

BREAKING IT DOWN: FRACTURE FUNDAMENTALS

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OBJECTIVES:

1. Review anatomic landmarks of the upper and lower extremity joints on imaging.

2. Recognize and describe abnormal imaging findings for urgent and emergent orthopaedic conditions.

3. Engage in the diagnostic process of fractures and other musculoskeletal conditions.

4. Determine clinical and radiographic indications for advanced musculoskeletal imaging and discuss anticipated findings based on presumptive diagnosis.

5. Differentiate imaging features consistent with benign versus malignant bone tumors and lesions.

MUSCULOSKELETAL IMAGING

Choice of Imaging:

1. Clinical presentation: history, MOI, location of pain
2. DDX
3. Availability of imaging modalities

Guidelines for Imaging:

ACR Appropriateness Criteria

Plain radiographs are the initial **imaging of choice** for most MSK conditions

“ONE VIEW IS NO VIEW”

Principle Views

- Posterior/Anterior (PA) or Anterior/Posterior (AP)
- Lateral
- Obliques
- Supplemental views may be needed: specific to site

ONE VIEW IS NO VIEW





Case courtesy of Dr Jeremy Jones, Radiopaedia.org, rID: 22111

SUPPLEMENTAL VIEW



Case courtesy of Dr Naim Qaqish, Radiopaedia.org, rID: 73814

FRACTURE DESCRIPTION

Clinical Presentation is Key:

- Always evaluate the joint above, joint below, and contralateral side.
- Let exam findings and MOI guide your imaging.
- If open fracture, start with this description!

Fracture Description

Location
Type
Pattern
Position

Possible challenges and complications: open fractures, occult fractures, physeal involvement, nonaccidental trauma, and fragility/pathologic fractures

EPONYMOUS INJURIES

Named injuries for those who first described, classified, or popularized the unique fracture or fracture/dislocation pattern

Benefit: Provides a rapid, succinct description of complex fracture patterns.

Disadvantage: Often mistermed, which creates confusion and misdirects management.

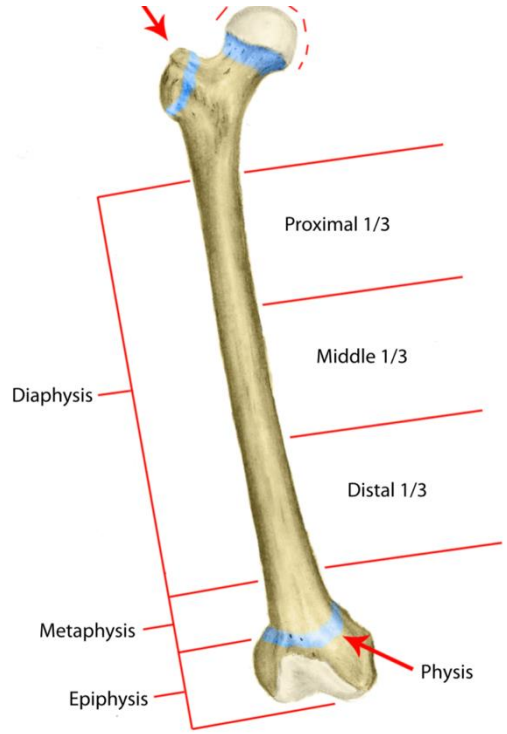
**Does not account for the severity of the injury.*

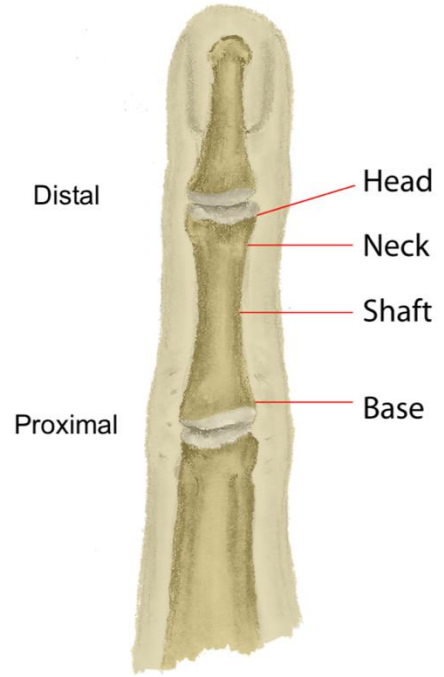
LOCATION

Which bone?

Where in the bone?

Joint involvement?





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PSEUDO-JONES FRACTURE

Case courtesy of Dr Abdulmajid Bawazeer, Radiopaedia.org, rID: 59182

JONES FRACTURE

- Pattern: transverse fracture at the metadiaphyseal junction without proximal articular extension

- MOI: plantarflexion with adduction force to forefoot

*Higher rate of nonunion, delayed union, or refracture due to limited blood supply



Case courtesy of Dr Matt Skalski, Radiopaedia.org, rID: 35716

Jones



Pseudo-Jones



Apophysis

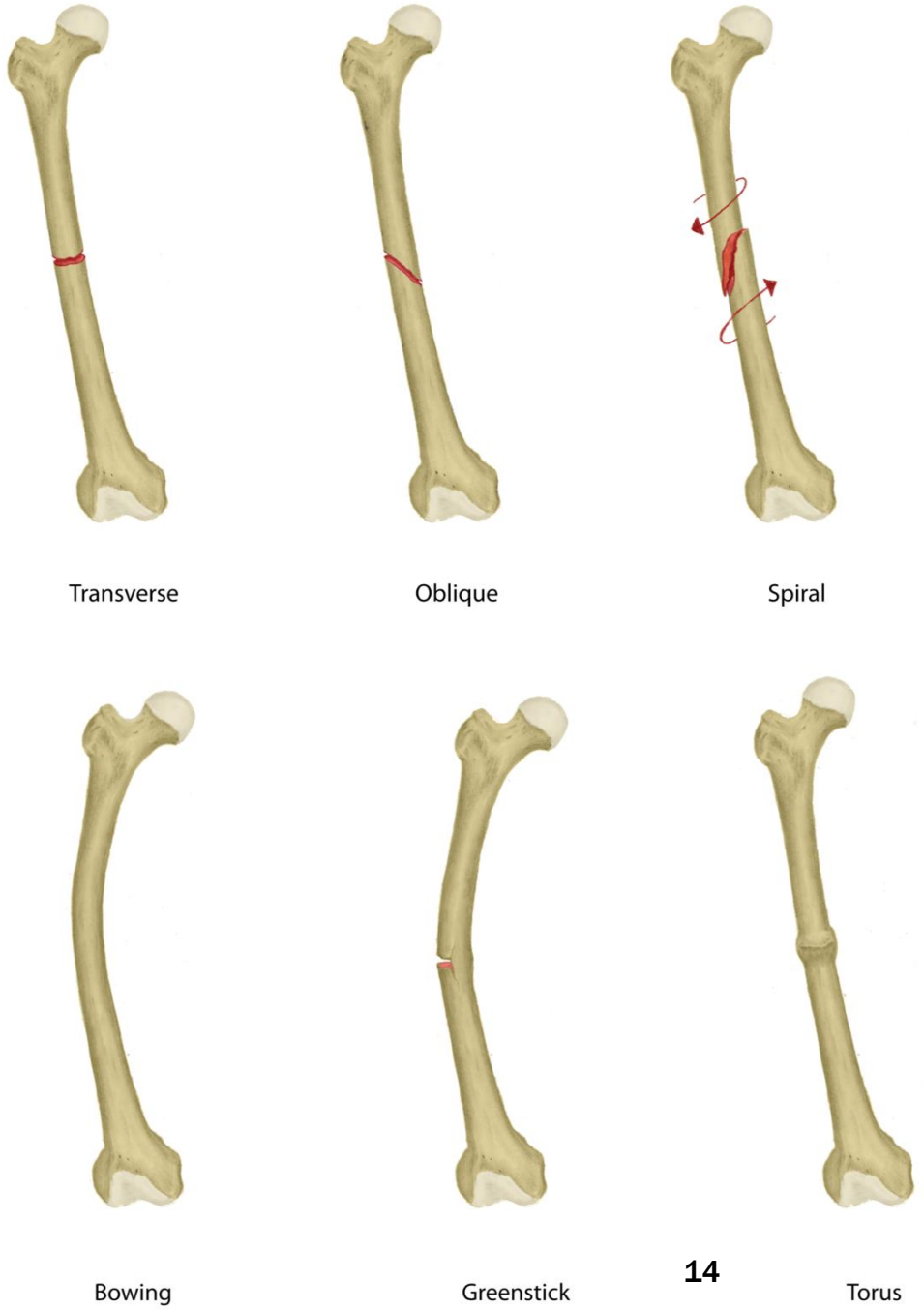


PATTERN

Complete: transverse, oblique, spiral

Incomplete: greenstick, torus, bowing

Unique pattern considerations: compression, impaction, avulsion, stress



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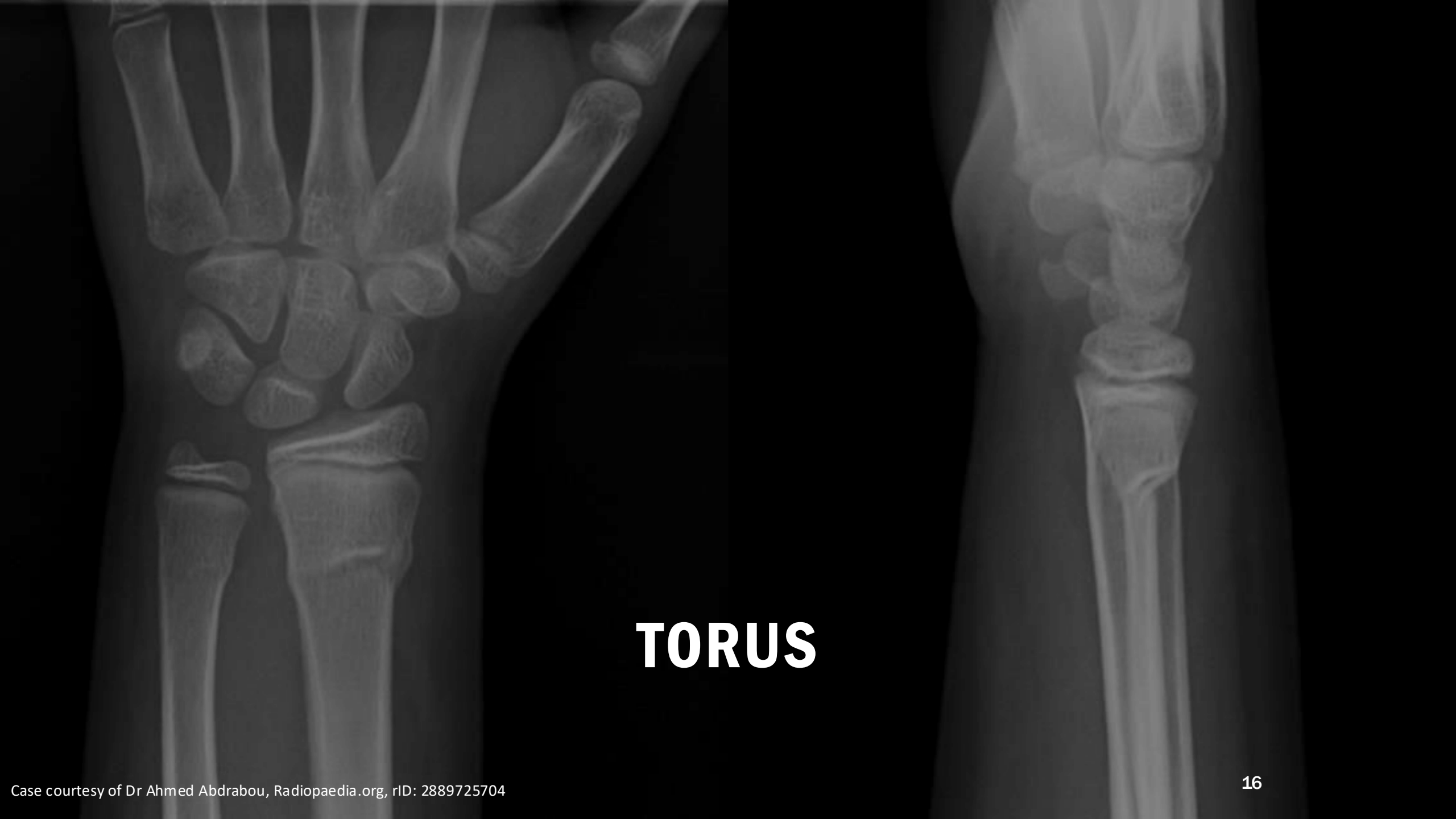
PEDIATRIC PERIOSTEUM

Metabolically more active

- Promotes callus formation
- Remodeling ability

Thicker and more durable

- Less likely to displace
- Unique patterns:
  - Buckle/torus
  - Greenstick
  - Plastic deformity/bowing



TORUS

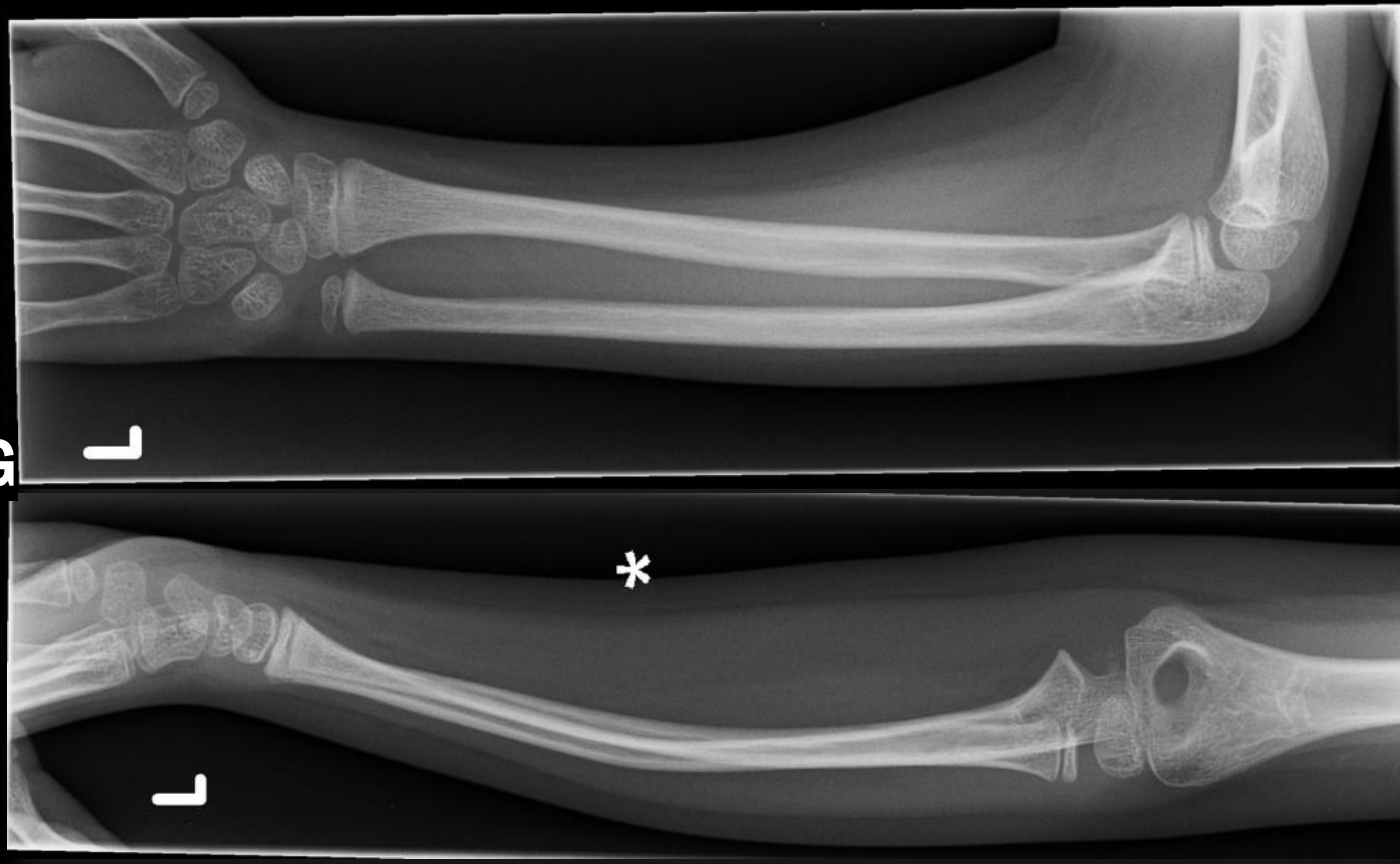
Case courtesy of Dr Ahmed Abdrabou, Radiopaedia.org, rID: 2889725704



GREENSTICK

Case courtesy of Dr Hani Salam, Radiopaedia.org, rID: 13297

BOWING

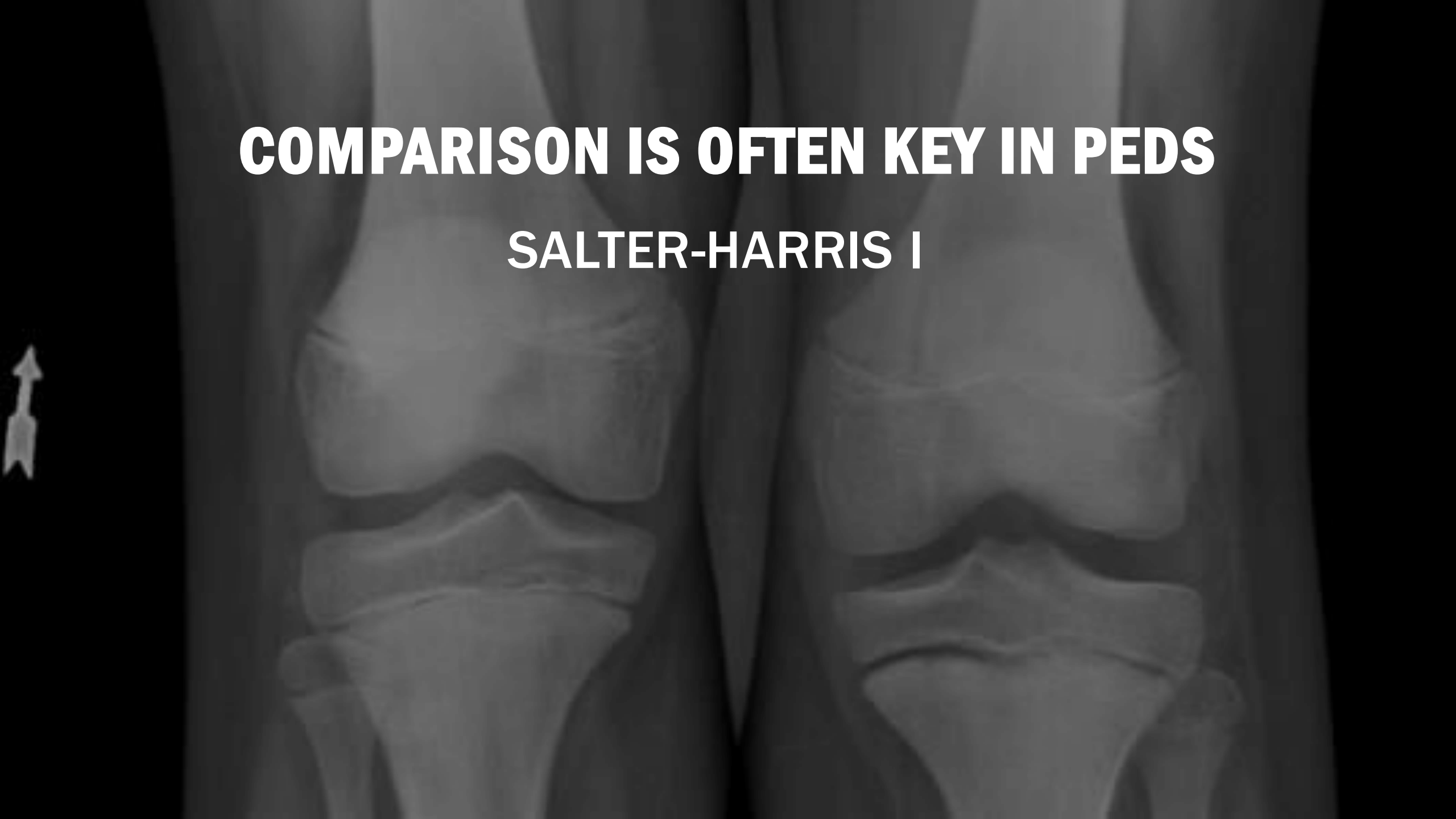




TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V
S	A	L	T	R

SALTER-HARRIS CLASSIFICATION

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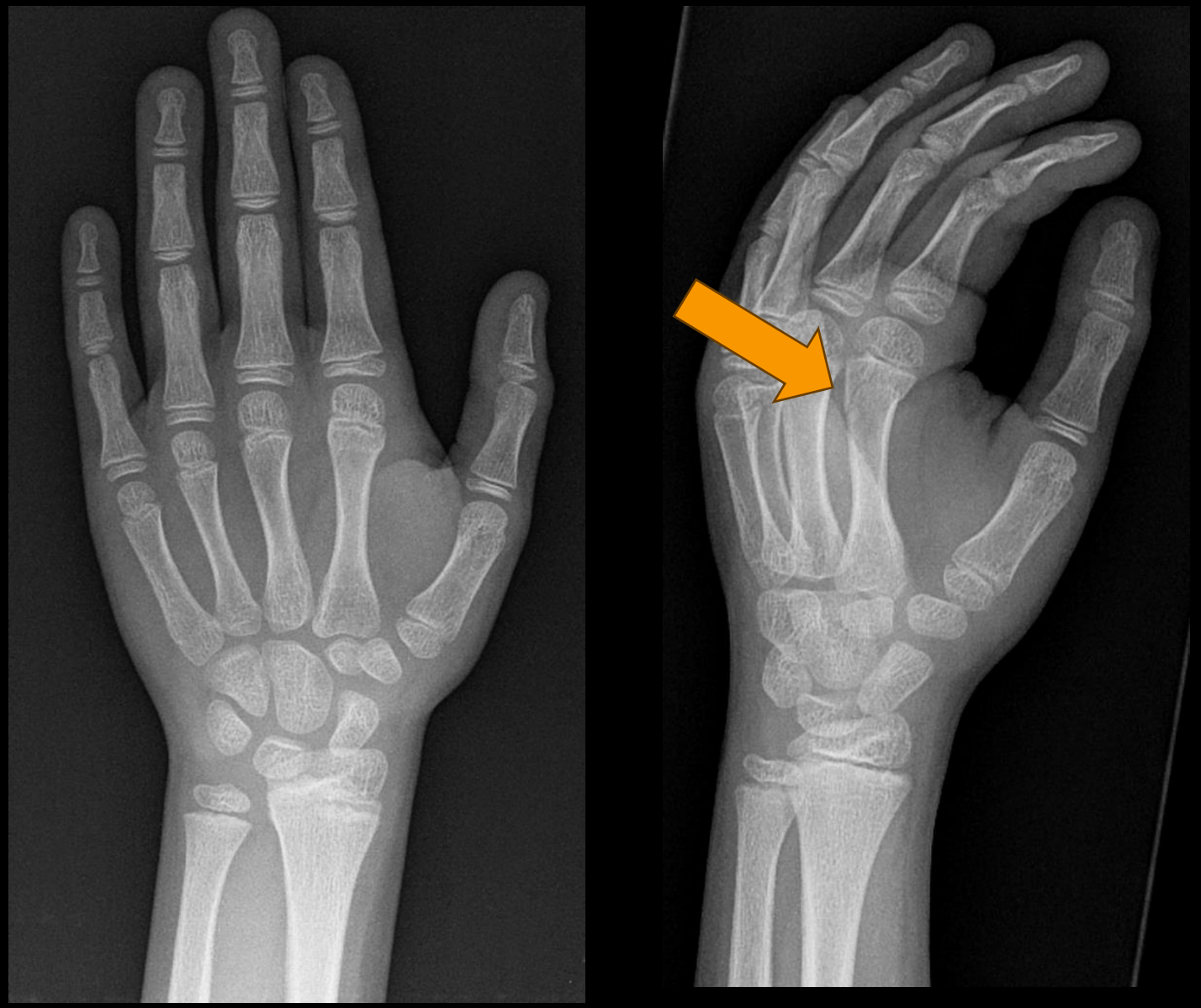

COMPARISON IS OFTEN KEY IN PEDS
SALTER-HARRIS I

SALTER-HARRIS I

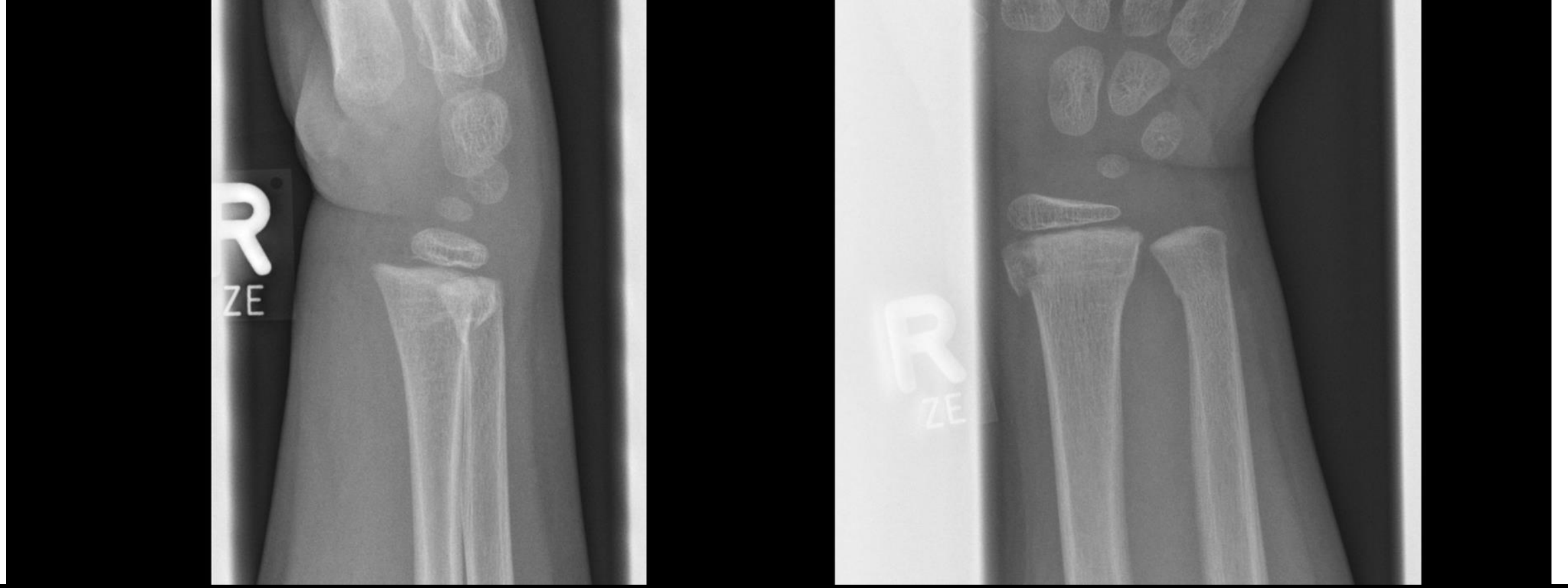


Case courtesy of Jeremy Jones, Radiopaedia.org, rID: 22229

SALTER-HARRIS II



Case courtesy of Henry Knipe, Radiopaedia.org, rID: 153737



SALTER-HARRIS II

Case courtesy of Miriam Leiderer, Radiopaedia.org, rID: 81838

SALTER-HARRIS III



Case courtesy of Yahya Baba, Radiopaedia.org, rID: 155162



SALTER-HARRIS IV

Case courtesy of Assoc Prof Craig Hacking, Radiopaedia.org, rID: 68652

ADOLESCENT SALTER-HARRIS ANKLE FRACTURES

TILLAUX FRACTURE

- Pattern: fracture of the anterolateral tubercle of the distal tibia
- MOI: pull of the anteroinferior tibiofibular ligament in abduction/external rotation
  - Fracture requires an open physis: adolescent injury

*Salter-Harris Type III



Case courtesy of Dr Balint Botz, Radiopaedia.org, rID: 74925

TRIPLANE FRACTURE



Case courtesy of Dr Yasser Asiri, Radiopaedia.org, rID: 64779

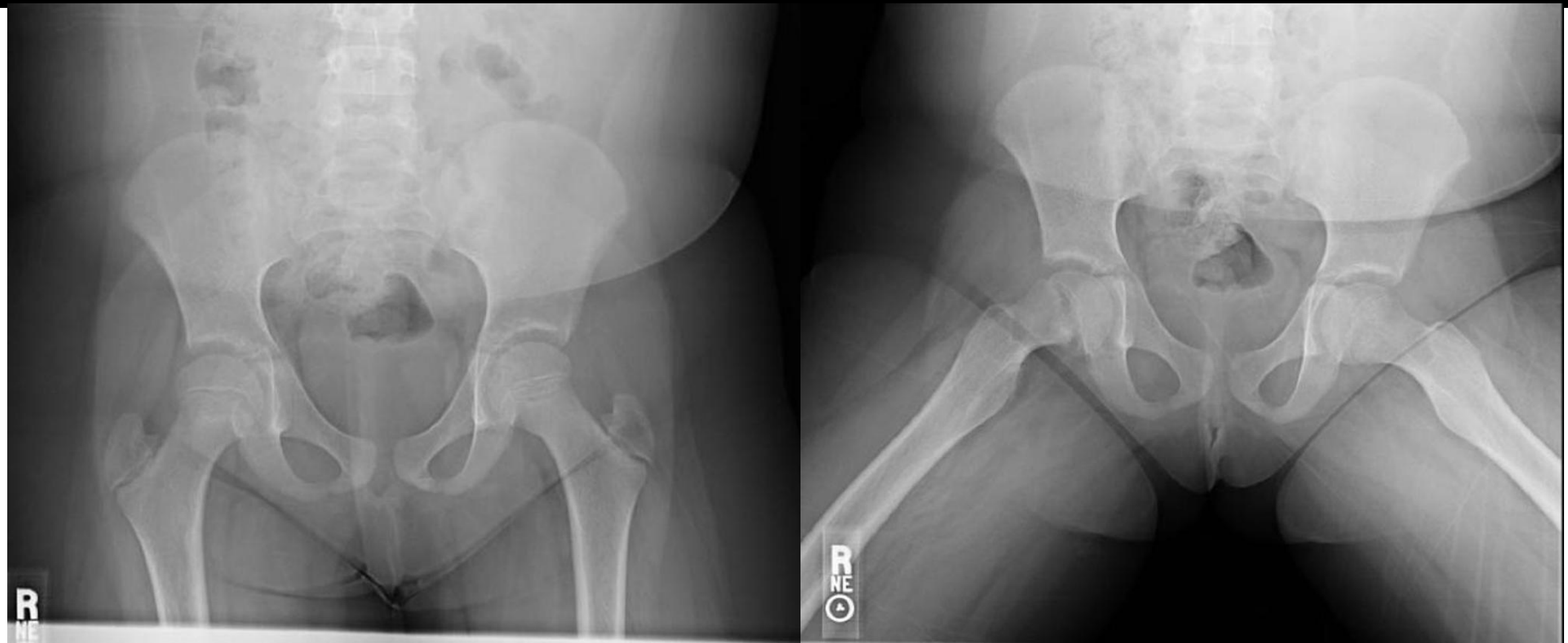
- Name reflects the injury extending along different planes

- Pattern: SH IV fracture of the distal tibia
  - Epiphysis: vertical fx
  - Physis: horizontal fx
  - Metaphysis: oblique fx
- MOI: external rotation and supination injury in adolescents as epiphyseal plate is closing

*Fractures appear as SH III on AP and SH II on lateral.

Case courtesy of Radswiki, Radiopaedia.org, rID: 11938

WHEN IN DOUBT...COMPARE!
SLIPPED CAPITAL FEMORAL EPIPHYSIS (SCFE)



NUMBER OF FRAGMENTS

Simple

- Two fragments

Comminuted

- More than two fragments

BENNETT FRACTURE

- Pattern: intra-articular oblique fracture at the base of the first metacarpal
  - Associated with subluxation or dislocation of carpometacarpal joint
- MOI: axial trauma with partially flexed metacarpal

*Two-part fracture



Case courtesy of eduardo bravo, Radiopaedia.org, rID: 55586

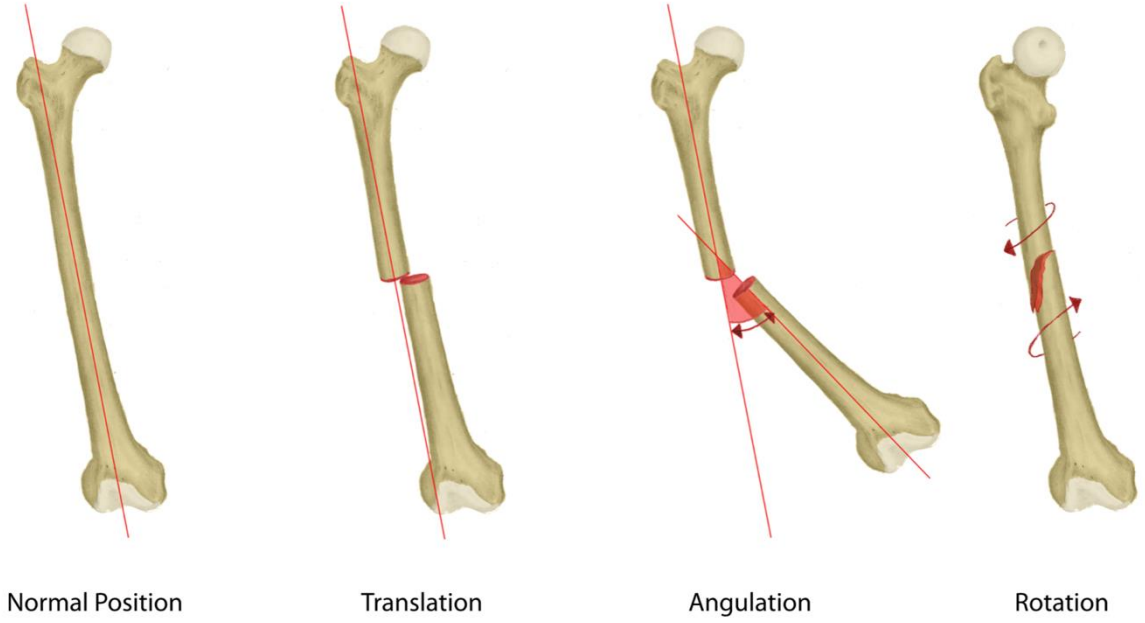
ROLANDO FRACTURE

- Pattern: comminuted intra-articular first metacarpal base fracture
  - ≥3 parts, T or Y shaped
- MOI: axial trauma with partially flexed metacarpal

*“Comminuted Bennett fx”: unstable fx



POSITION



Nondisplaced vs Displaced:

- Translation (Apposition)
- Angulation
- Rotation
- Shortening
- Distraction

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BOXER'S FRACTURES

Case courtesy of Dr Bahman Rasuli, Radiopaedia.org, rID: 81113

Case courtesy of Dr Shailaja Muniraj, Radiopaedia.org, rID: 50051

COLLES FRACTURE

- Pattern: **extra-articular** distal radius fracture with impaction and dorsal angulation/displacement
  - "Dinner fork deformity"
- MOI: FOOSH or high impact trauma

*50% associated ulnar styloid fracture



Case courtesy of Townsville radiology training, Radiopaedia.org, rID: 17977

SMITH FRACTURE

- Pattern: transverse fracture of the distal radius with volar angulation/displacement
  - Also termed Reverse Colles
- MOI: fall on flexed wrist

*Type I is most common which is extra-articular



Case courtesy of Dr Jan Frank Gerstenmaier, Radiopaedia.org, rID: 2519

BARTON FRACTURE

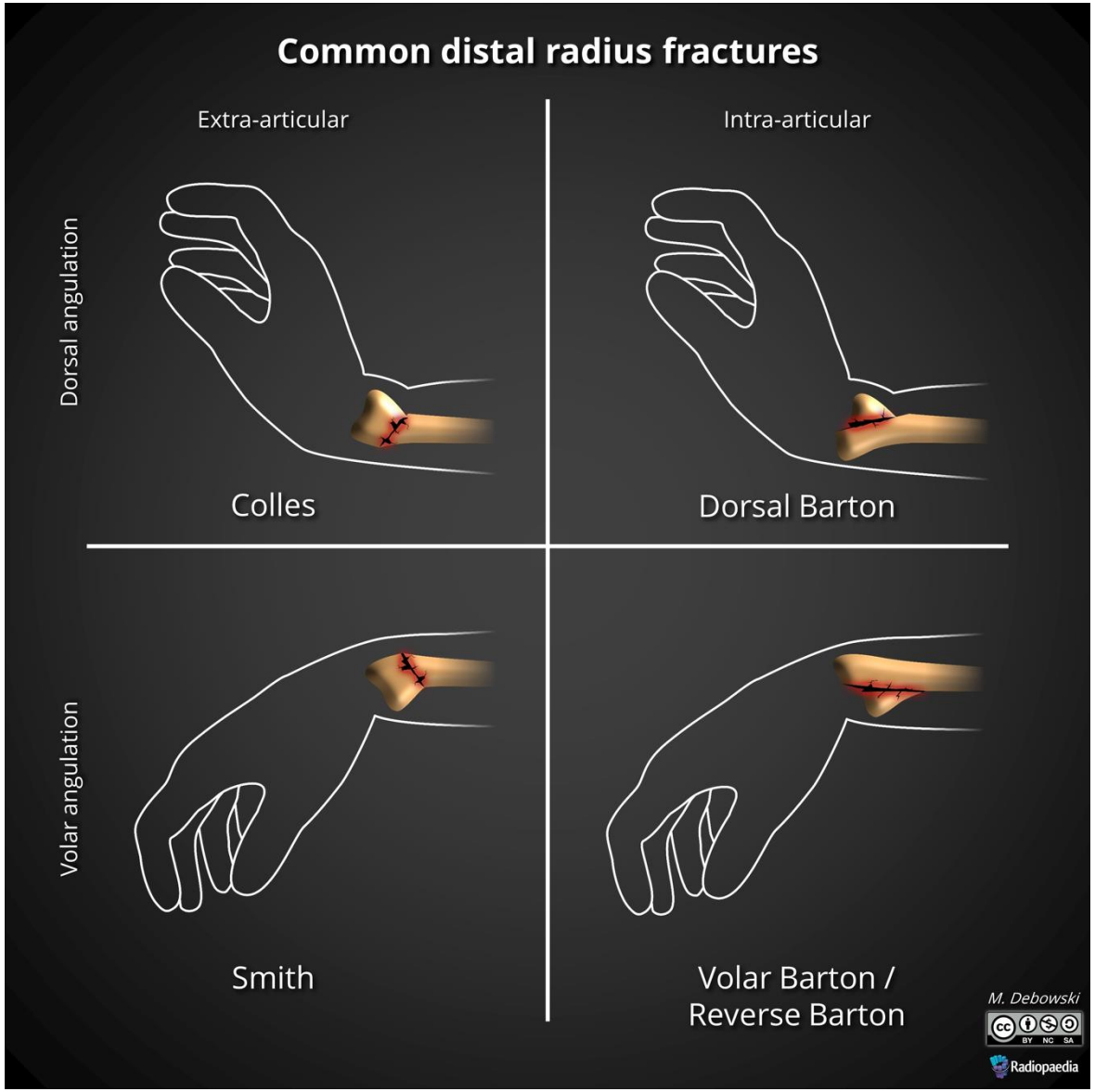
- Pattern: oblique fracture of the distal radius with articular extension dorsally
  - Dorsal-type: Barton fracture
  - Volar-type: reverse Barton fracture

*Often associated with dorsal subluxation/dislocation of radiocarpal joint



Case courtesy of Dr Aditya Shetty, Radiopaedia.org, rID: 28755

Case courtesy of Dr Maciej Debowski, Radiopaedia.org, rID: 66146



DO NOT MISS:
MONTEGGIA FRACTURE-DISLOCATION



- Pattern: ulna shaft (proximal third/middle) fx with dislocation of radial head
- MOI: majority are FOOSH with forearm pronation or hyperextension
    - Bado classification (Type I-IV) based on pattern variability

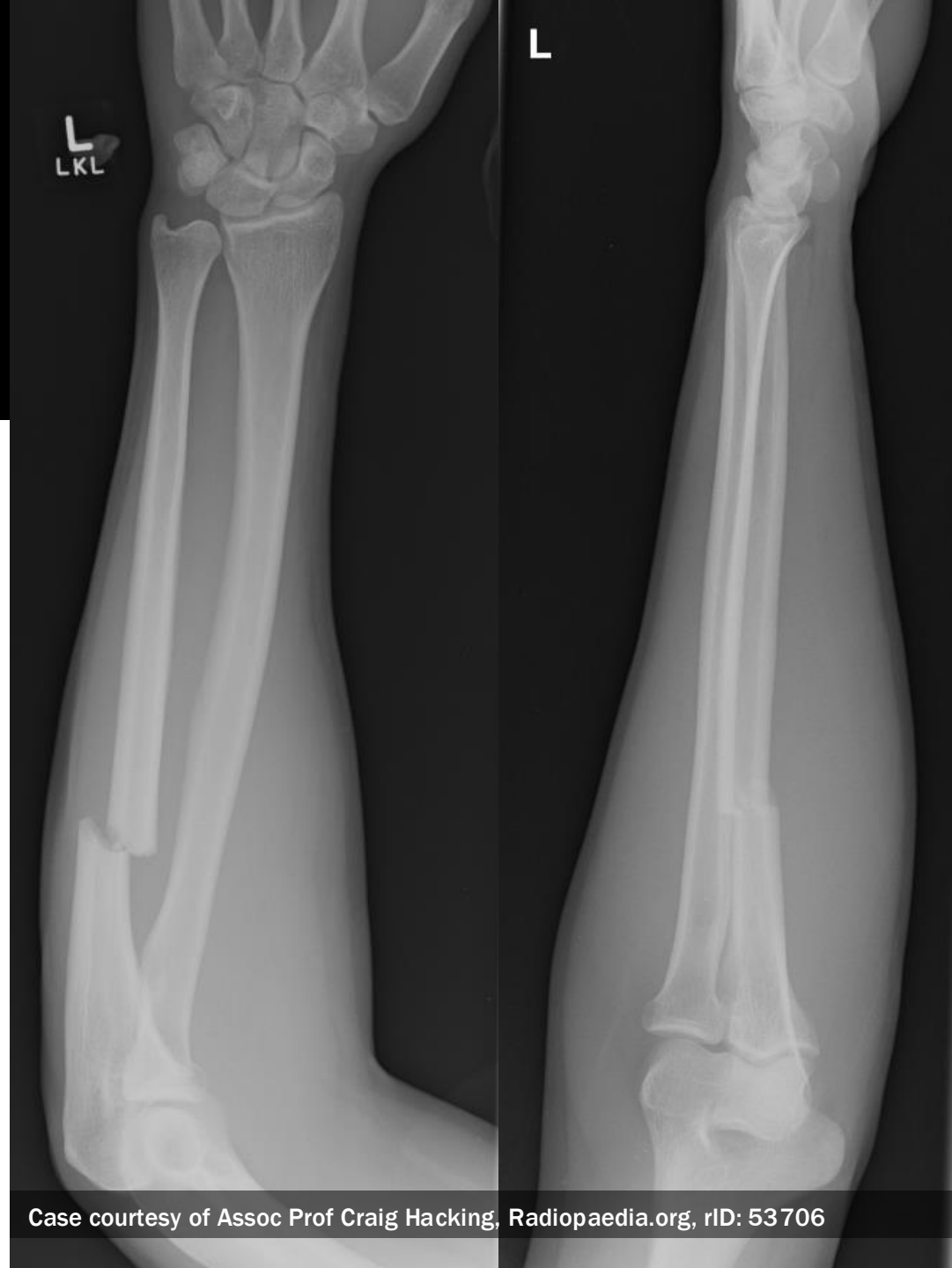
*Missed or delayed diagnosis of radial head dislocation may lead to significant complications

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 80

NIGHTSTICK FRACTURE

- Named after police baton (nightstick) impacting the midshaft of the ulna with a direct blow
  - Typically transverse in midshaft
- MOI: direct impact of blunt object to the forearm often while attempting to block a blow to head
  - Must consider defensive wound, assault

*When “isolated” ulnar shaft fx identified, consider physical exam findings and dedicated elbow images to assess for associated injuries



Case courtesy of Assoc Prof Craig Hacking, Radiopaedia.org, rID: 53706

GALEAZZI FRACTURE-DISLOCATION

- Pattern: radial shaft fracture (middle/distal third) with associated dislocation of the distal radioulnar joint (DRUJ)
- MOI: FOOSH, forearm pronation or supination

Rare in kids: consider Galeazzi equivalent

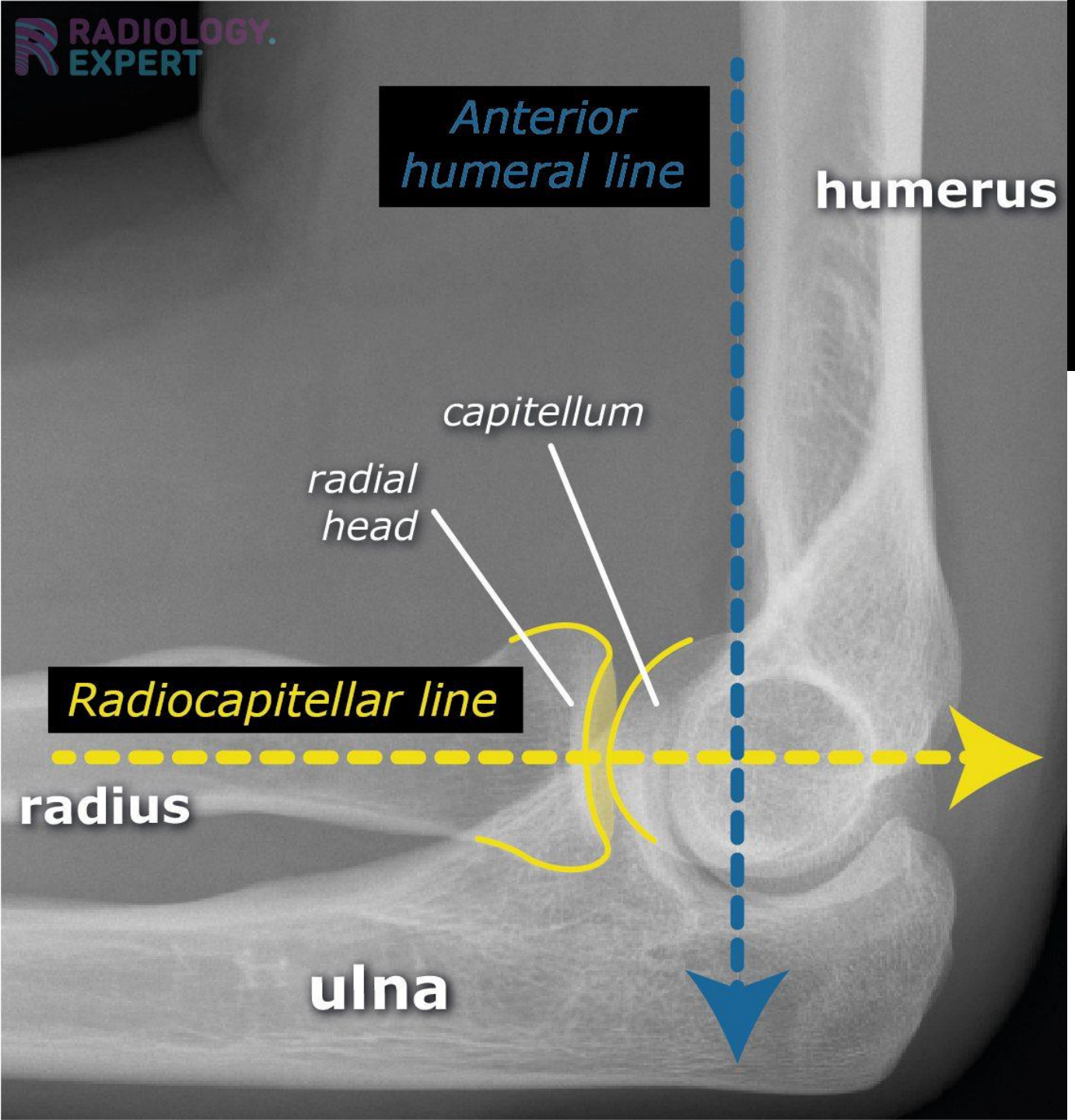
- Radial shaft fx with distal ulnar physis displacement (DRUJ remains intact)



Case courtesy of Dr Alexandra Stanislavsky, Radiopaedia.org, rID: 10961

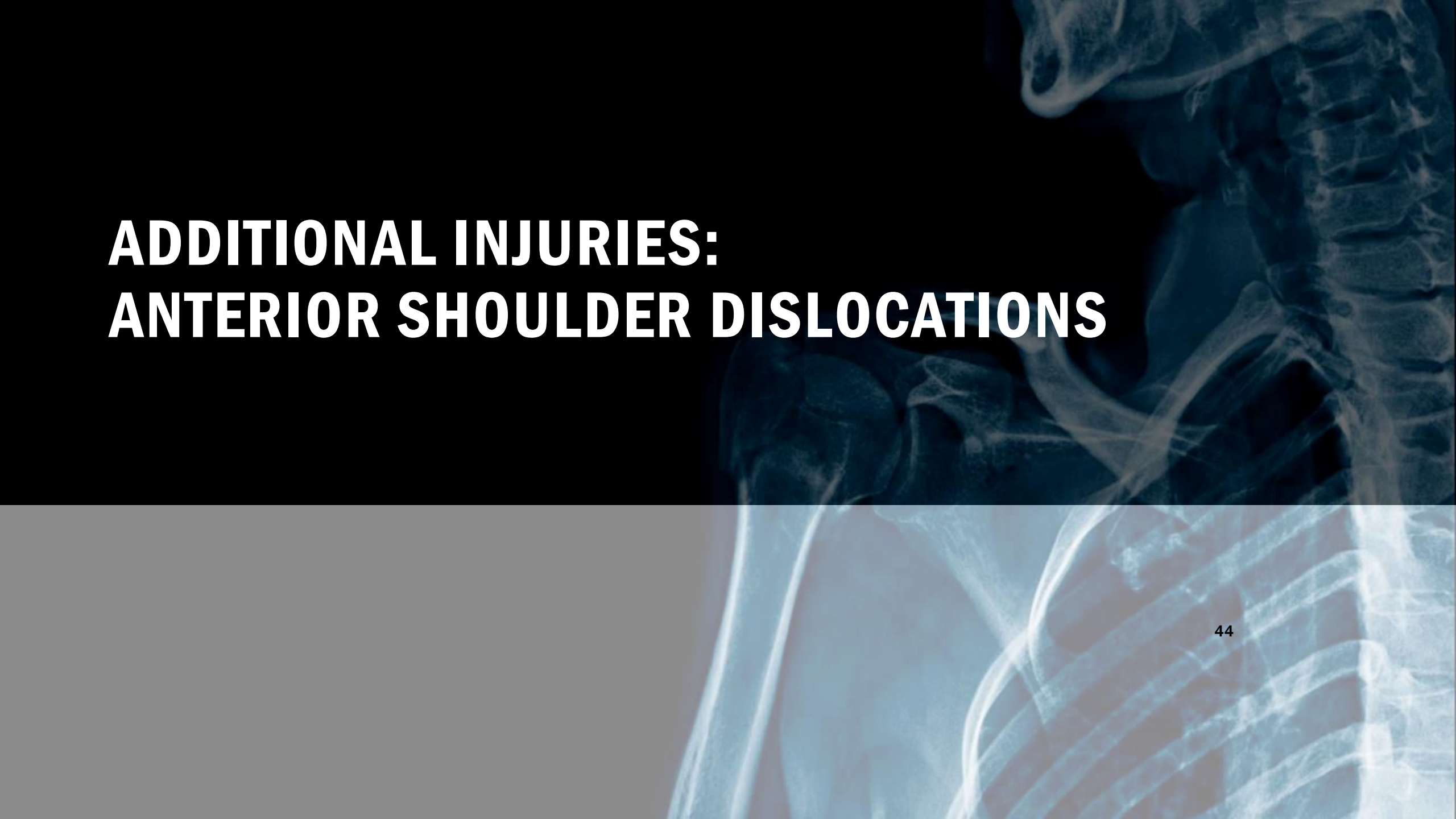
FOREARM FRACTURES: PEARLS TO AVOID PITFALLS

- Consider at least **two** injuries in forearm fractures
  - Dislocations may be subtle so **always** assess (and document) these findings!
- Obtain dedicated elbow films



Critical Lines: Radiocapitellar and Anterior Humeral

ADDITIONAL INJURIES: ANTERIOR SHOULDER DISLOCATIONS



HILL-SACHS DEFECT

- Pattern: impaction fracture of the posterolateral humeral head
- MOI: anterior shoulder dislocations
  - Impaction against the anterior glenoid rim

*AP with internal rotation of the shoulder necessary to avoid missing this defect



Case courtesy of Dr Benoudina Samir, Radiopaedia.org, rID: 58016

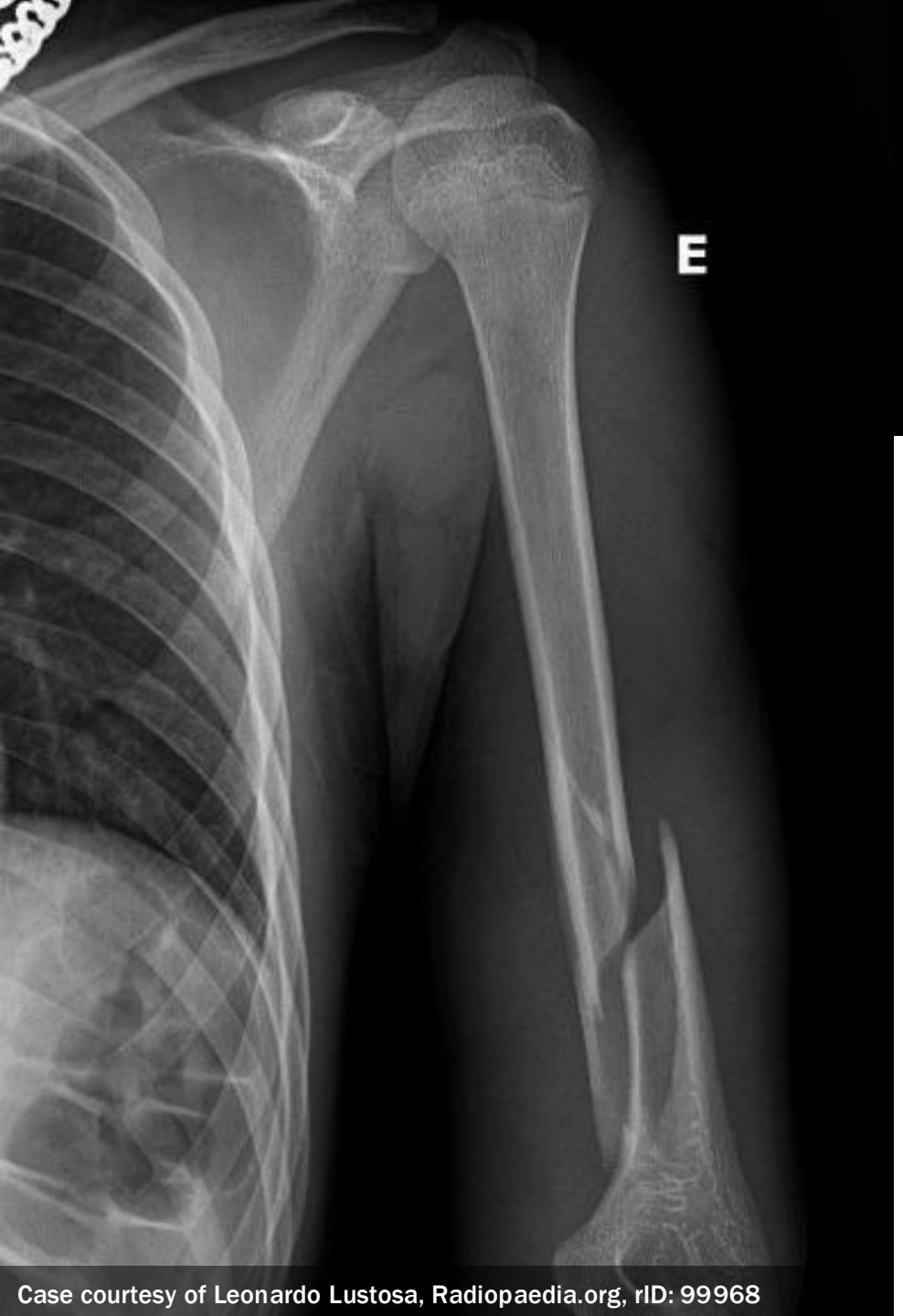
BANKART LESION

- Pattern: soft tissue injury of the anteroinferior labrum
  - **Bony Bankart: fracture of the glenoid**
- MOI: anterior shoulder dislocation

**Commonly associated with Hill-Sachs*

- Both are associated with an increased risk for instability and repeat dislocations





Case courtesy of Leonardo Lustosa, Radiopaedia.org, rID: 99968

HOLSTEIN-LEWIS FRACTURE

- Pattern: spiral fx of the distal third of the humerus
- MOI: trauma

*Increased risk of radial nerve palsy



LOWER EXTREMITY: ASSOCIATED INJURIES

SEGOND FRACTURE

- Pattern: avulsion fracture of the proximal lateral tibia (inferior to the tibial plateau)
- MOI: internal rotation of the knee with varus stress

*Frequent association with **ACL tears**, meniscal tears, and other soft tissue injuries



Case courtesy of Dr Maulik S Patel, Radiopaedia.org, rID: 9758

MAISONNEUVE FRACTURE

- Pattern: spiral fracture of the proximal fibula with associated unstable ankle injury
  - Disruption of the distal tibiofibular syndesmosis +/- medial malleolus fx, and interosseous tear
  - May have widening at ankle mortise
- MOI: force on externally rotated ankle with a pronated foot

*Always assess proximal fibula with ankle injuries to avoid missing this injury



Case courtesy of RMH Core Conditions, Radiopaedia.org, rID: 29088

CASES WITH CONCERNING FEATURES ON IMAGING



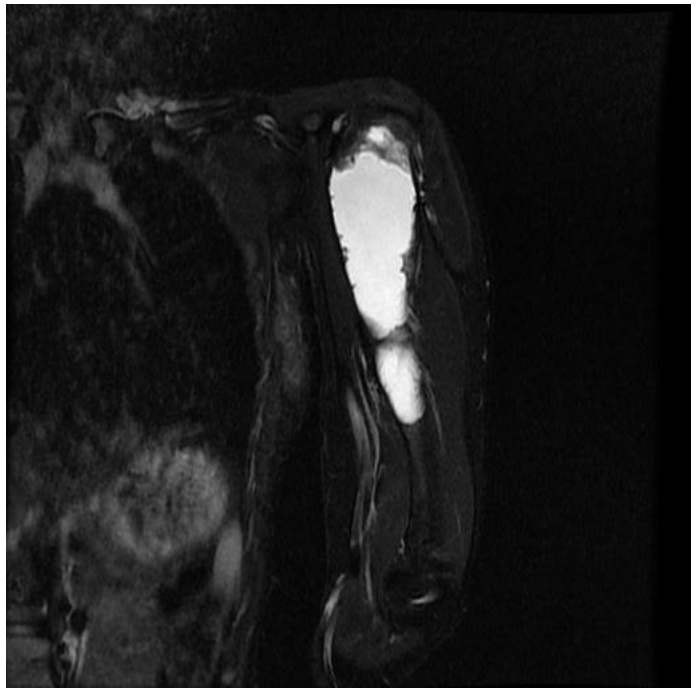
Images courtesy of Henk Jan van der Woude and Robin Smithuis and Radiology Assistant

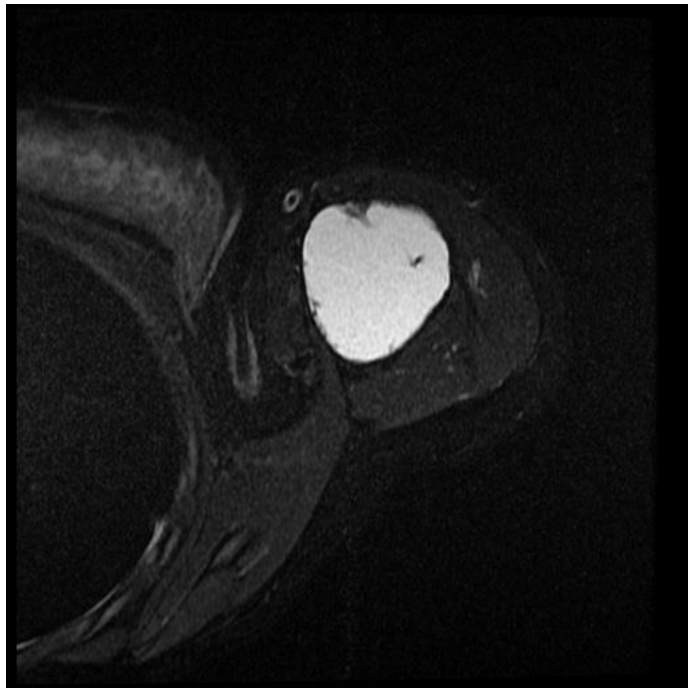


UNICAMERAL BONE CYST (UBC)

Case courtesy of Dr Yasser Asiri, Radiopaedia.org, rID: 65130

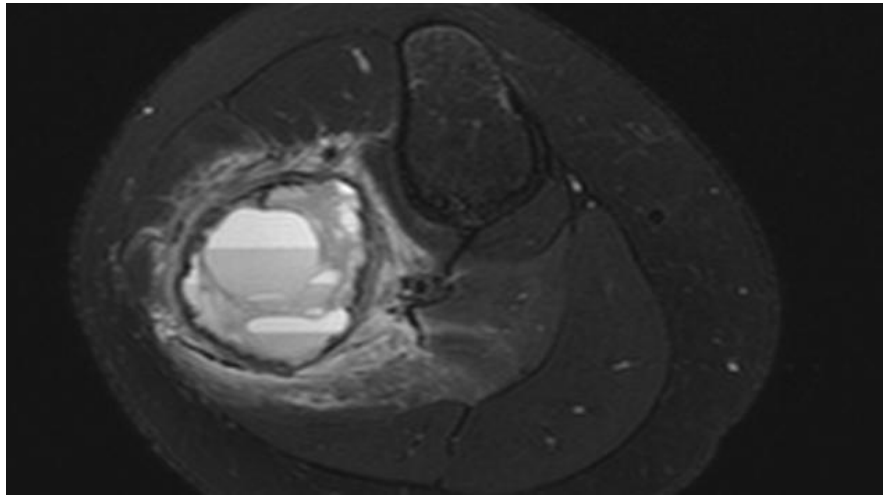
MRI: UBC





Case courtesy of Dr Yasser Asiri, Radiopaedia.org, rID: 65130

ABC



Case courtesy of Dr Alexandra Stanislavsky, Radiopaedia.org, rID: 14333

IMAGING

Radiographic Imaging: first-line for all tumors

MRI: preferred with aggressive features on radiographs

CT: sensitive for cortical destruction and mineralization

Bone Scan (Technetium Tc 99m): Sensitive for new bone formation

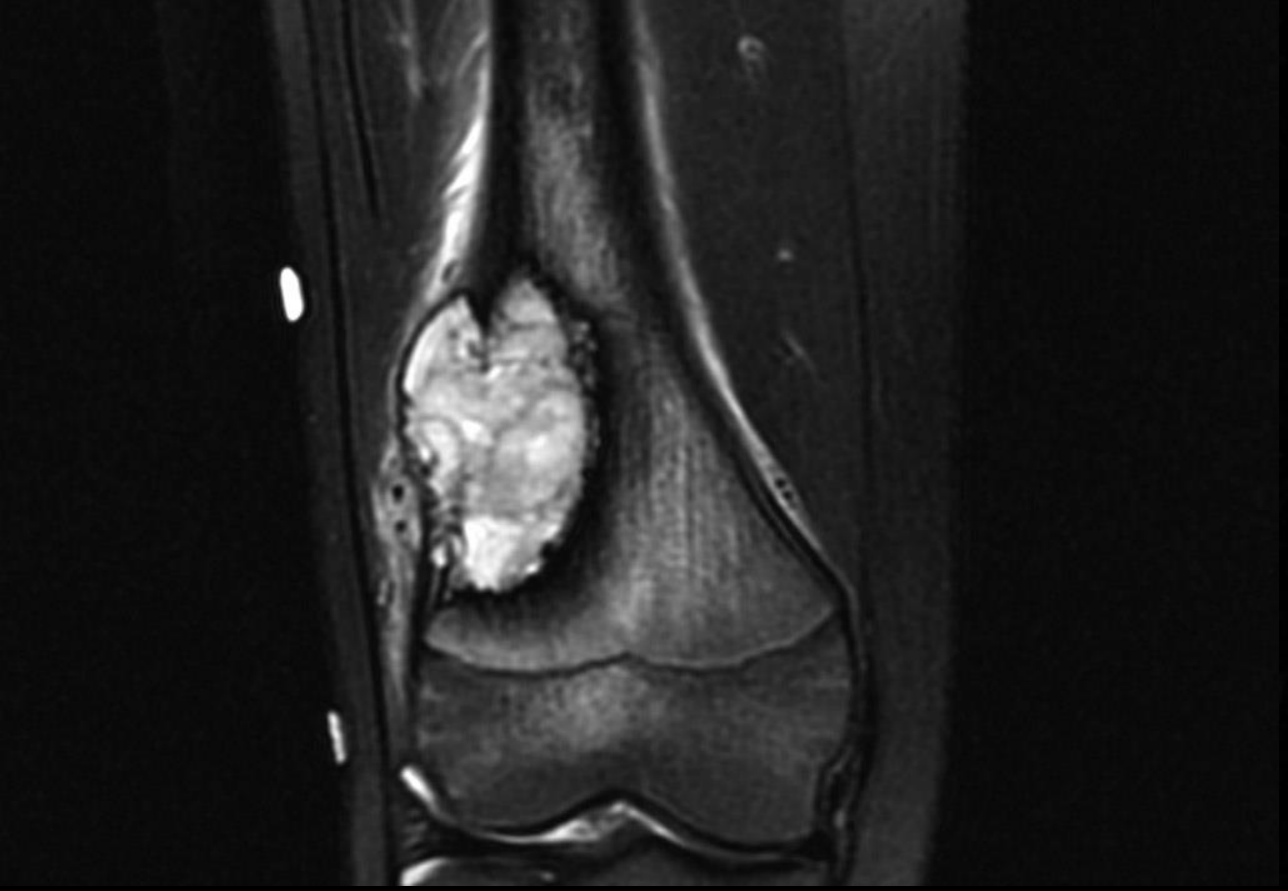
BONE TUMORS AND LESIONS

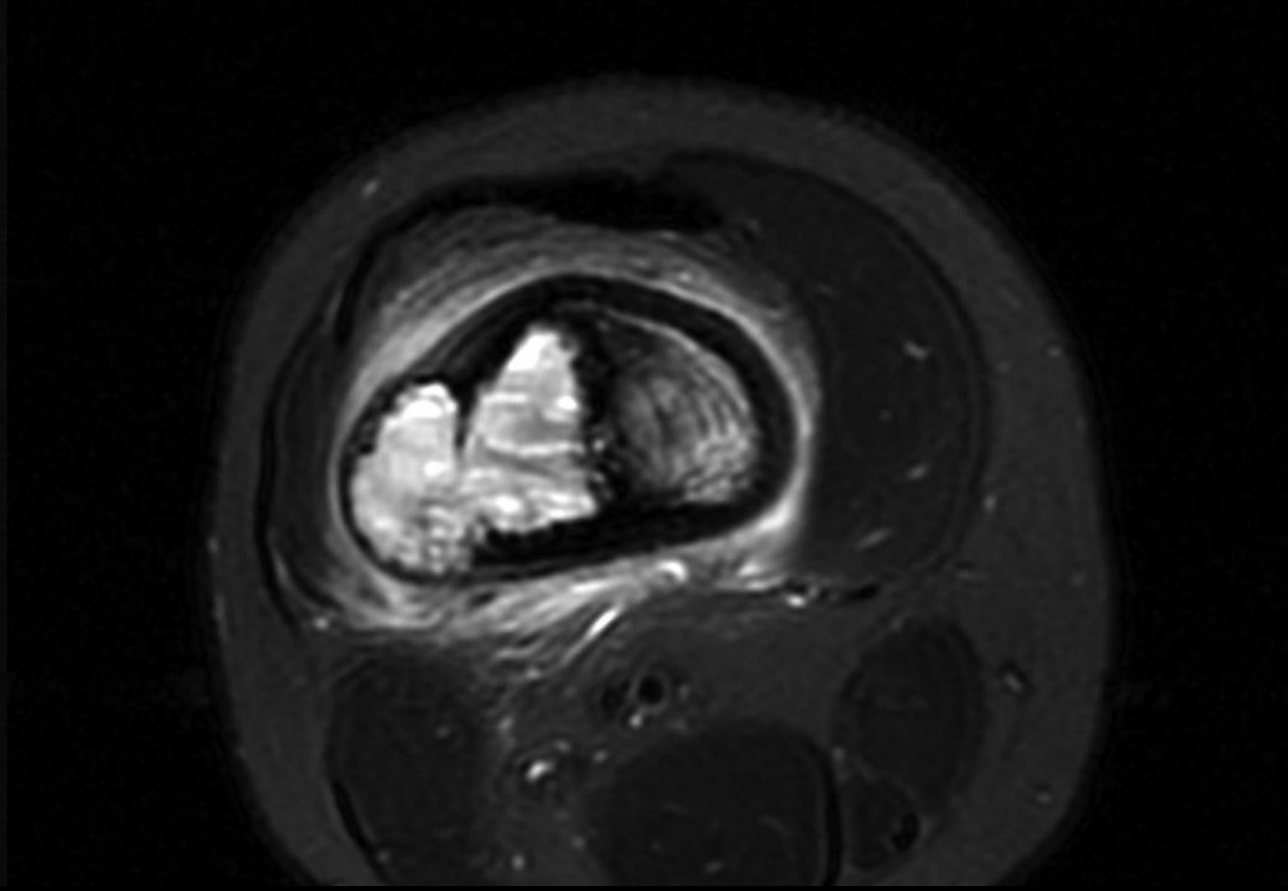
Concerning Features:
Rapid growth
Indistinct margins
Soft tissue mass/invasion
Abnormal periosteal reaction



INDISTINCT MARGINS

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 7527





OSTEOSARCOMA

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 7527

BORDER

WELL-DEFINED, NARROW ZONE OF TRANSITION



Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 7473

ILL-DEFINED, WIDE ZONE OF TRANSITION



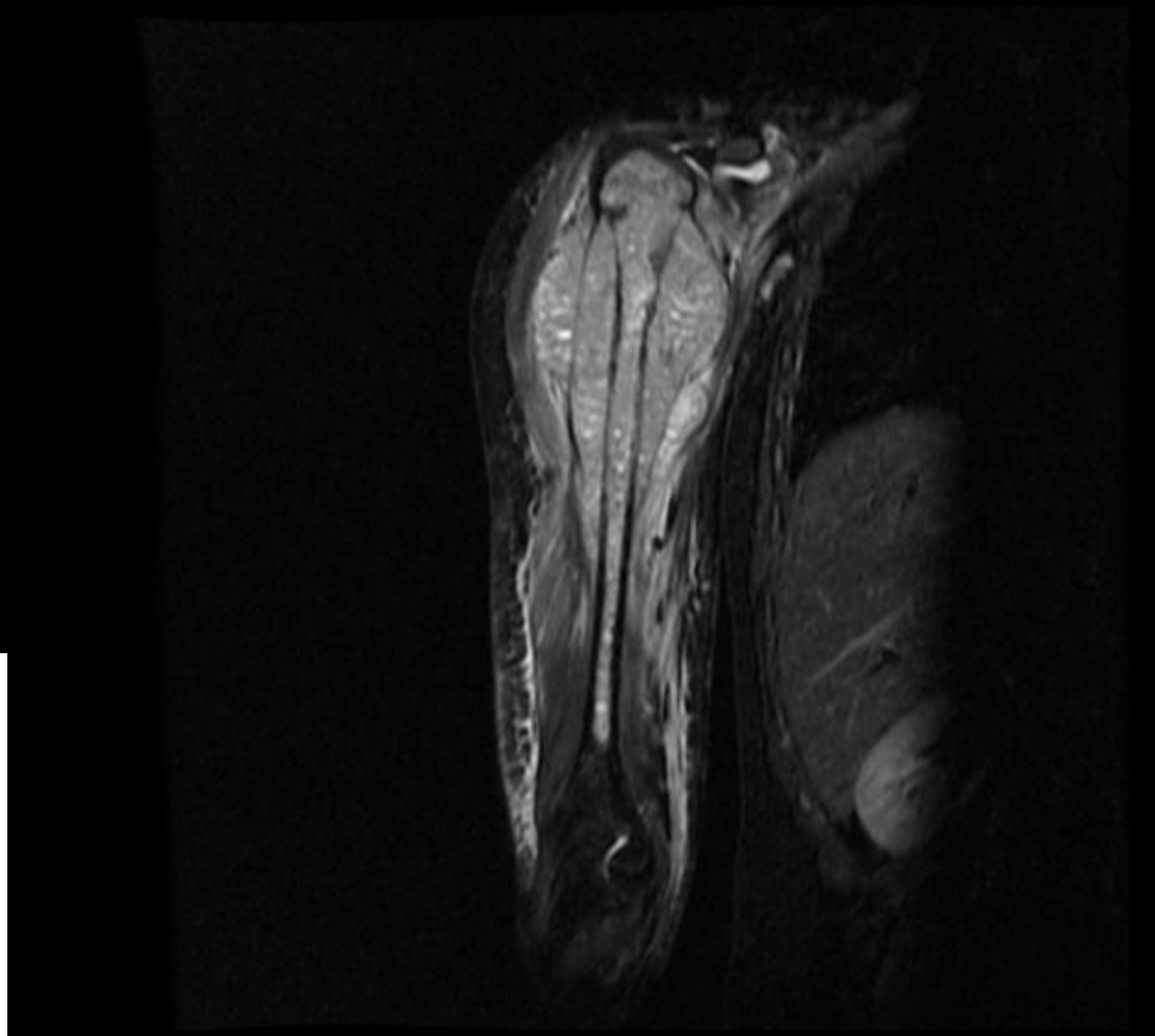
Case courtesy of Dr Hani Salam, Radiopaedia.org, rID: 7874

Images courtesy of Henk Jan van der Woude and Robin Smithuis and Radiology Assistant



SOFT TISSUE INVOLVEMENT

Ewing Sarcoma

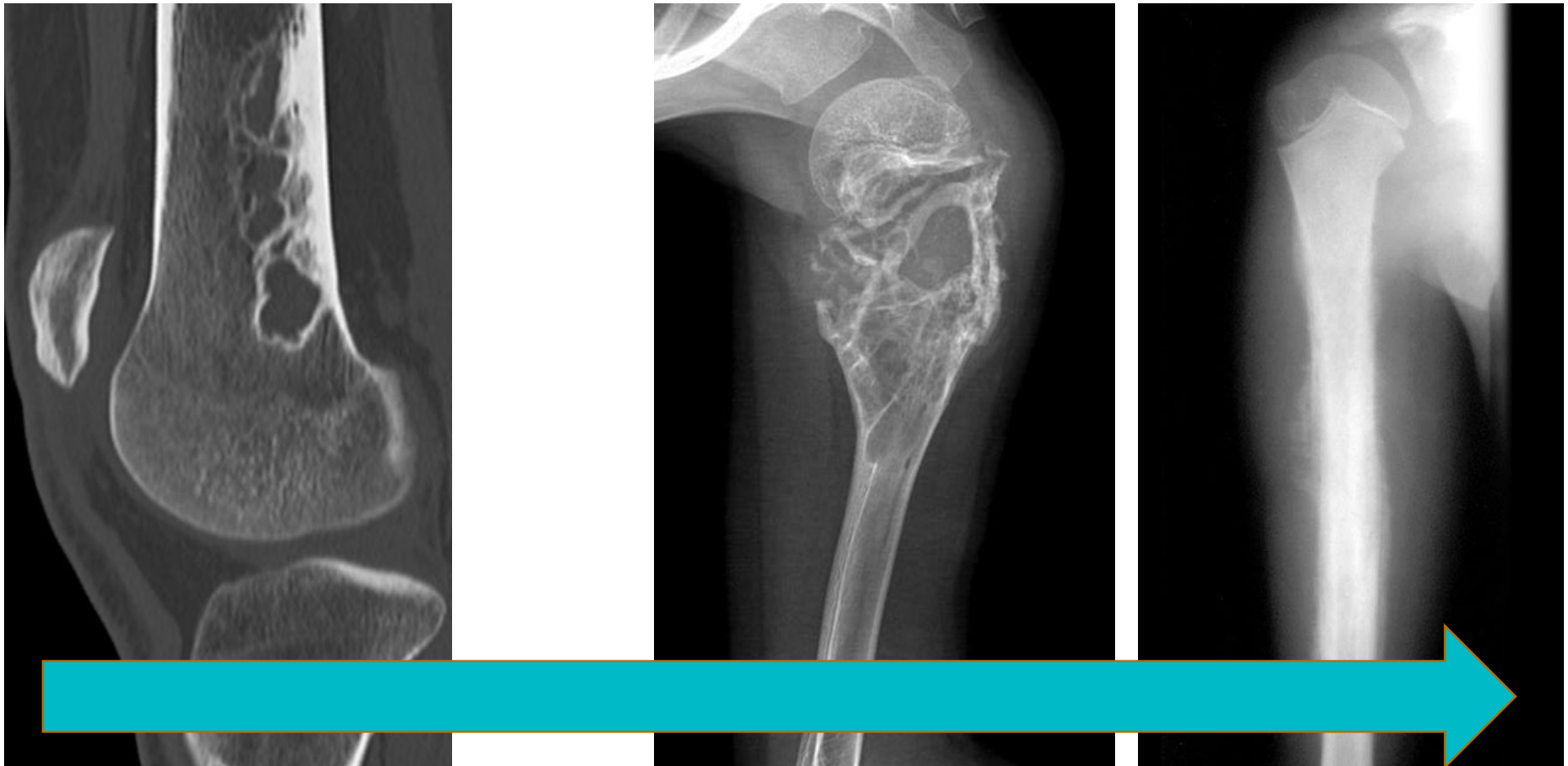


Case courtesy of Dr Hani Salam, Radiopaedia.org, rID: 8024

BONE DESTRUCTION

CONFINED: GEOGRAPHIC

INFILTRATIVE: MOTH-EATEN/PERMEATIVE

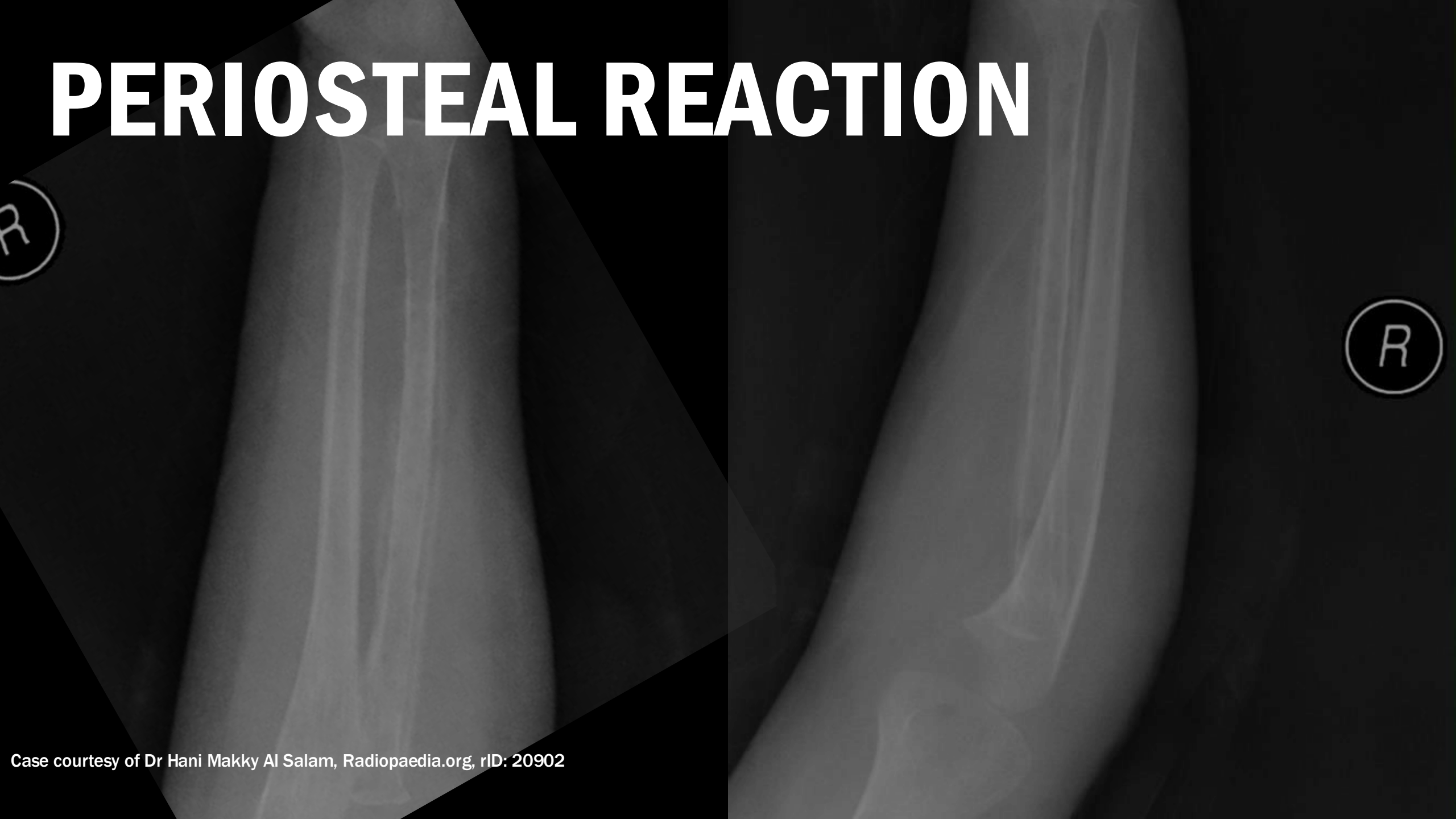


Case courtesy of Dr Roberto Schubert, Radiopaedia.org, rID: 14173

Case courtesy of Dr Hani Salam, Radiopaedia.org, rID: 8002

Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 14003

PERIOSTEAL REACTION



Case courtesy of Dr Hani Makky Al Salam, Radiopaedia.org, rID: 20902

OSTEOMYELITIS



Case courtesy of Dr Hani Makky Al Salam, Radiopaedia.org, rID: 20902

FINAL TIPS

1

Correlate with clinical findings

2

Document potential associated injuries

3

Describing a fracture is far more important than the unique name!

RESOURCES

PAOS: https://paos.org/

AAOS: http://www.aaos.org/

POSNA: https://posna.org/

AAFP: http://www.aafp.org/

Radiopaedia: http://radiopaedia.org/

OrthoBullets: https://www.orthobullets.com

Radiology Assistant: https://radiologyassistant.nl/

Books:

Essentials of Musculoskeletal Imaging

- Johnson TR, Steinbach

Basics of Musculoskeletal Imaging

- Tehranzadeh J

Handbook of Fractures

- Egol KA, Koval KJ, Zuckerman JD