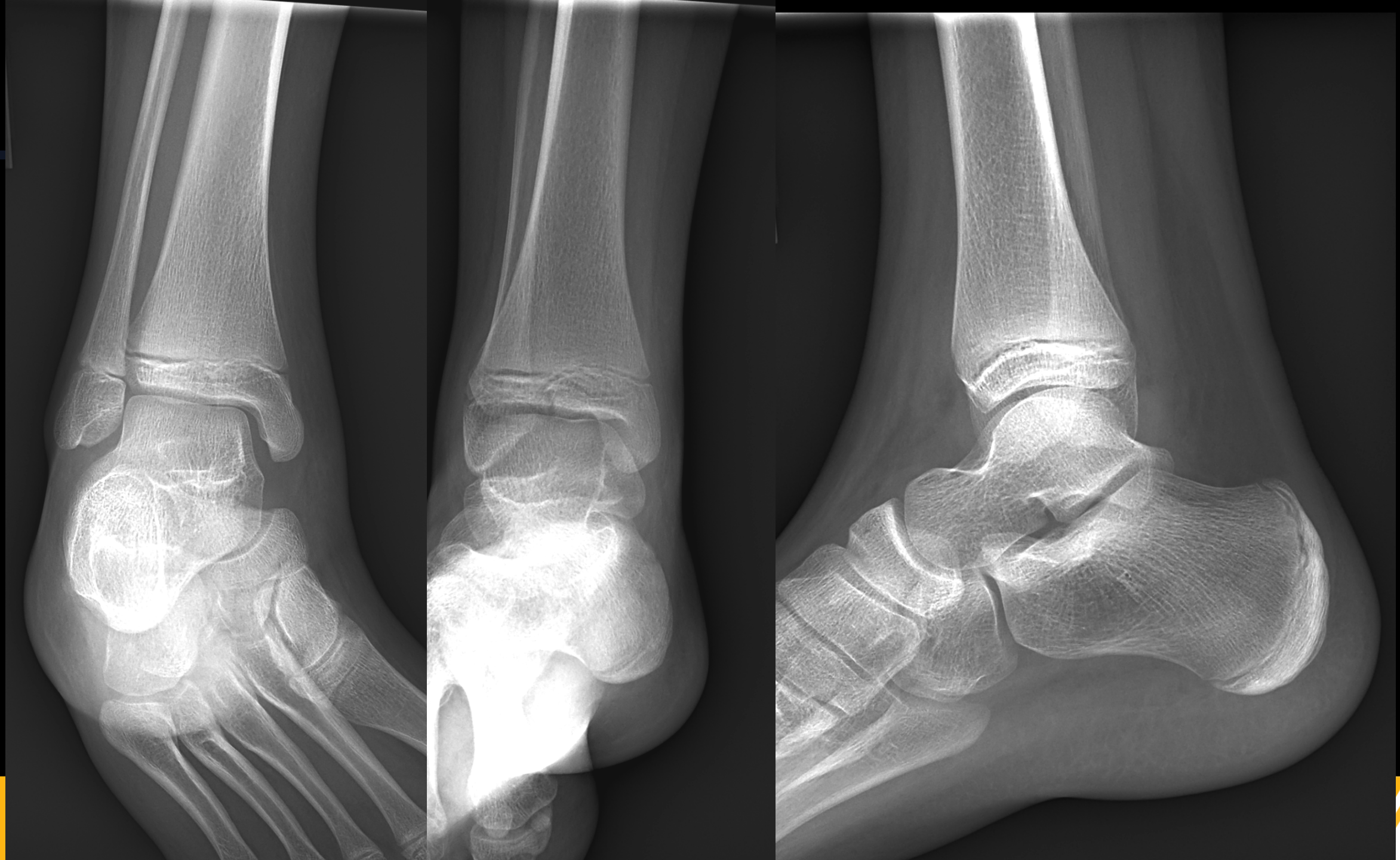


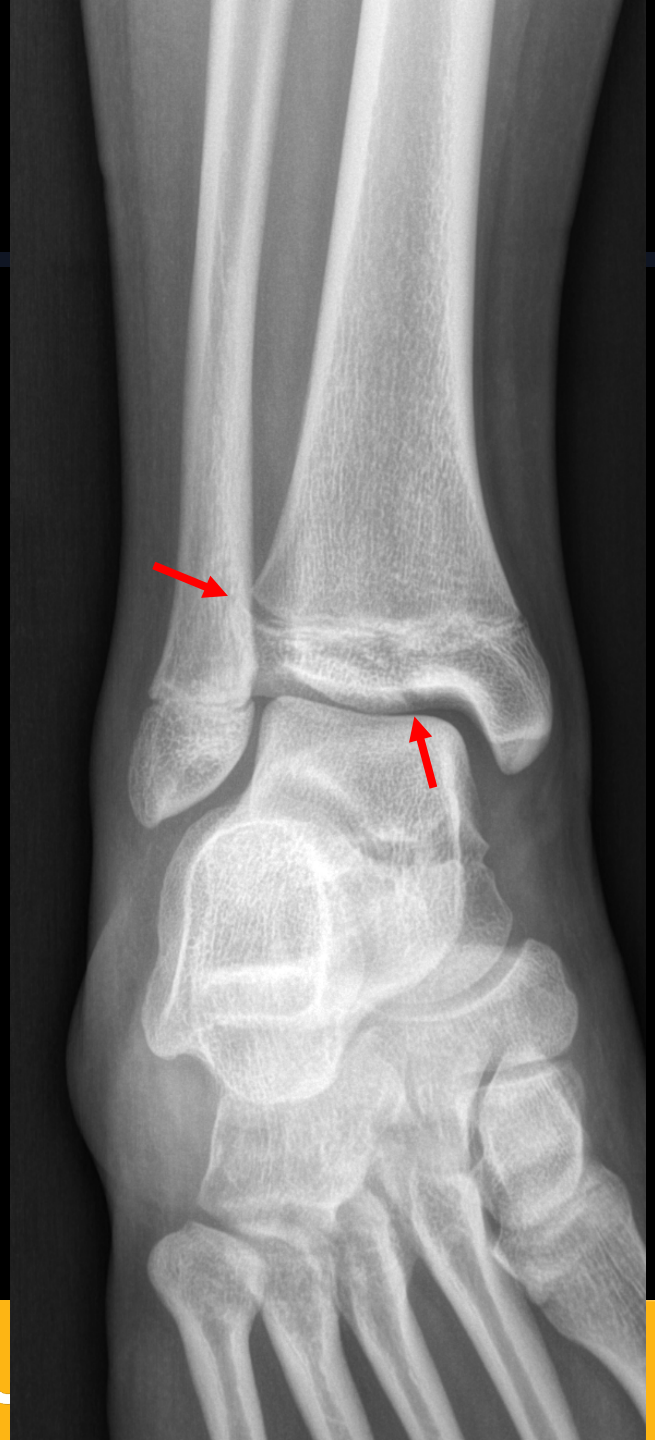
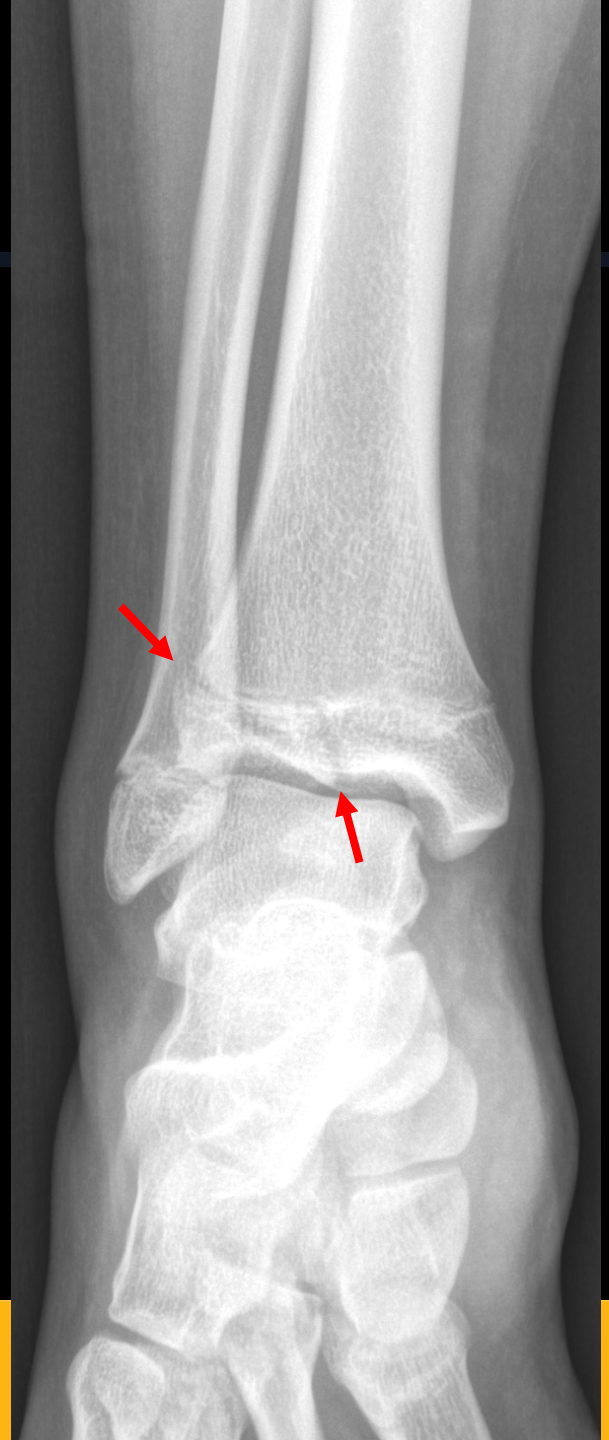
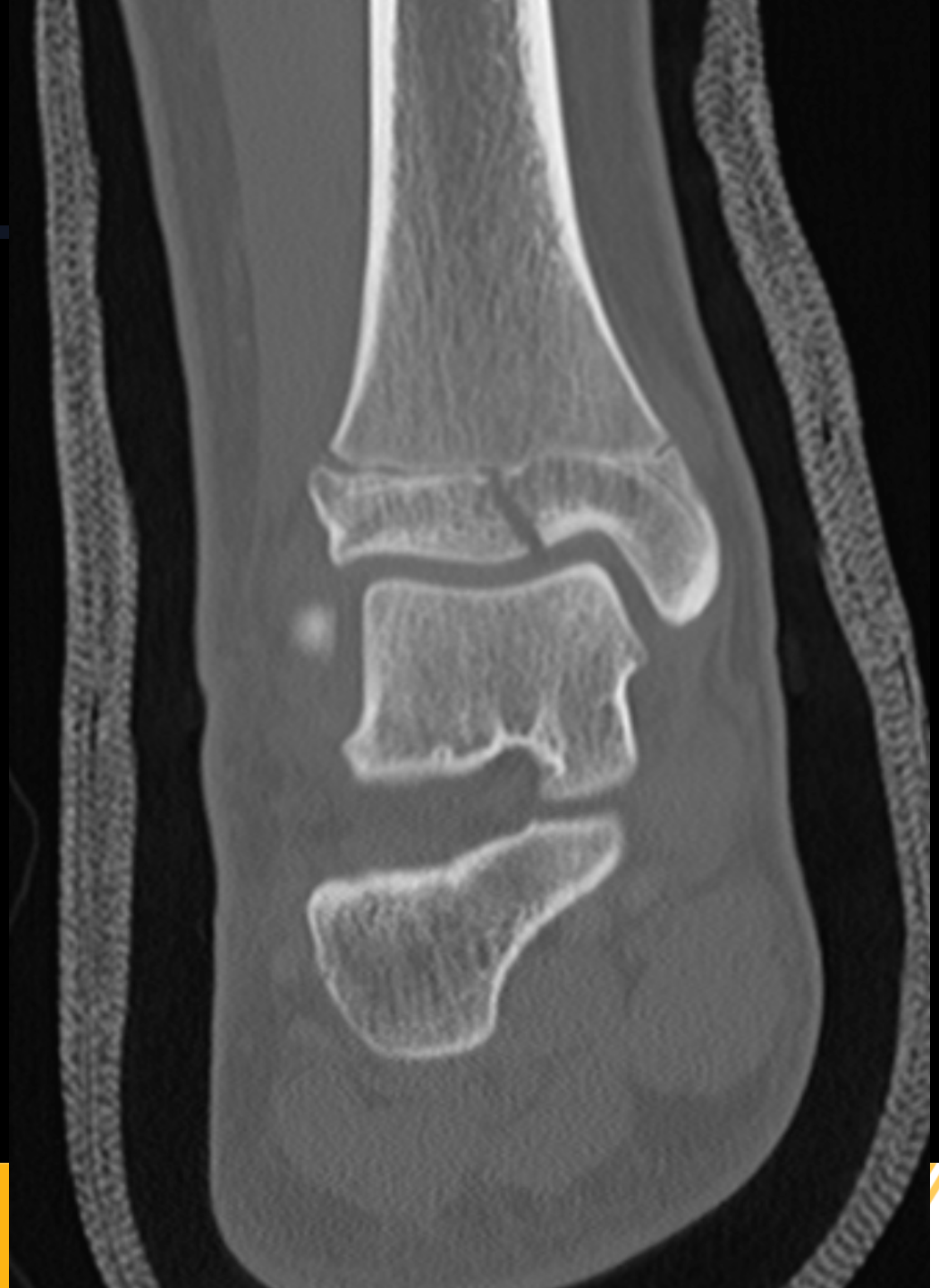
Tips:

- **Only seen on the lateral view**
- **Often subtle and overlooked.**
- **Small linear bone fragments.**

Dorsal Navicular Avulsion

- **Most Common Navicular Fracture:** Often results from a **twisting injury** or extreme plantarflexion causing traction from the dorsal talonavicular capsule.
- **Radiographic Hallmark:** Visualized as a small, irregular bone "flake" or fragment at the **proximal dorsal margin** of the navicular on the lateral foot X-ray.
- **The "N-Spot" Tenderness:** Pathognomonic clinical finding of point tenderness at the proximal dorsal portion of the navicular, lateral to the tibialis anterior tendon.
- **The Great Mimic:** Must be differentiated from the **Os Supranaviculare**, a common accessory ossicle that is smoothly corticated and lacks adjacent soft tissue swelling.
- **Management:**
  - **Conservative:** Usually treated similarly to a sprain with a walking boot and progressive weight-bearing for **6 weeks**.
  - **Operative:** Required if the fragment involves **>20–25% of the articular surface** or causes significant instability.



Tillaux Fracture: Adolescent Transitional Injury

- **Definition:** Salter-Harris Type III fracture affects the anterolateral distal tibial epiphysis.
- **Occurs:** In adolescents (12–14 years) during physis closure, with the lateral side being vulnerable.
- **Cause:** Forceful external foot rotation causes the AITFL to pull off a bone fragment.
- **Imaging:** Seen on AP and Mortise X-rays; CT is used if needed.
  - **Treatment:**<2 mm displacement: cast immobilization.
  - 2 mm displacement: requires reduction and internal fixation.

Conclusion

- Pediatric fractures can be very subtle
  - Good XR technique is paramount (well positioned later view)
  - Use tools like magnification, and supplemental views when needed
  - When in doubt, immobilize and get a follow-up in 7-10 days
- Apply the Salter Harris classification system for physeal fractures
- Consider developmental variants versus fractures in the Ddx when assessing pediatric injuries

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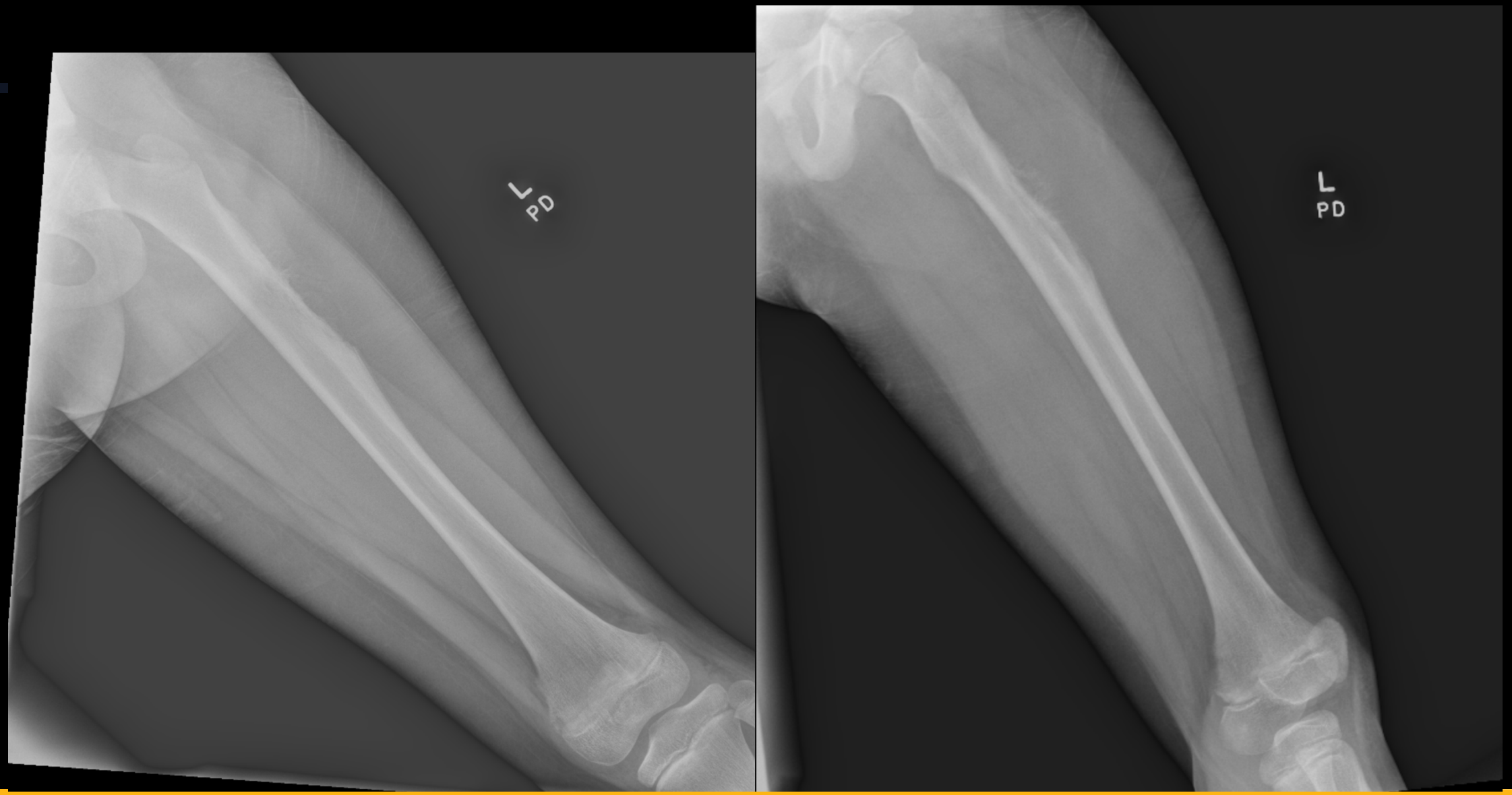
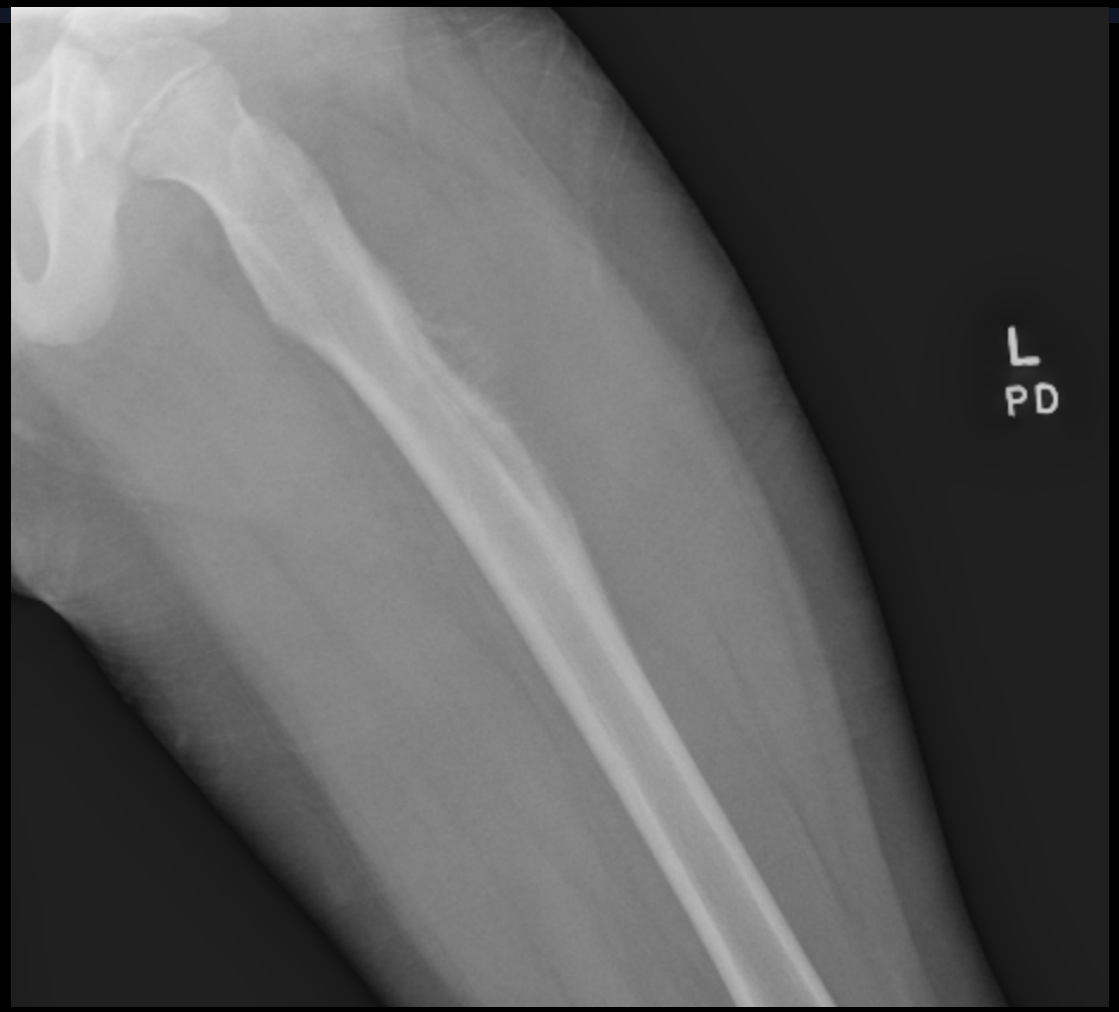
Extras

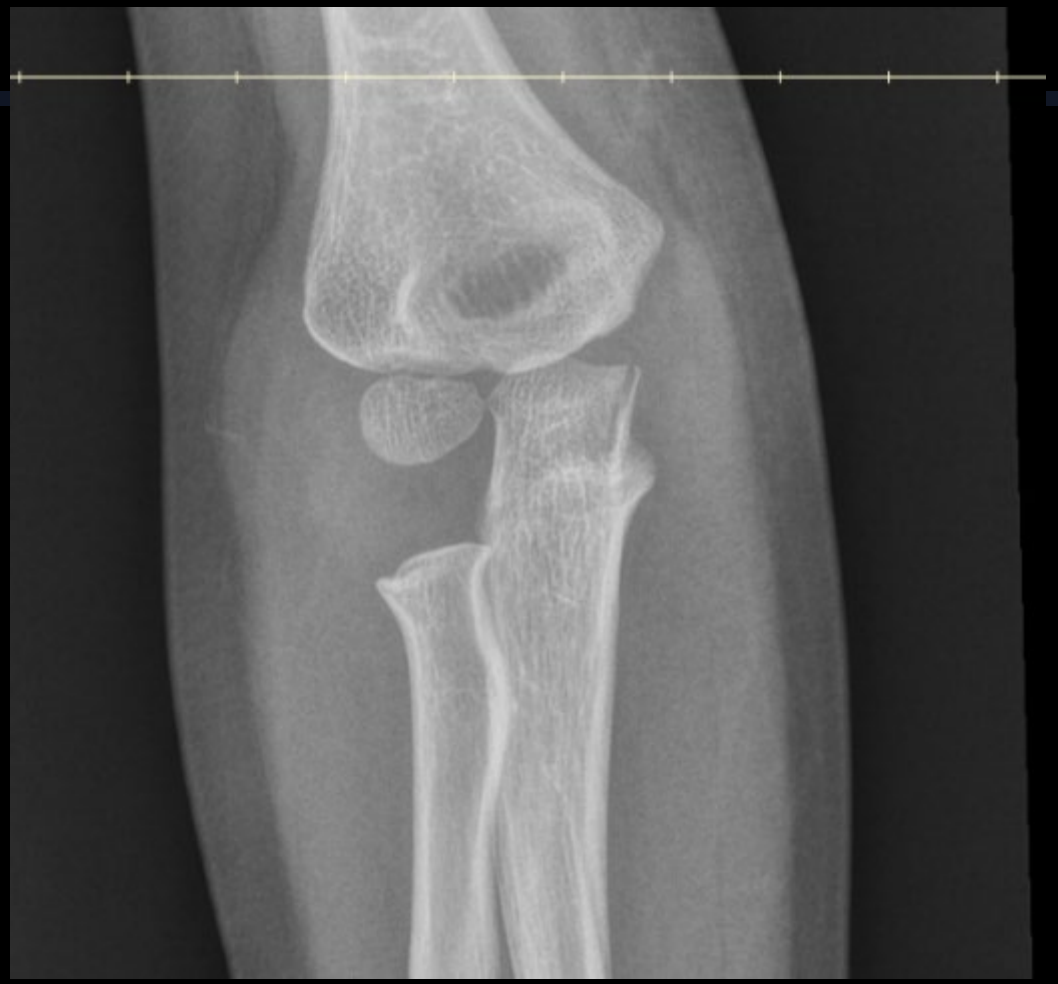
8 year old with pain and tenderness

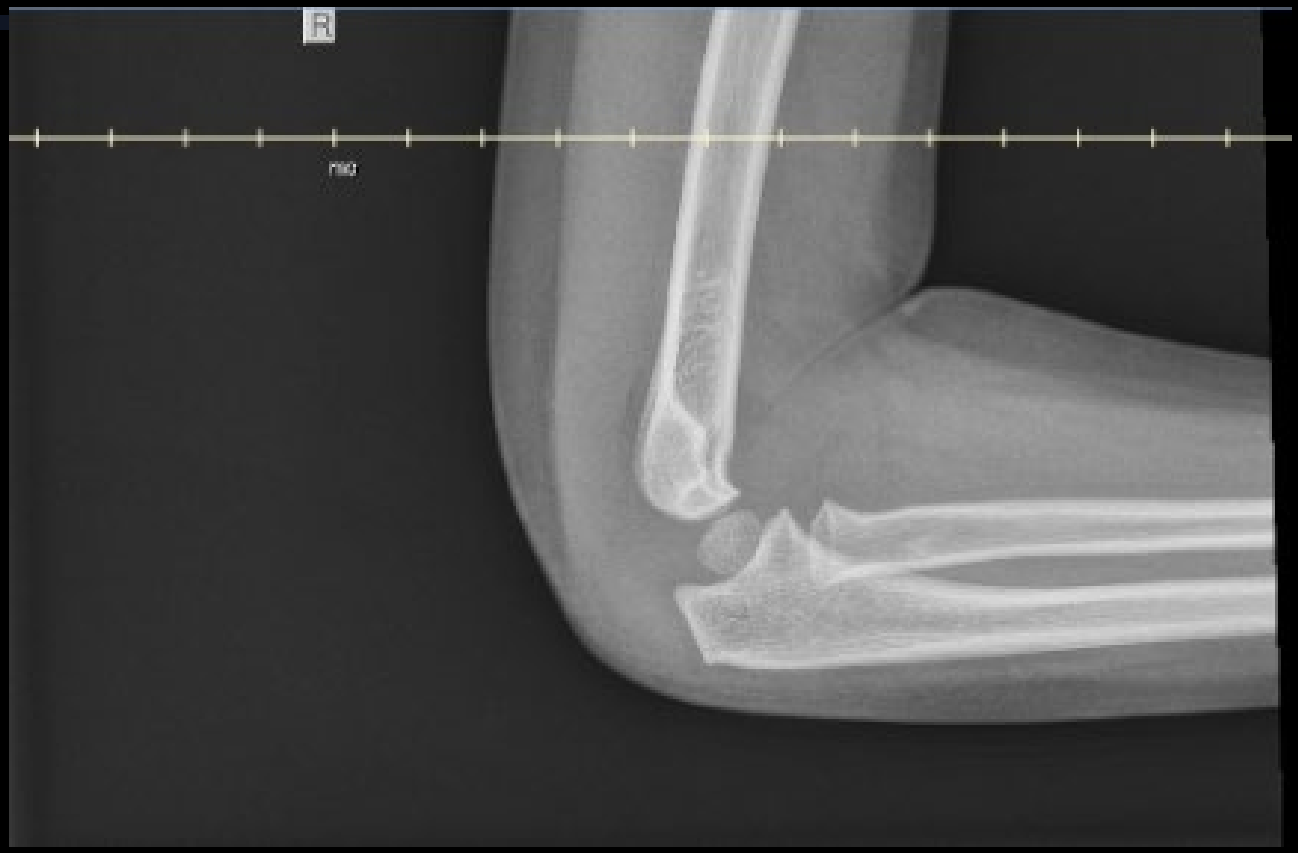


Sunburst Periosteal Reaction



- Aggressive fast-growing malignancy
  - Ewings sarcoma
  - Osteosarcoma

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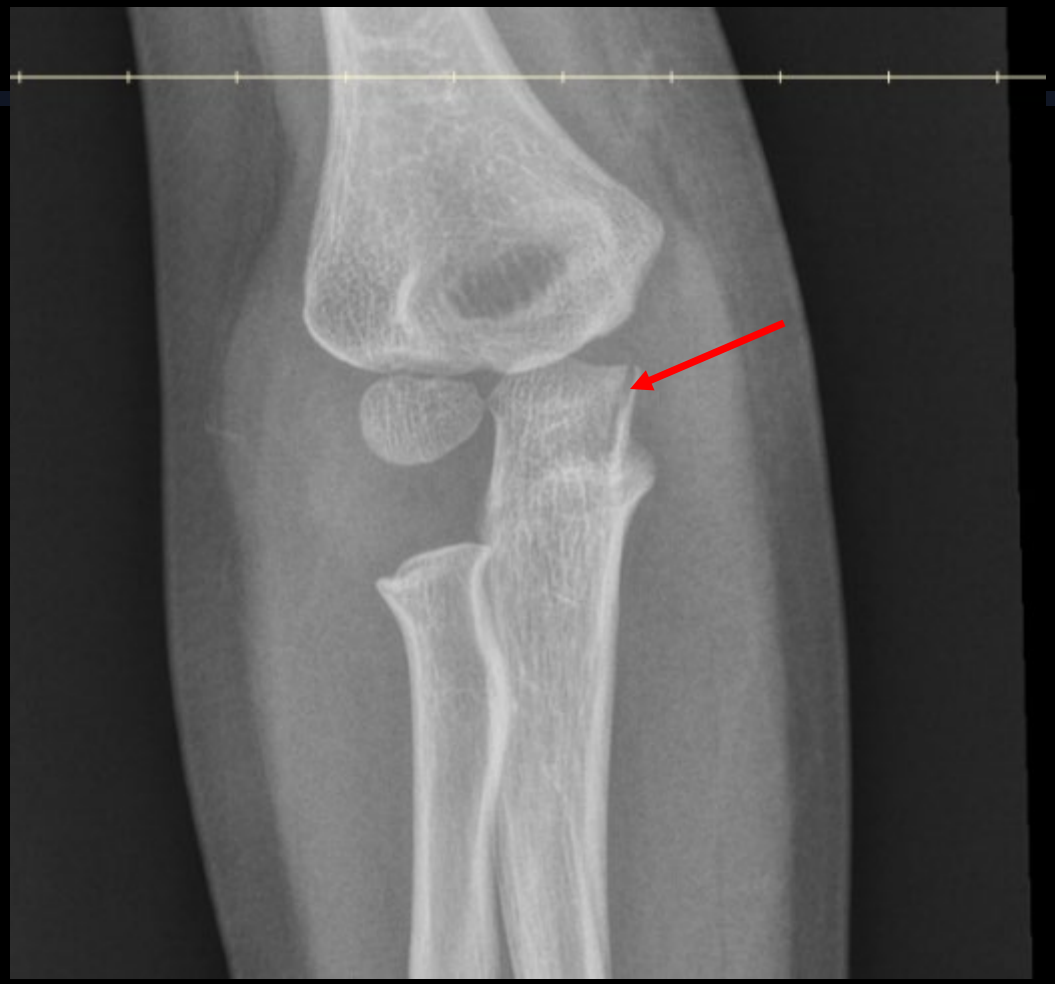
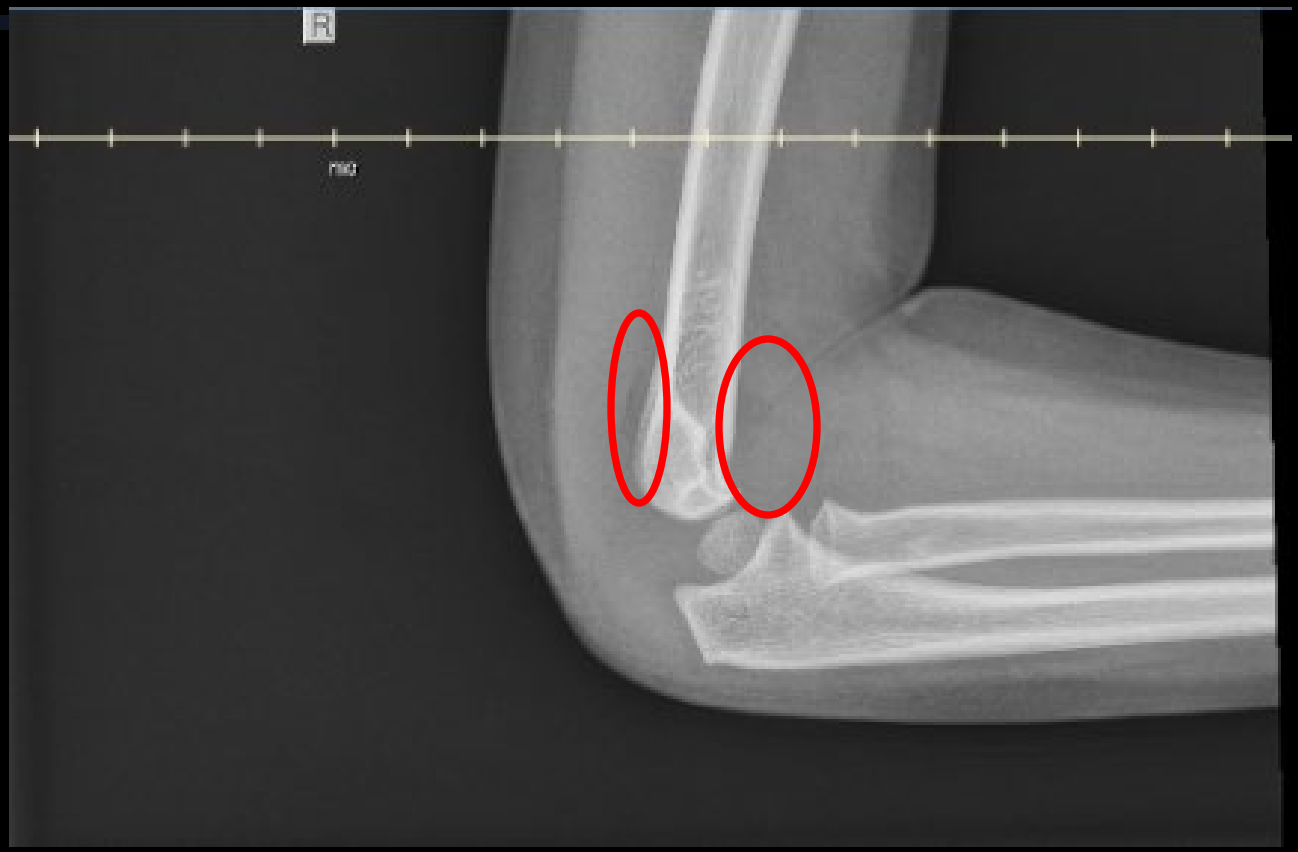
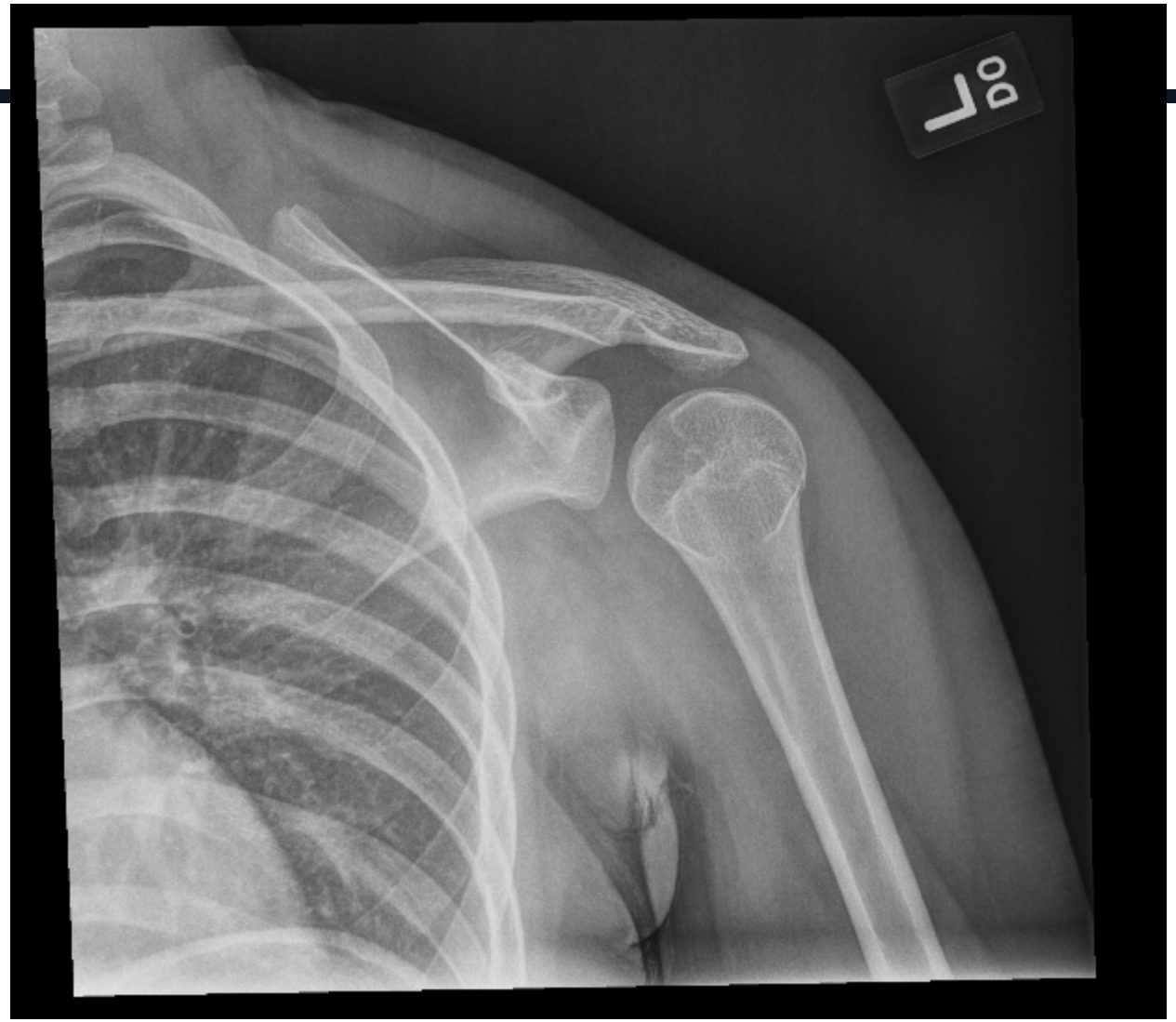
Nondisplaced olecranon fracture

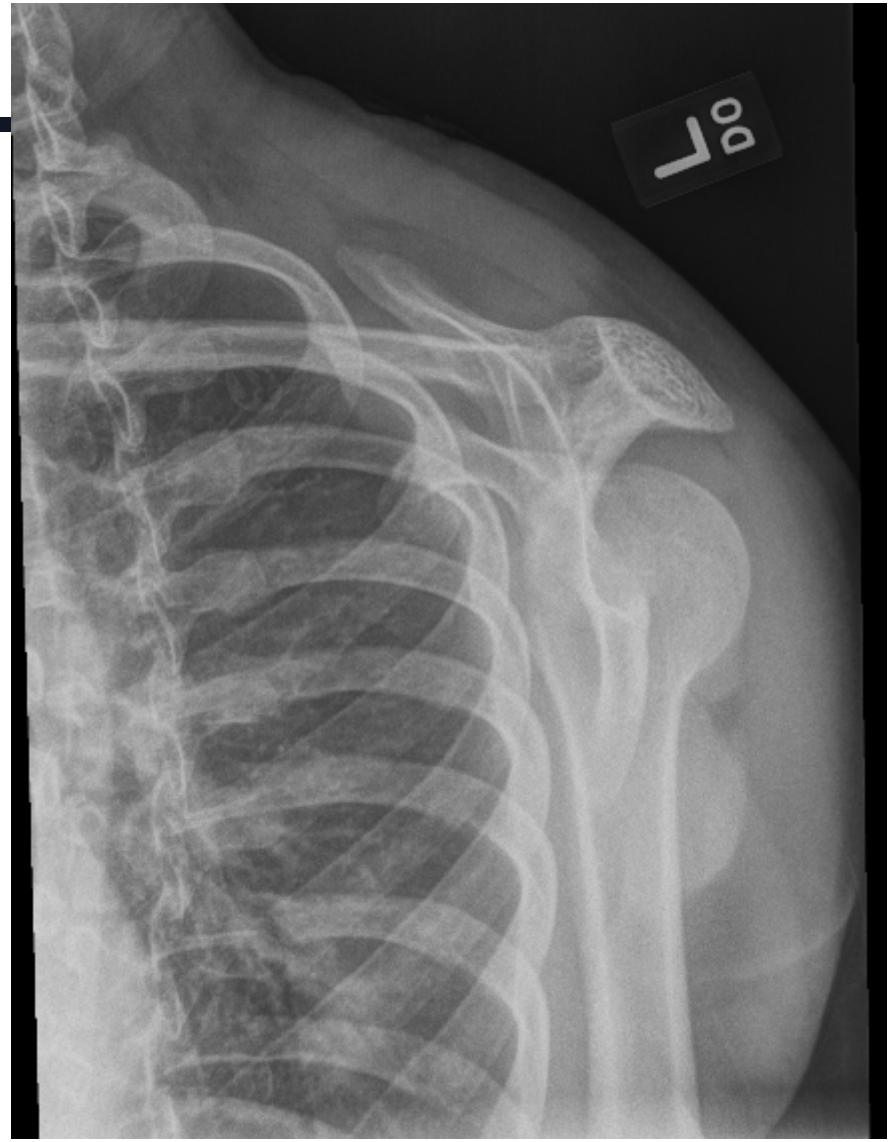




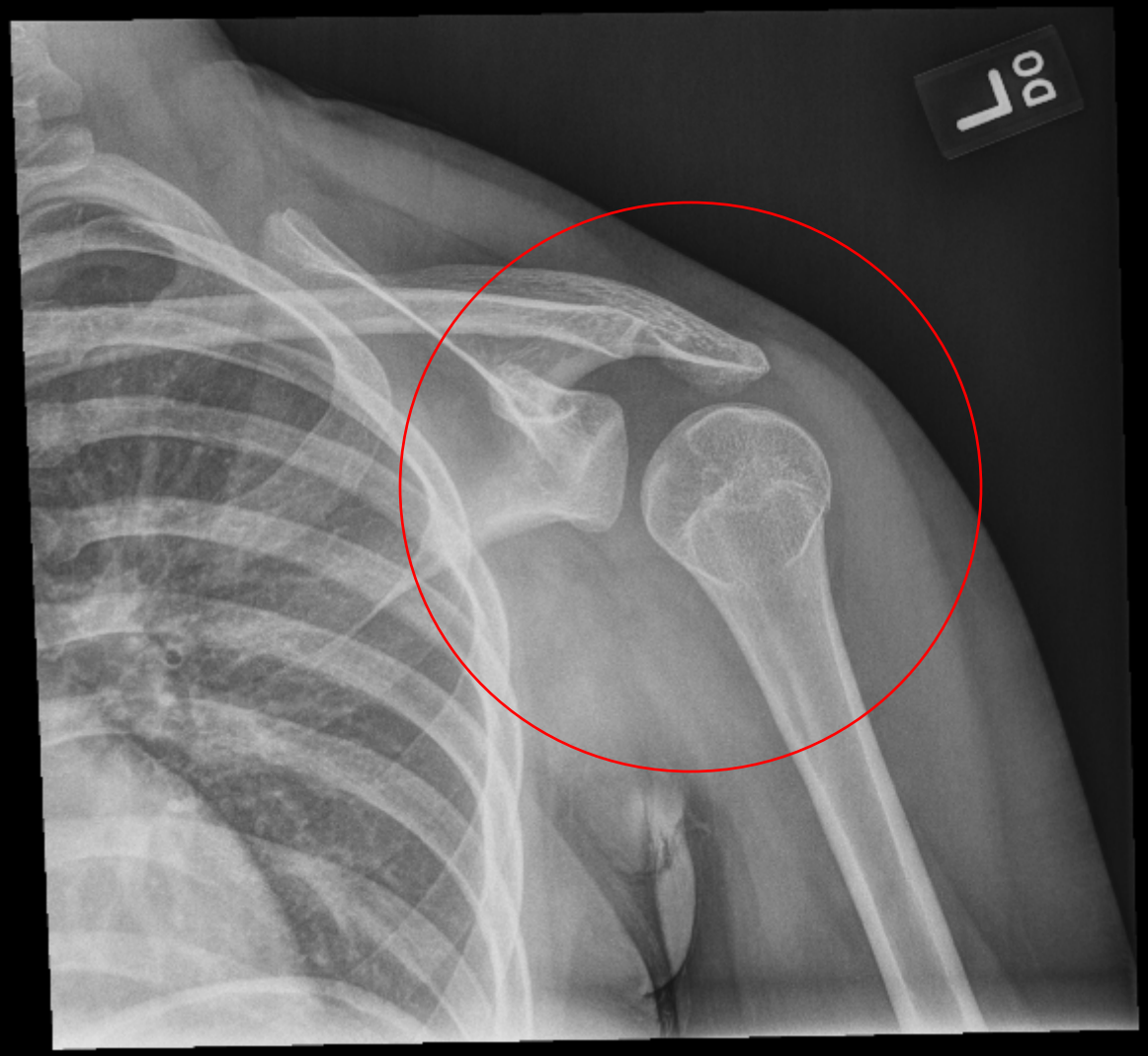
Tips

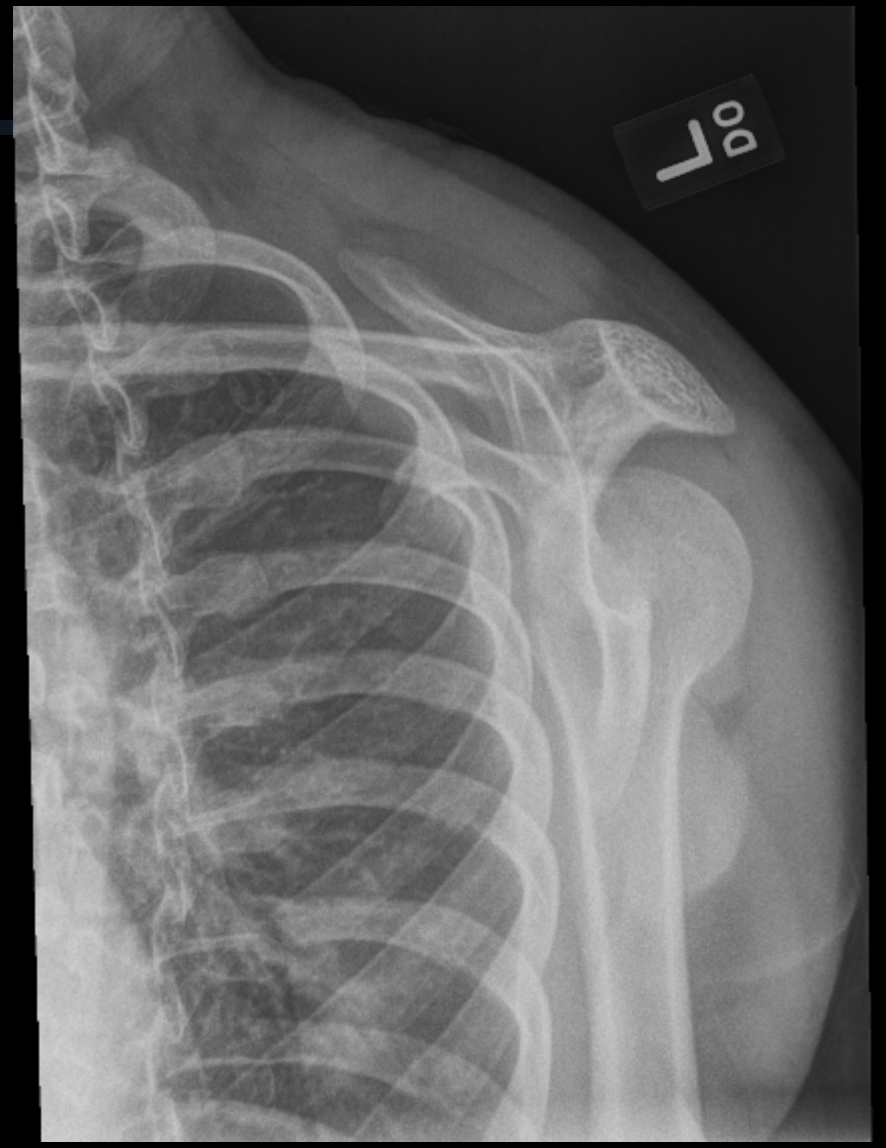
- ***For Interpretation:***
- Check ulnohumeral alignment.
- Look for associated elbow dislocation or subluxation.
- Look for transverse fracture line through the olecranon and cortical disruption.
- Fat pad signs:
  - Posterior fat pad= fracture until proven otherwise.
  - Elevated anterior fat pad (sail sign)= concerning.
- ***For Treatment:***
  - *Posterior elbow splint, f/u ortho*





Posterior shoulder dislocation

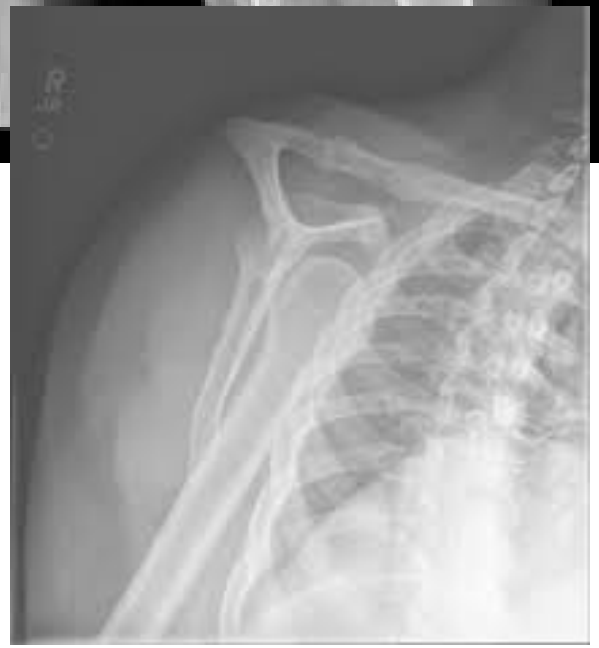


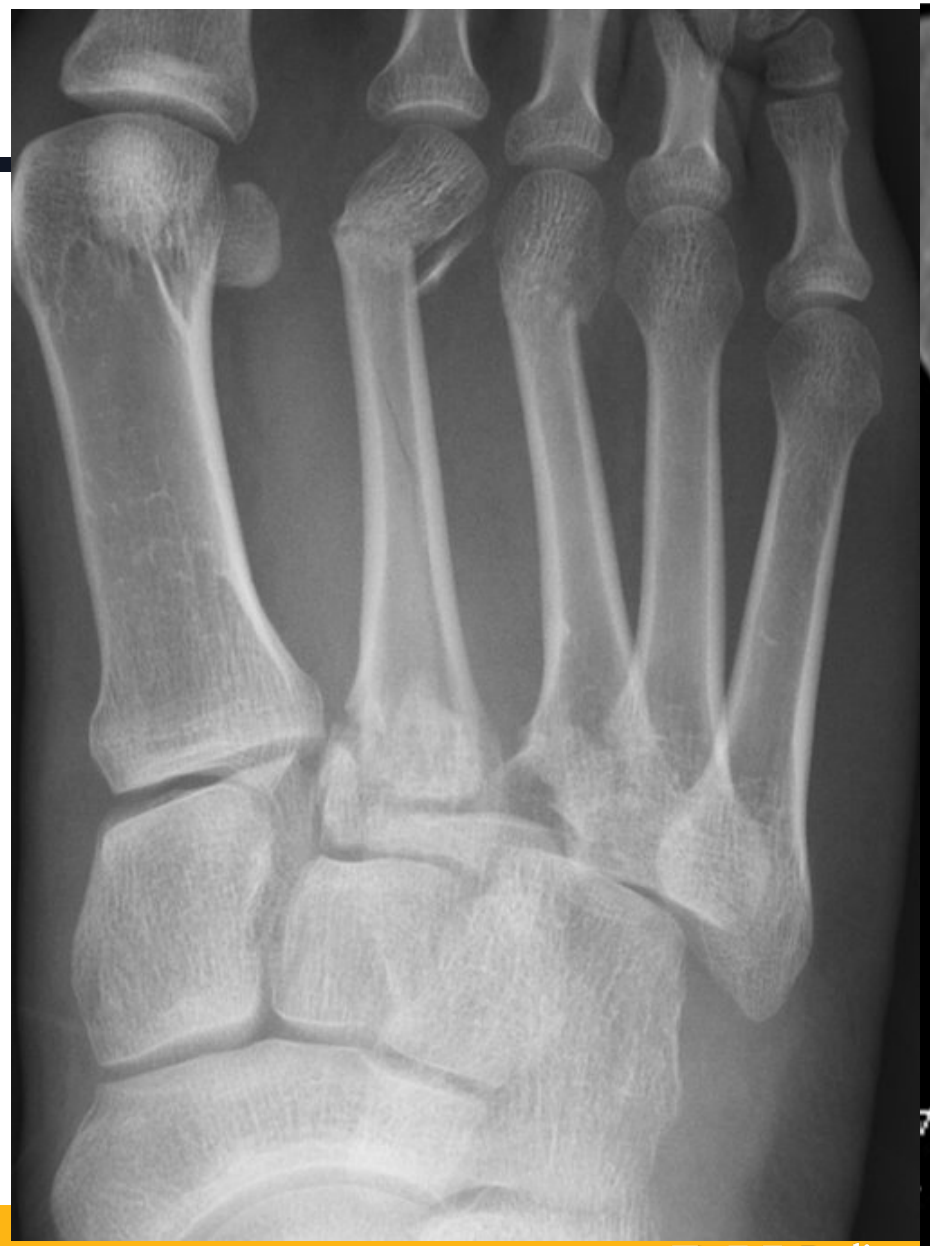


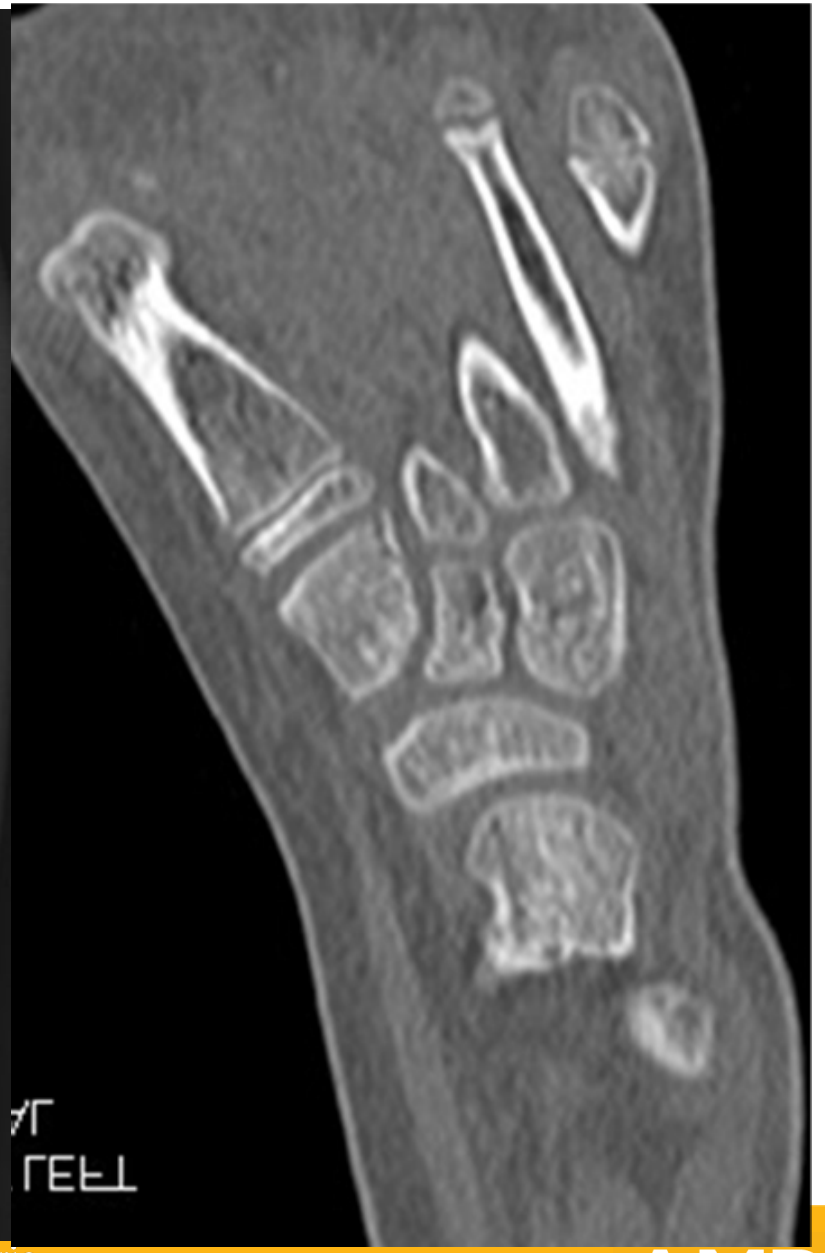
Posterior shoulder dislocation

- ***<u>For Interpretation:</u>***
- Posterior shoulder dislocations are rare, most are anterior.
- Light bulb sign signals posterior dislocation- rounded shape of humeral head and widening of glenohumeral joint space.
- Scapular Y view is important in determining posterior vs anterior displacement.
- Assess for associated fractures.
- ***<u>For Treatment:</u>***
  - *Transfer to ED (unable to reduce in office, only anterior is reducible in our setting)*
  - *Takes large amount of force to dislocate posteriorly (usually seizure, MVC, fall)*

Posterior Vs. Anterior Dislocation

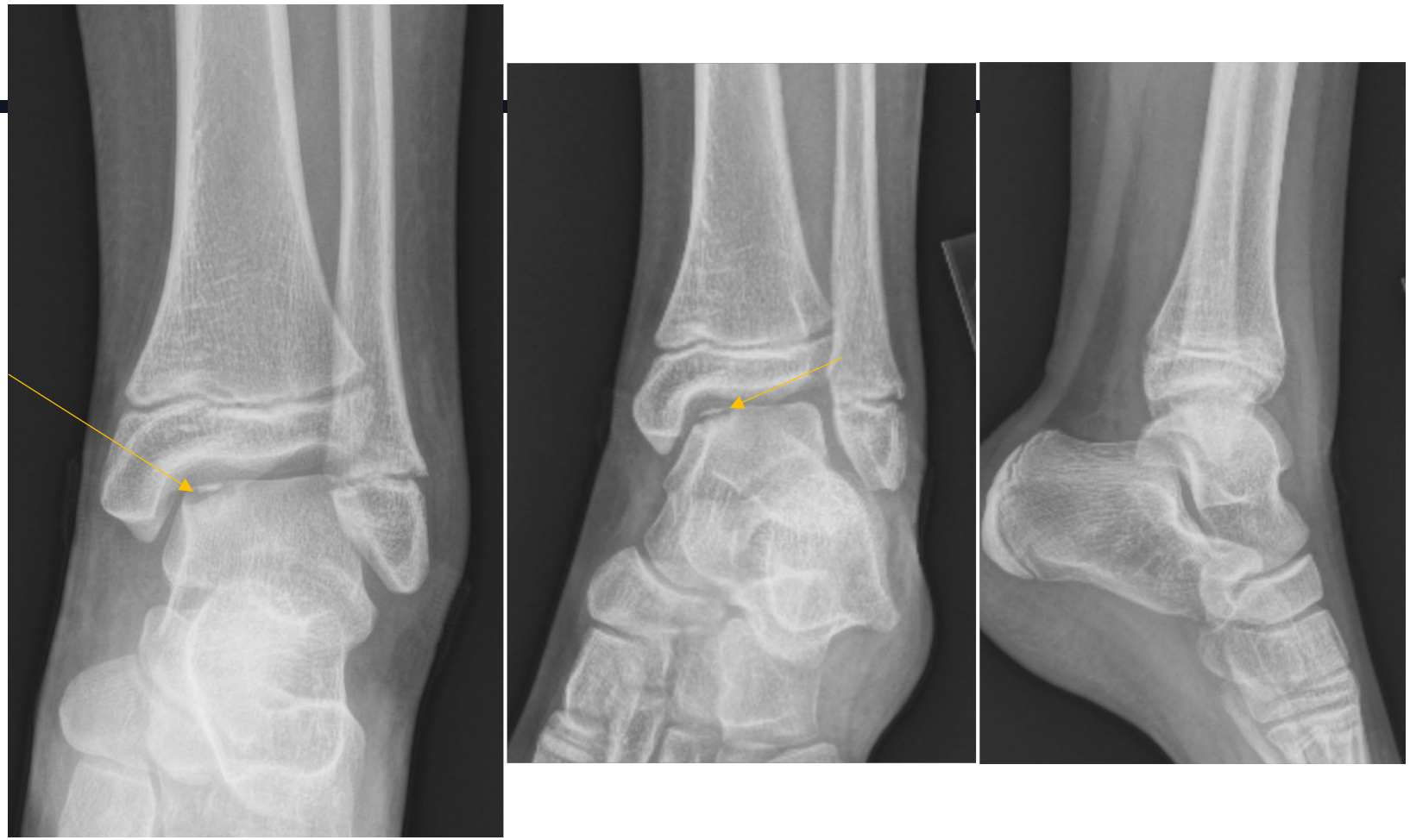





LEFT

Case #13: Left ankle.

HX: Rolled left ankle. TTP and swelling, lateral malleolus.

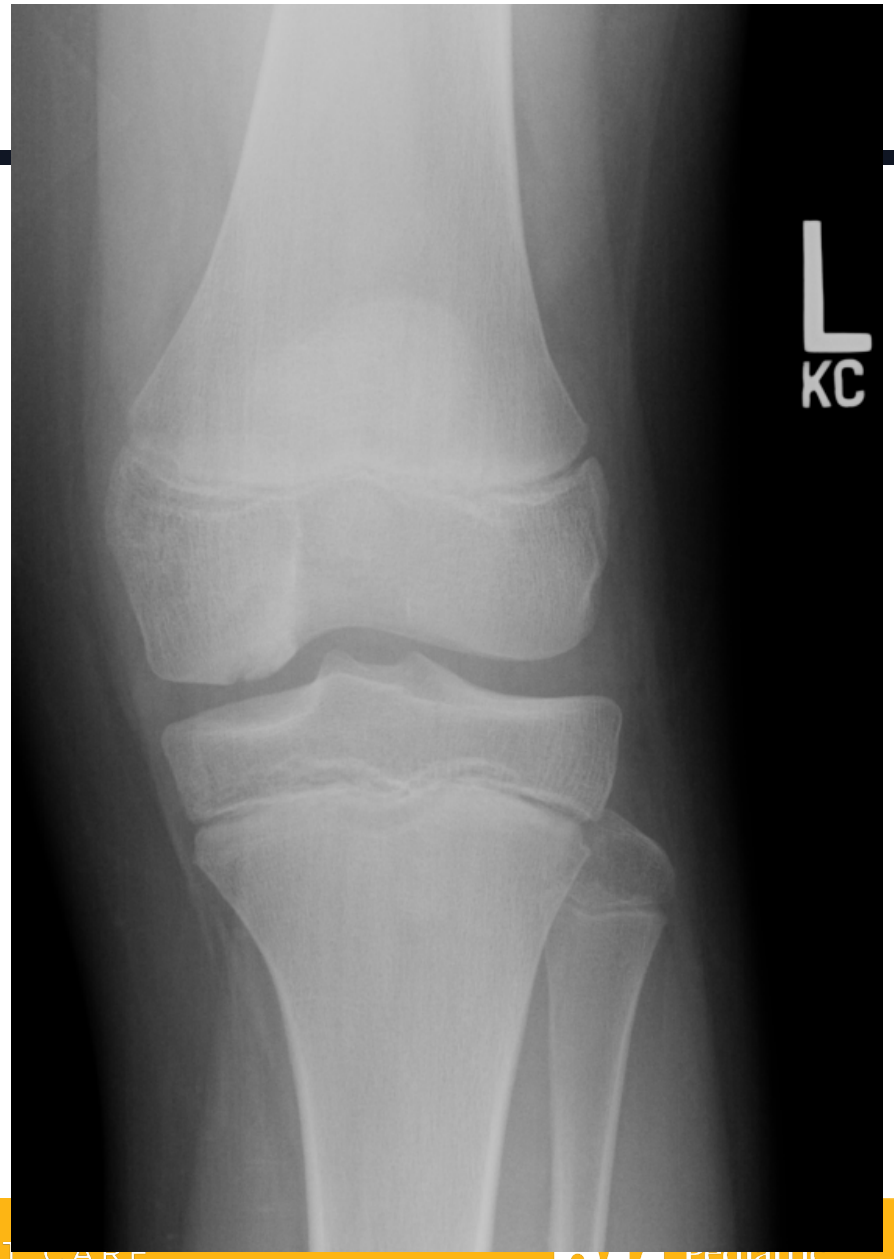


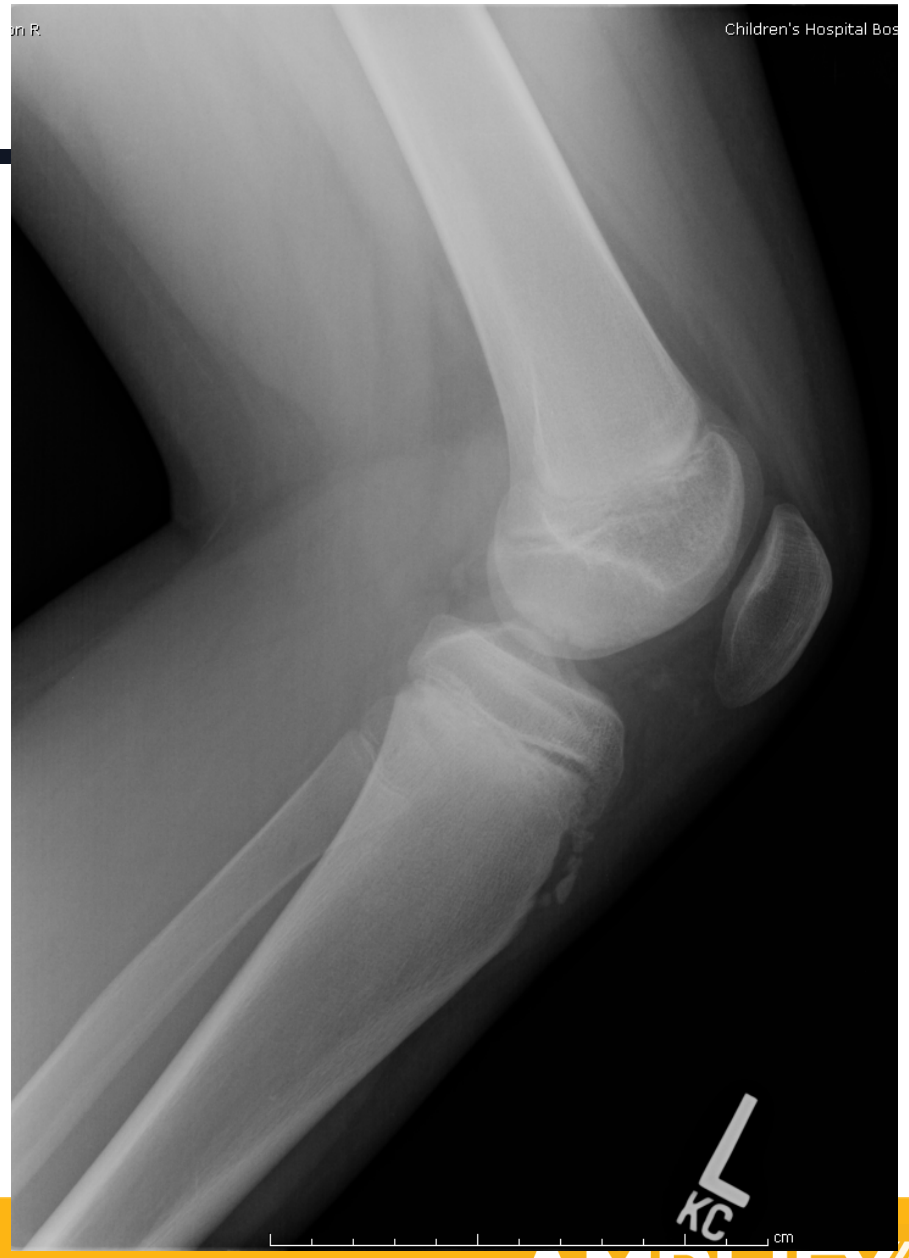
Medial talar dome lucency concerning for osteochondral lesion.

Tips:

-OCDs of the medial talar dome are usually from chronic repetitive micro trauma; lateral talar dome more often acute fractures.

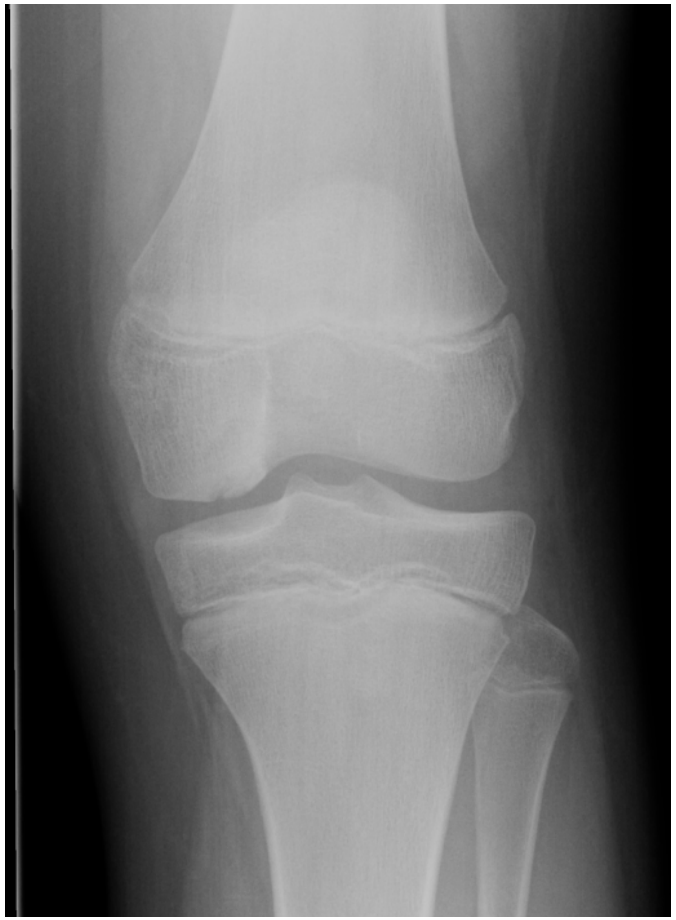
-Needs MRI to assess for features of instability.

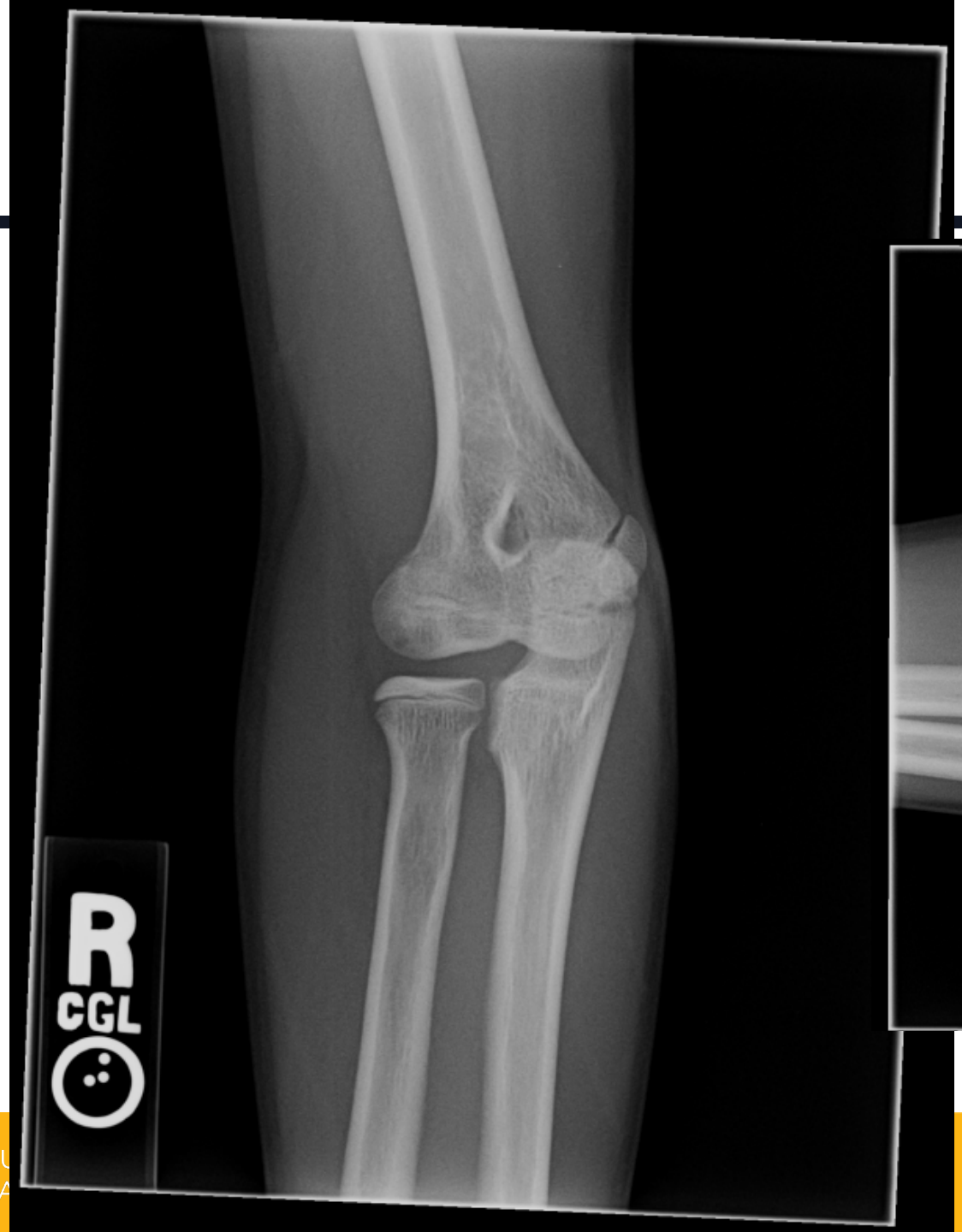

L
KC

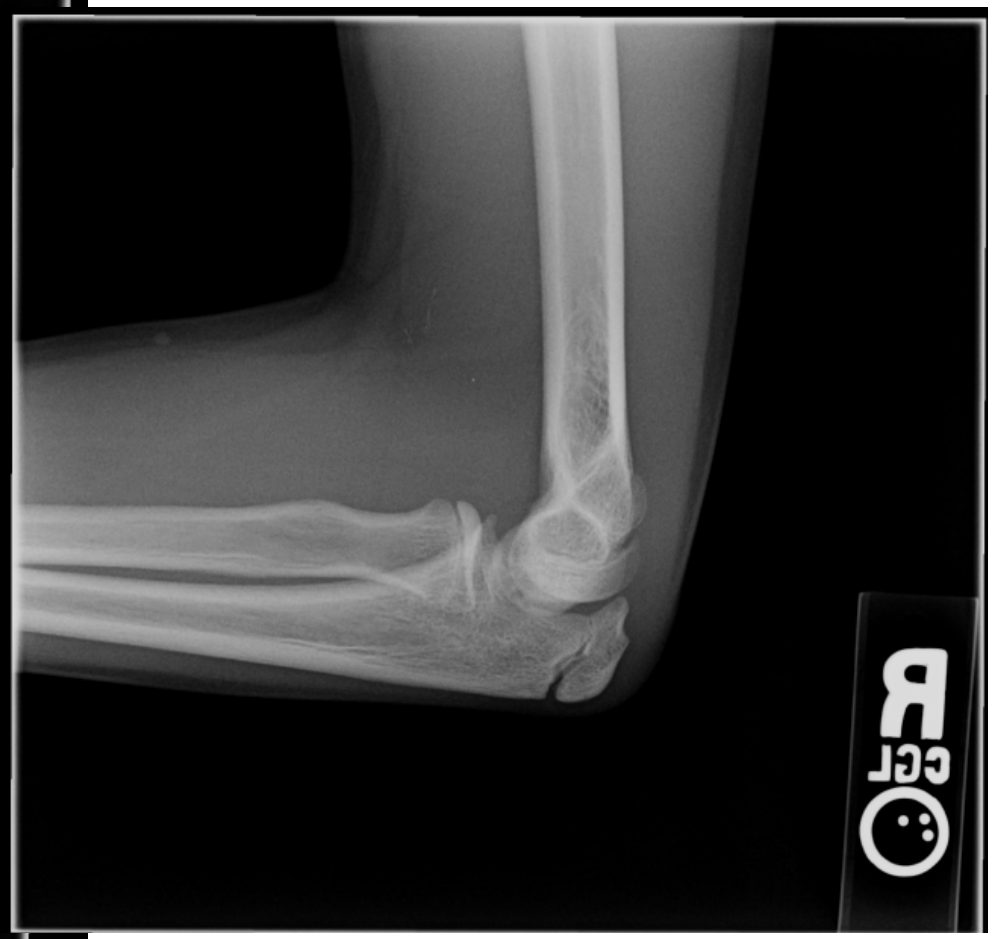

Children's Hospital Bos
L
KC
cm

Lateral femoral condyle OCD

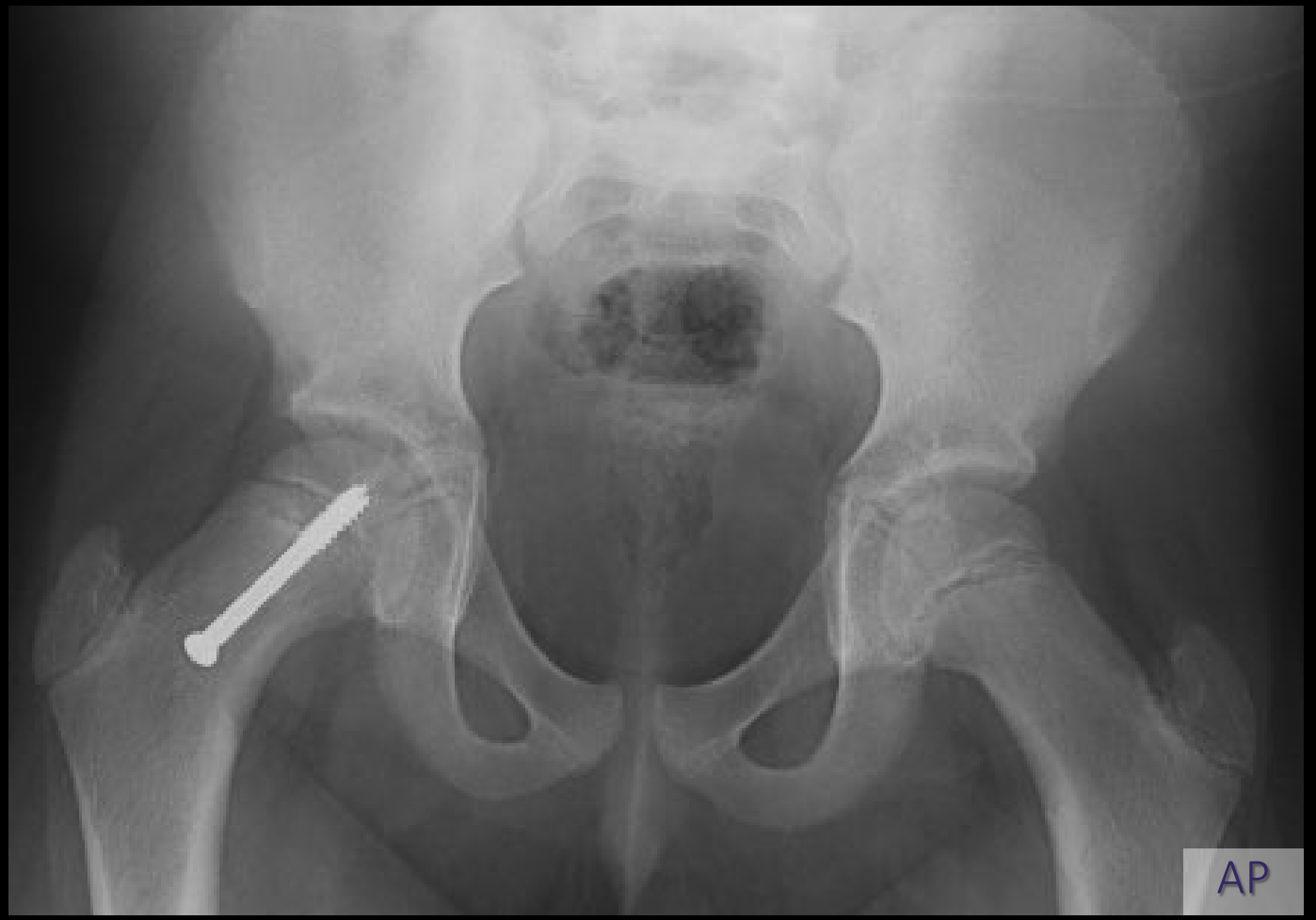
- Features suggesting instability include:
  - loose bodies
  - overlying cartilaginous thinning
  - subchondral cysts at the inter-face of the lesion and parent bone
  - fluid SI tracking between the lesion and parent bone




R
CGL


R
CGL

Prior right SCFE, now with atraumatic left hip rigidity



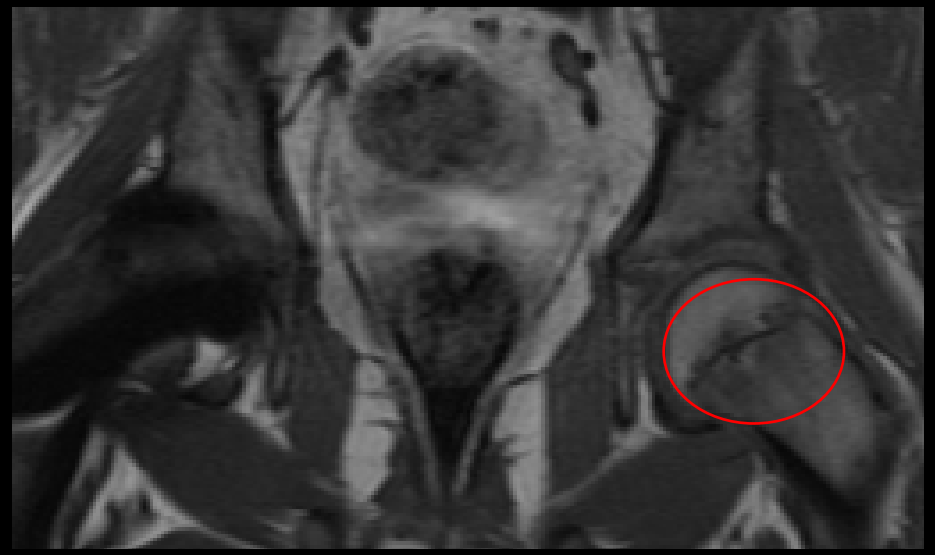
Pre-slip Left SCFE

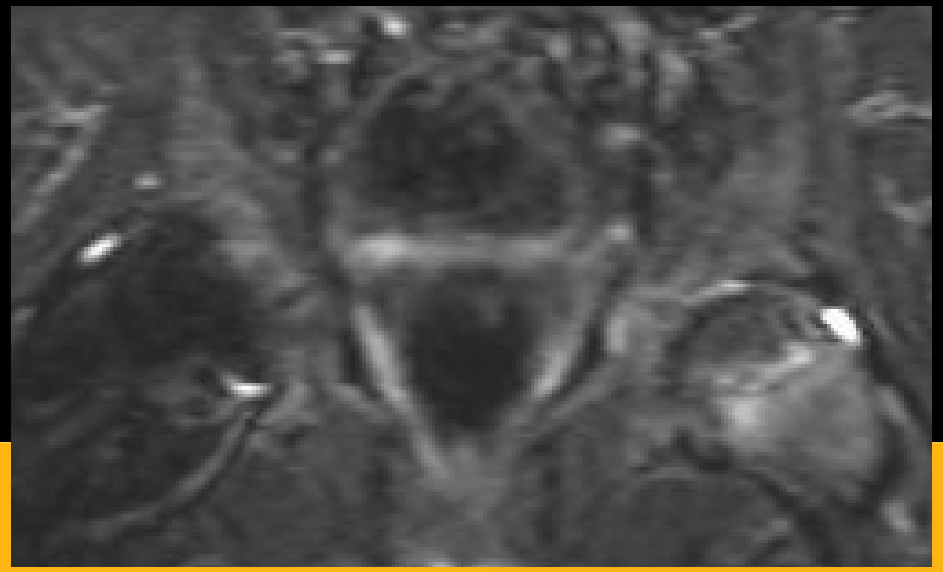
Clinical

- Hip pain with normal radiographs
- Subtle findings on physical exam

MRI Findings:

- Mild periphyseal edema
- Early physeal changes prior to slip





Feedback Requested – Scan the QR