BREAKING IT DOWN: FRACTURE FUNDAMENTALS

Sarah Bolander, DMSc, PA-C, DFAAPA

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 is 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

SCAPHOID FRACTURE

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 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.

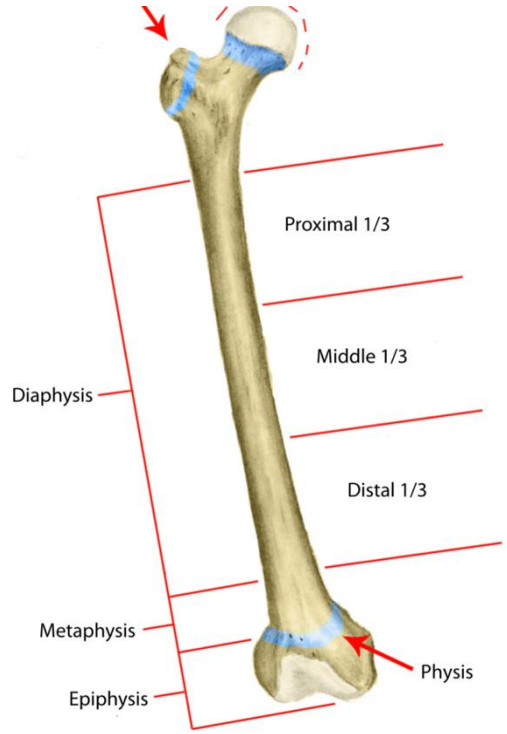
***Does not account for the severity of the injury.*

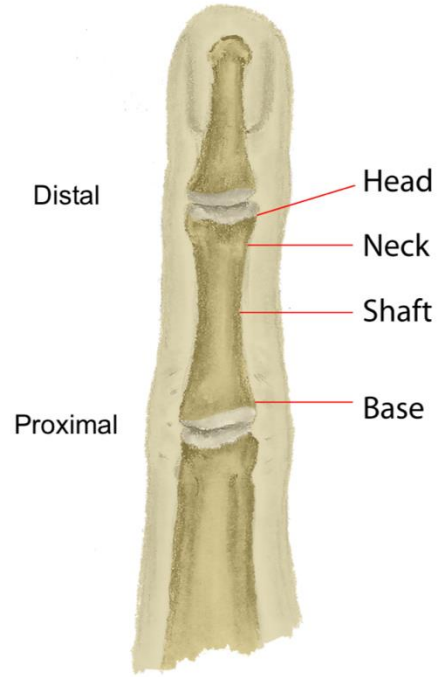
LOCATION

Which bone?

Where in the bone?

Joint involvement?





PSEUDO JONES FRACTURE

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

JONES FRACTURE

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

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

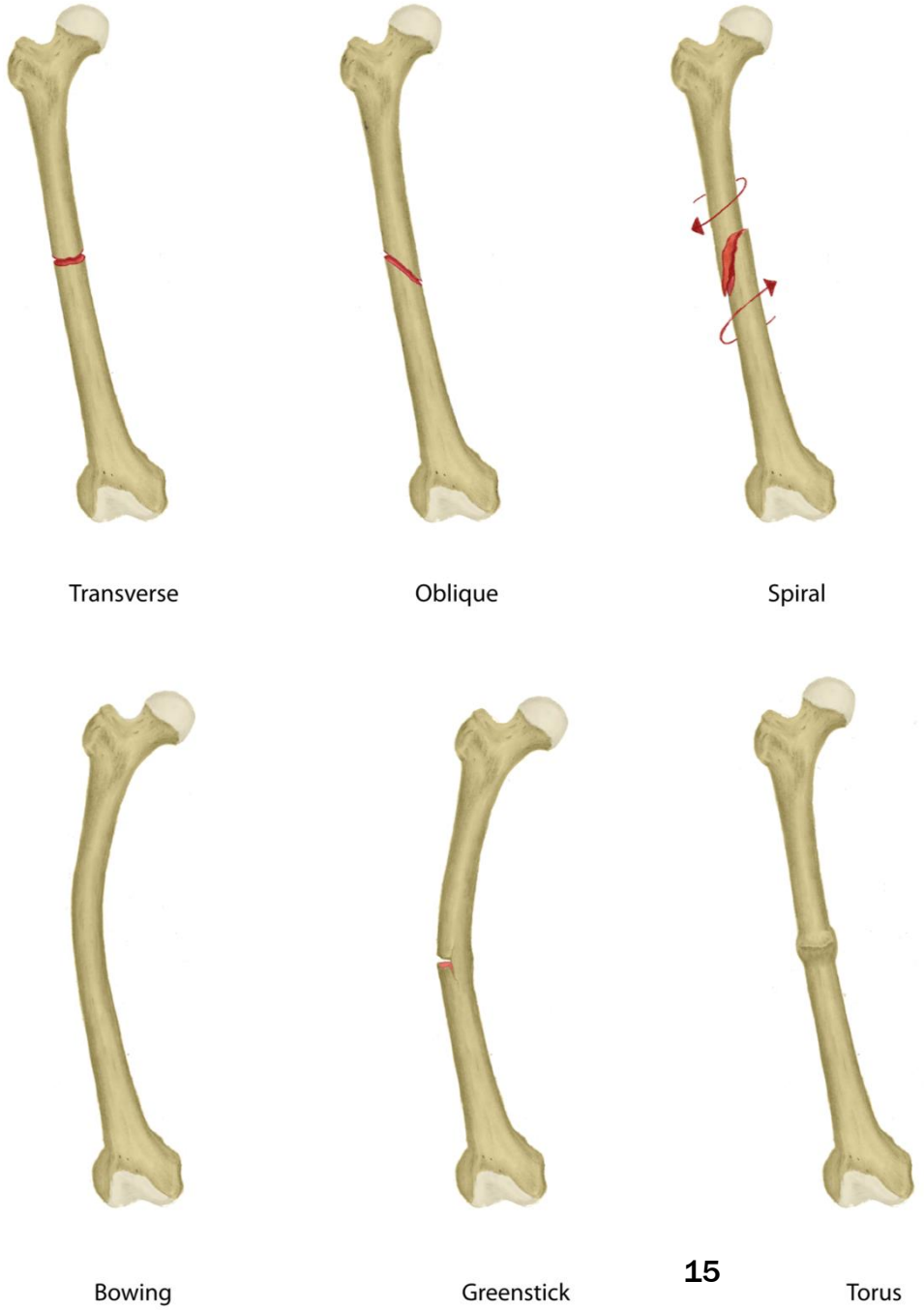
Apophysis

PATTERN

Complete: transverse, oblique, spiral

Incomplete: greenstick, torus, bowing

Unique pattern considerations: compression, impaction, avulsion, stress



Illustrations by Sandra Ehrler, PA-C. Reproduced with Permission.

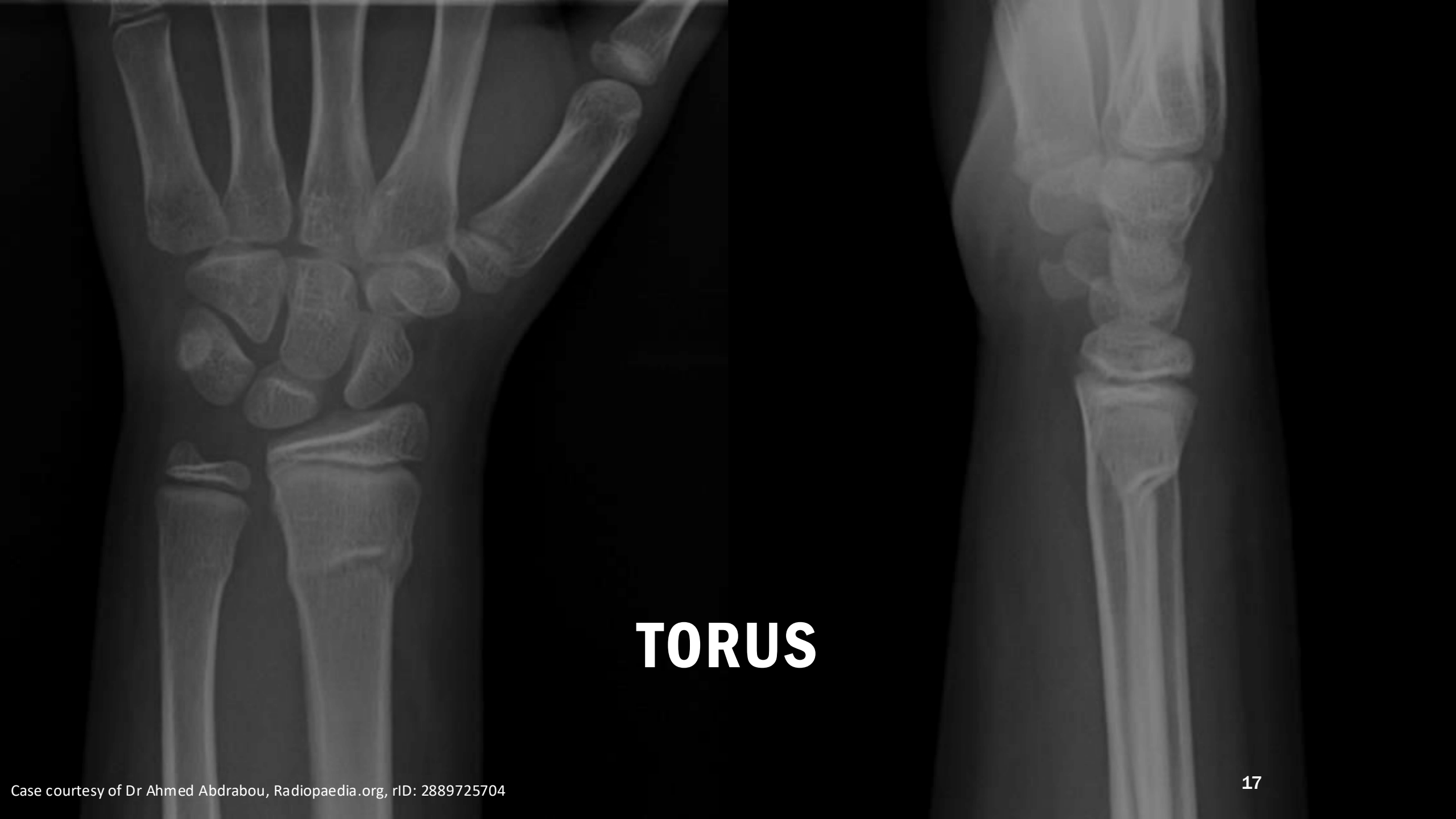
PEDIATRIC PERIOSTEUM

Metabolically more active

- Promotes callus formation
- Remodeling ability

Thicker and more durable

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



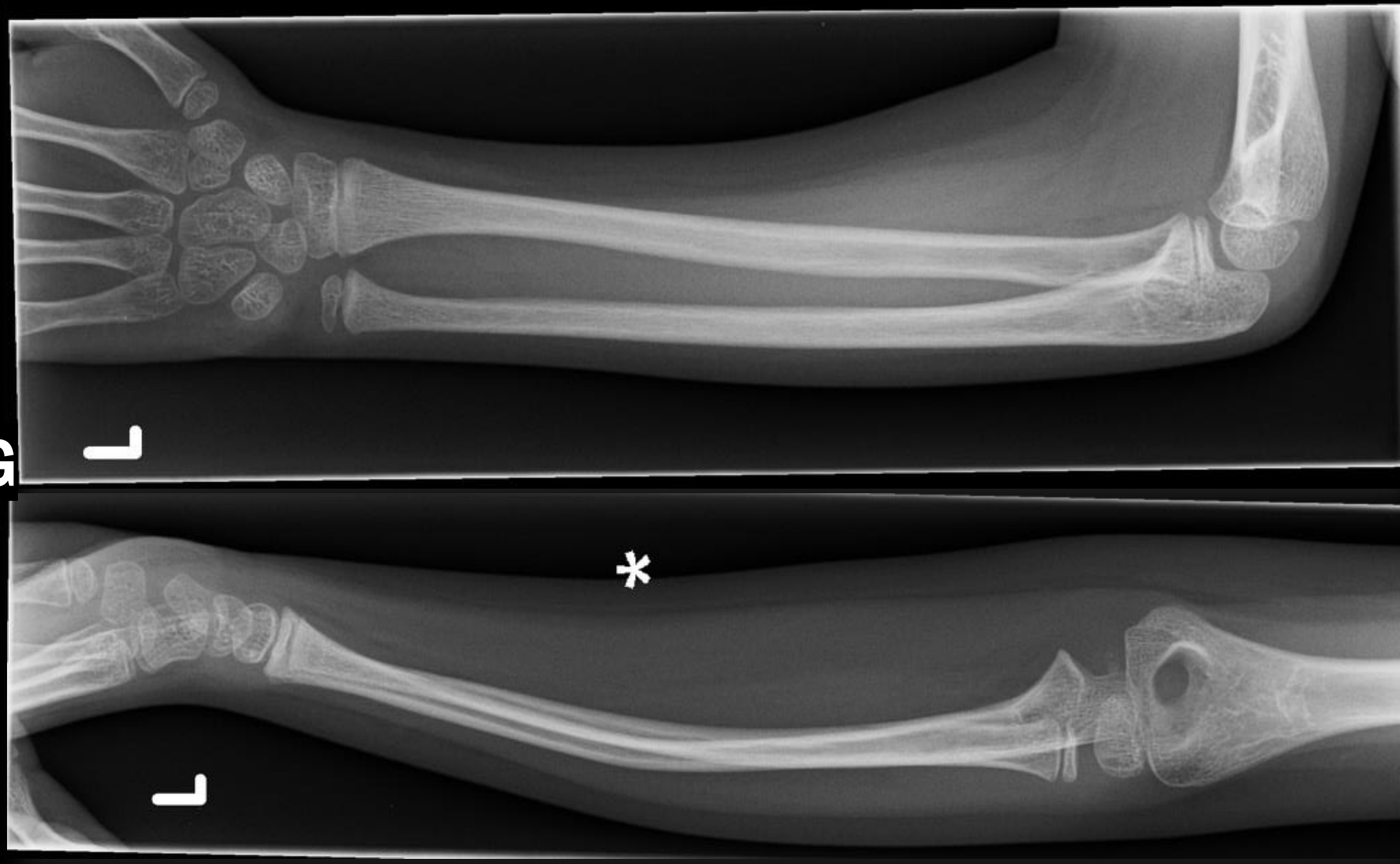
TORUS

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

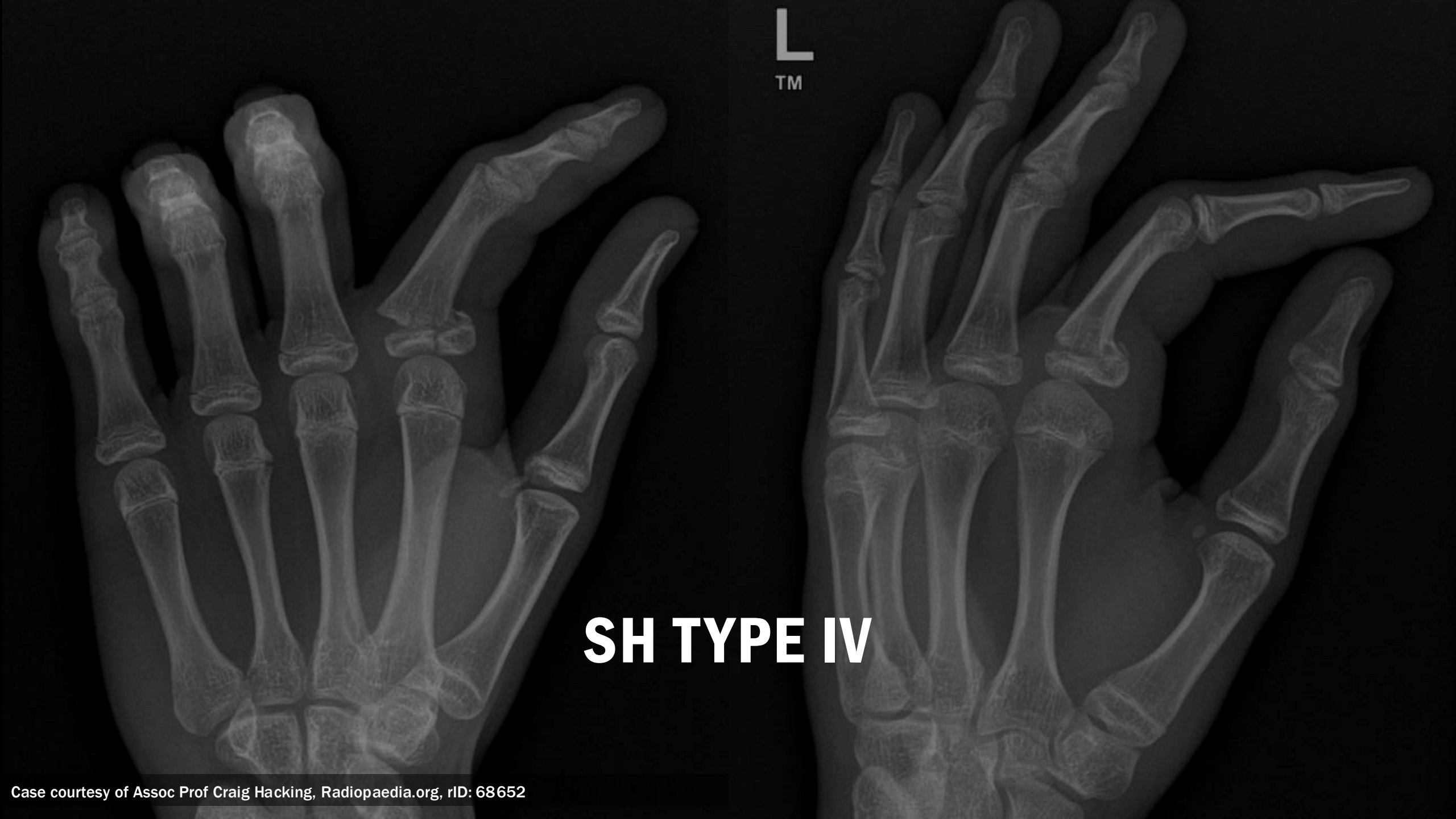
SALTER-HARRIS CLASSIFICATION

Illustrations by Sandra Ehrler, PA-C. Reproduced with Permission


COMPARISON OFTEN IS KEY IN PEDS
SH TYPE I

SALTER HARRIS II

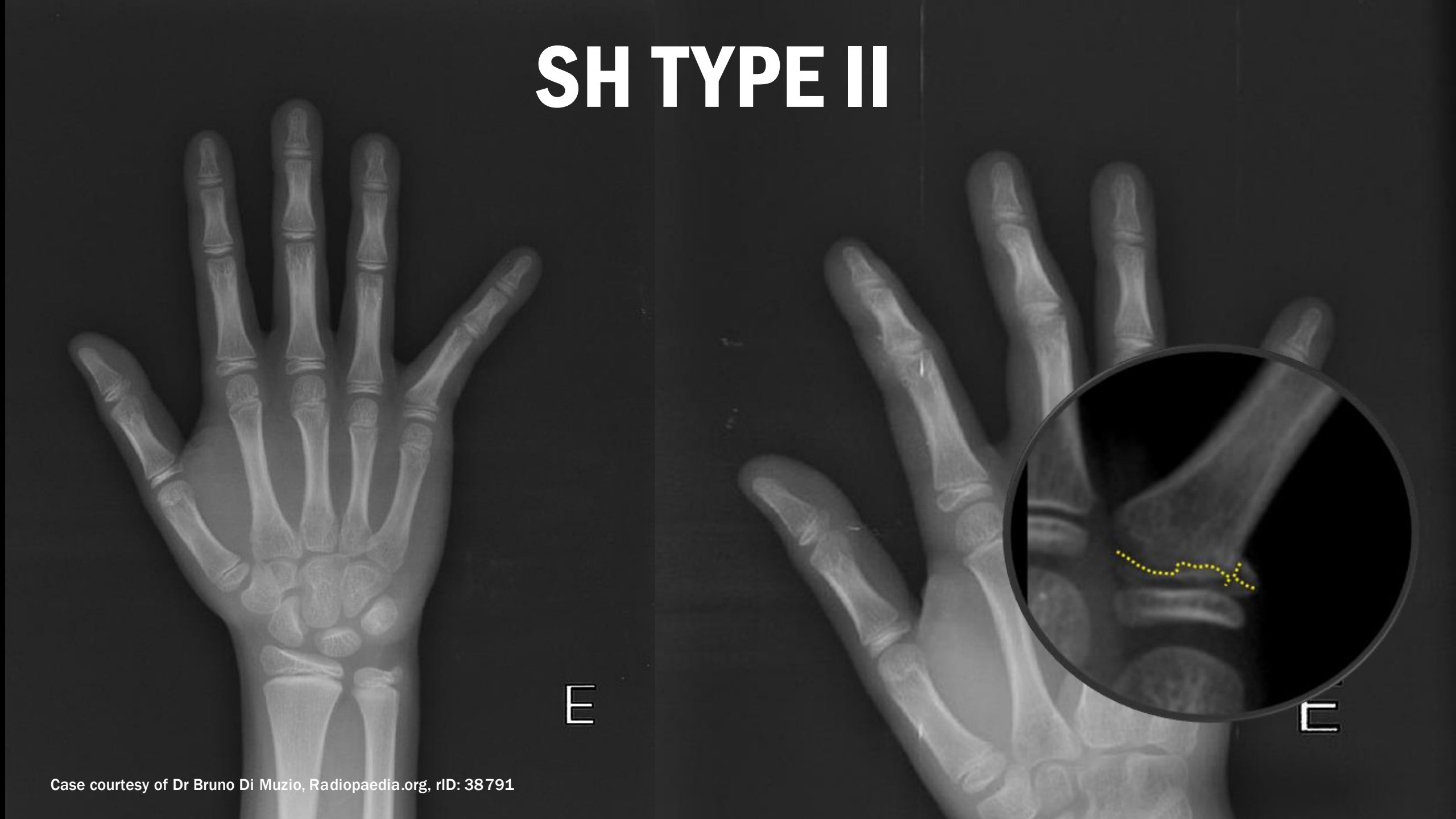
Case courtesy of Miriam Leiderer, Radiopaedia.org, rID: 81838



SH TYPE IV

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

SH TYPE II



Case courtesy of Dr Bruno Di Muzio, Radiopaedia.org, rID: 38791

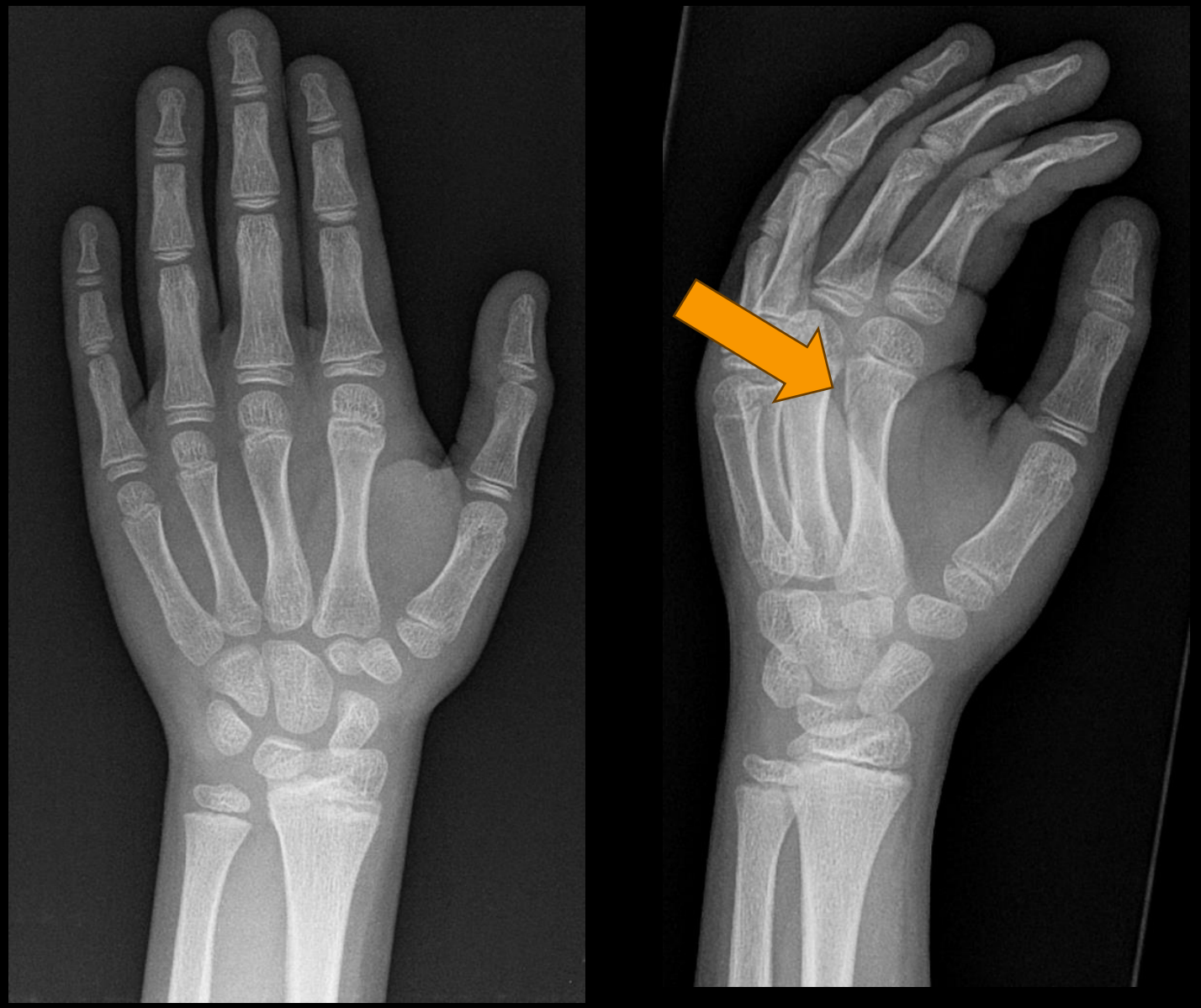
SALTER HARRIS I

Case courtesy of Andrew Dixon, Radiopaedia.org, rID: 30373

SALTER HARRIS III

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

SALTER HARRIS II



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

SALTER HARRIS IV

SALTER HARRIS I

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

SH TYPE I

e courtesy of Dr Mauricio Macagnan, Radiopaedia.org, rID: 47880

SH TYPE III

Case courtesy of Dr Colin-John Perrins, Radiopaedia.org, rID: 58038


R
Tillaux Fracture

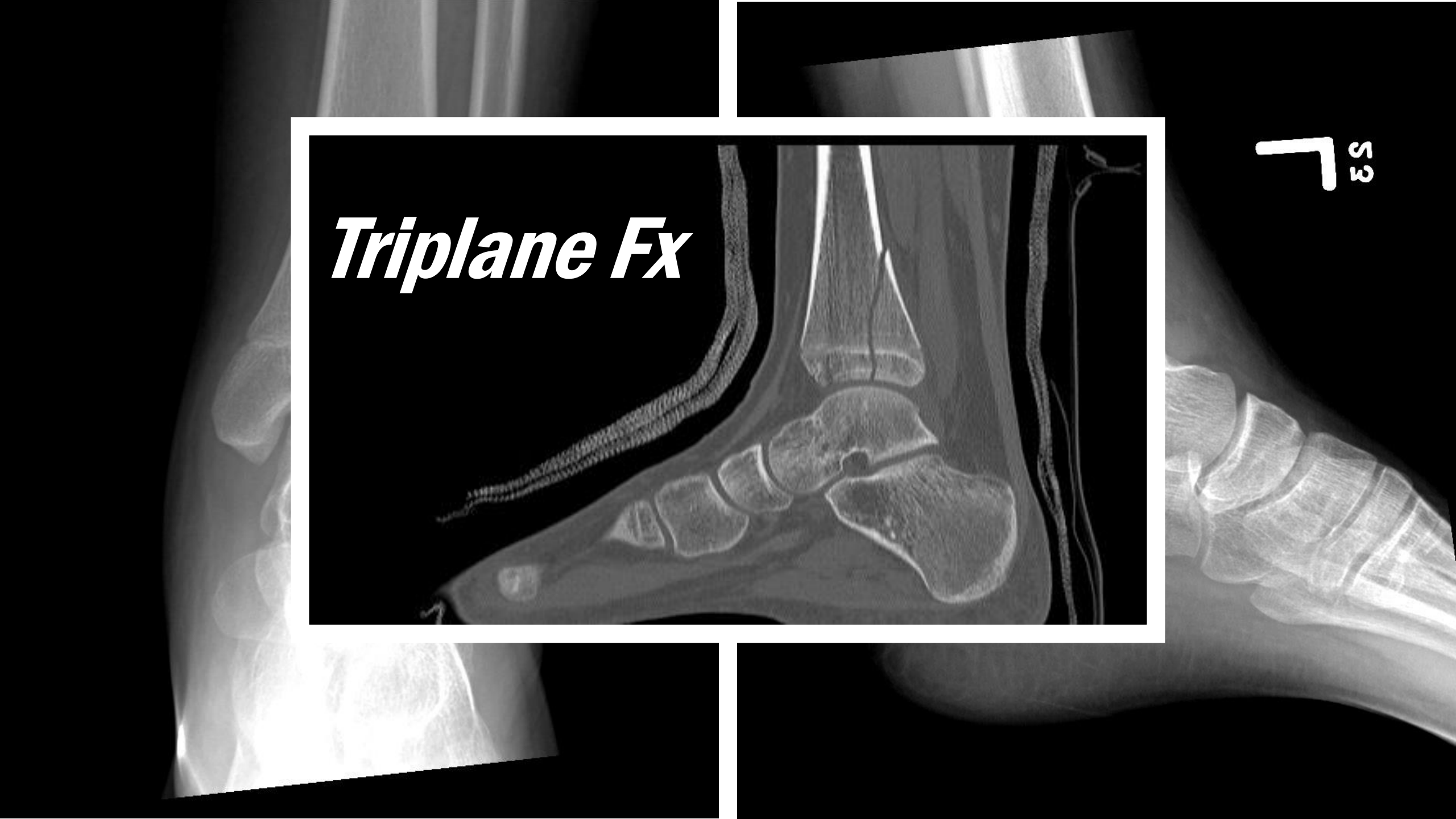
TILLAUX FRACTURE

- 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

WHAT IF THE METAPHYSIS IS INVOLVED?


Triplane Fx

TRIPLANE FX

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

- Name reflects the injury extending along the frontal, lateral, and transverse planes

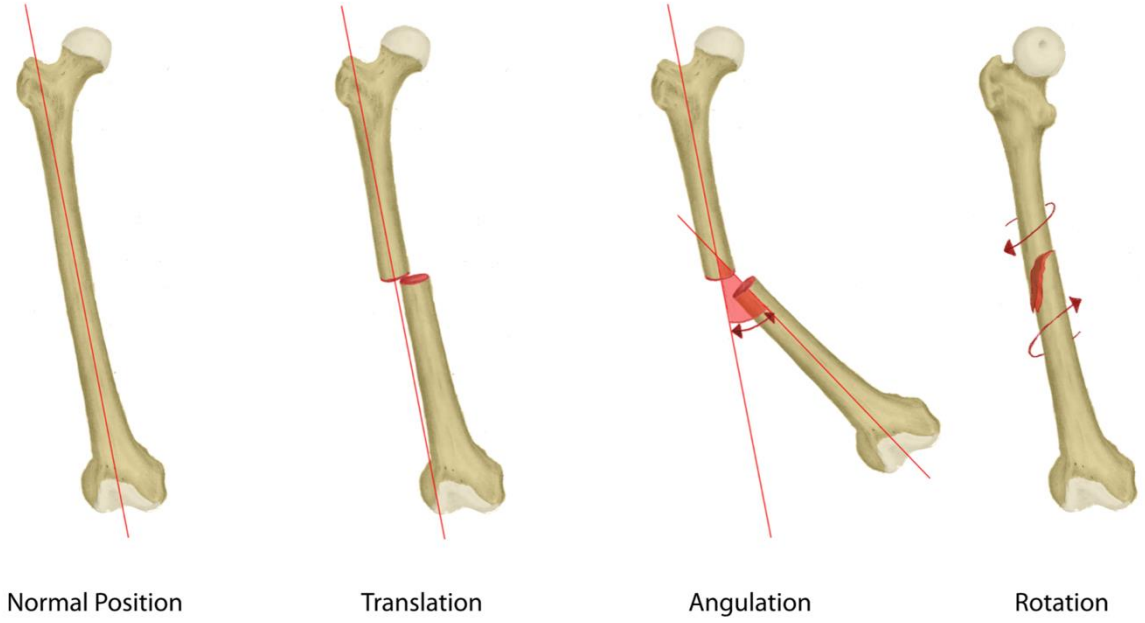
- Pattern: SH IV fracture of the distal tibia
  - Epiphysis: vertical fx
  - Physis: horizontal fx
  - Metaphysis: oblique fx
- MOI: External rotation and supination injury in adolescents as epiphyseal plate is closing

*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)

POSITION



Illustrations by Sandra Ehrler, PA-C. Reproduced with Permission.

Nondisplaced vs Displaced:

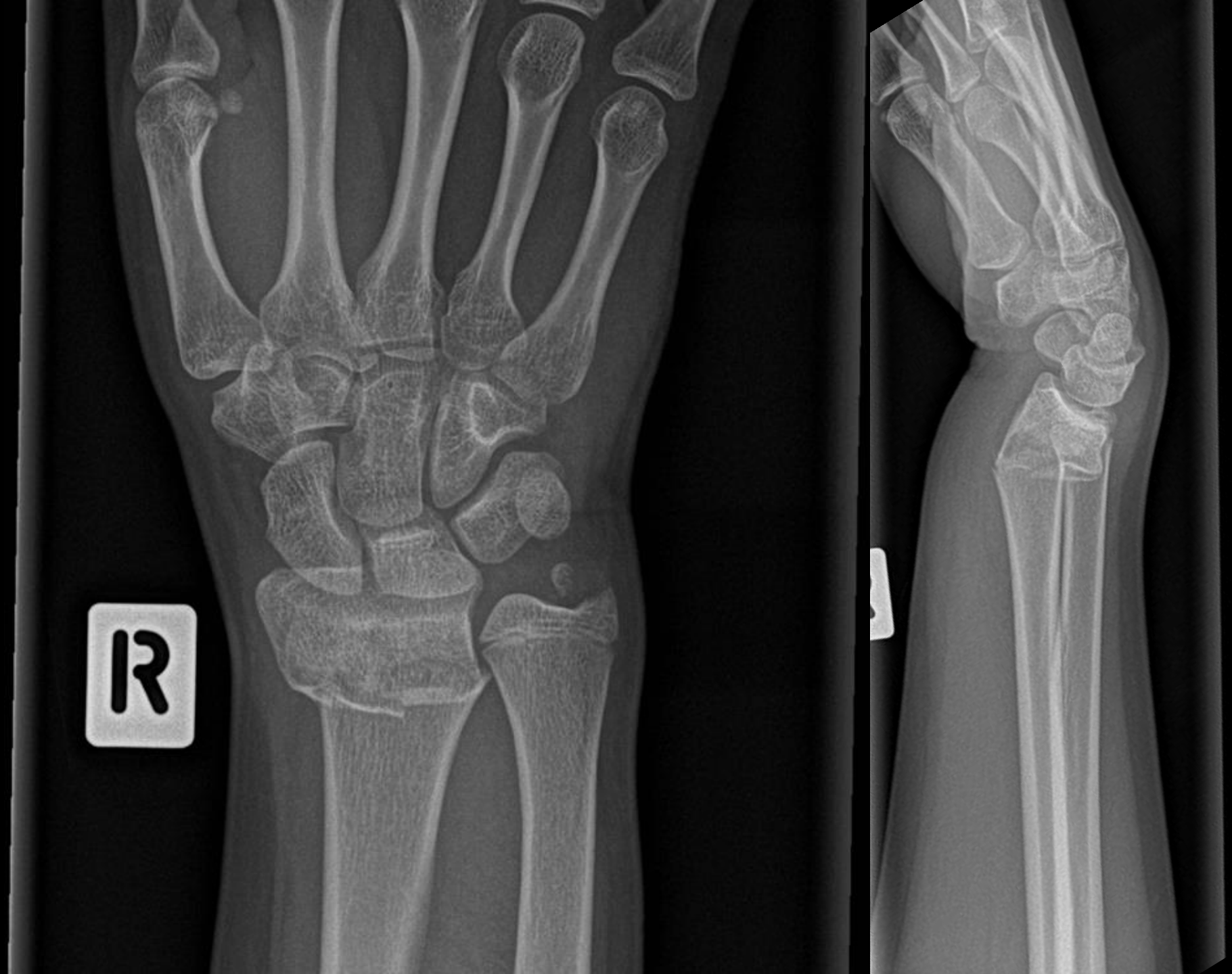
- Translation (Apposition)
- Angulation
- Rotation
- Shortening
- Distraction

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



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

WHAT HAPPENS IF YOU REVERSE THE MOI?

SMITH FRACTURE

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

WHAT IF THERE IS ARTICULAR INVOLVEMENT?

Articular Extension

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

BARTON FRACTURE

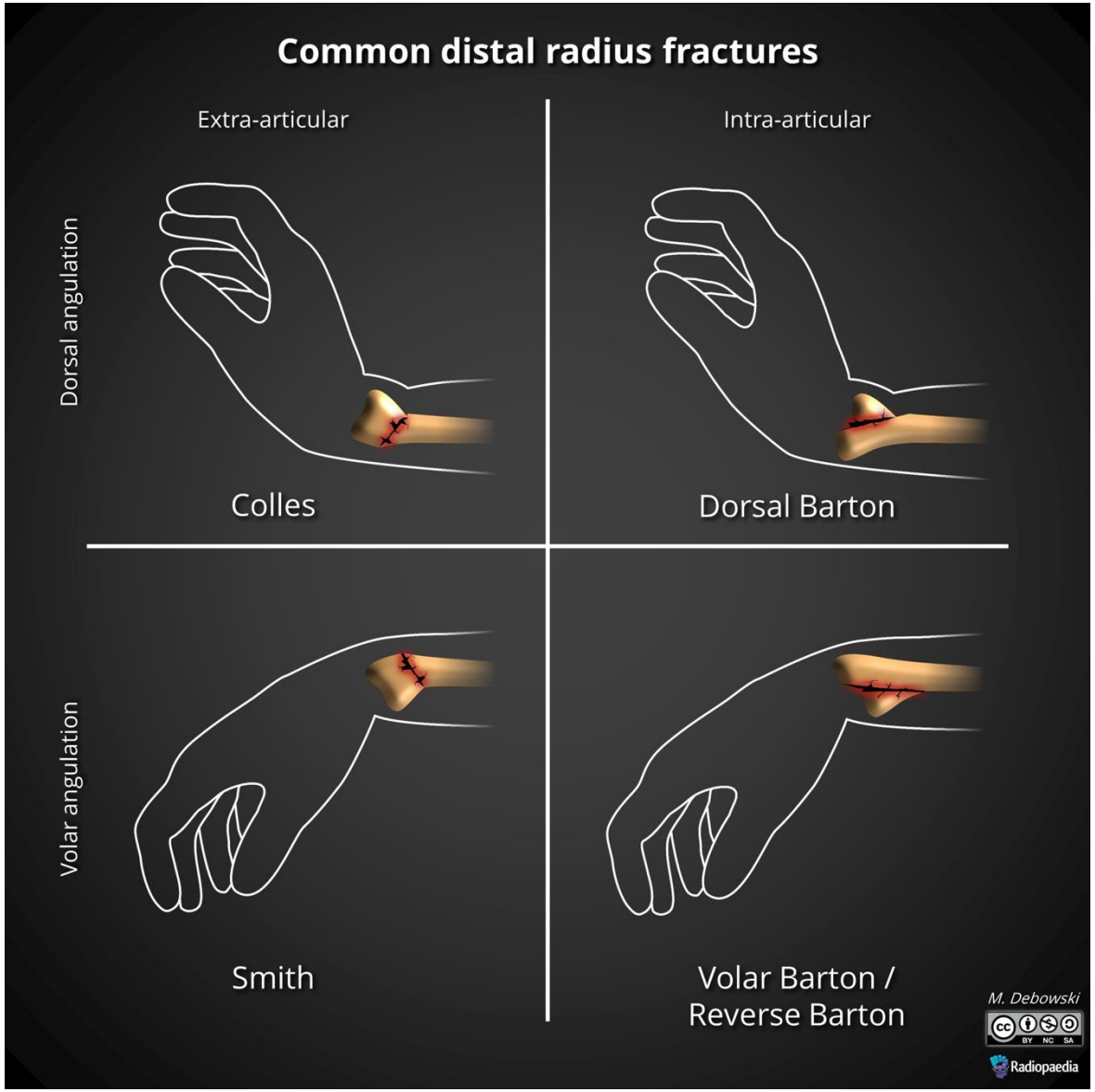
BARTON FRACTURE

- 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



NUMBER OF FRAGMENTS

Simple

- Two fragments

Comminuted

- More that two fragments

BENNETT FRACTURE

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

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


WHAT IF THE FRACTURE IS COMMINUTED?

ROLANDO FRACTURE

Case courtesy of Dr Maulik S Patel, Radiopaedia.org, rID: 48712

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


?
WHAT CAN WE NOT MISS?

ADDITIONAL INJURIES

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 8012

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

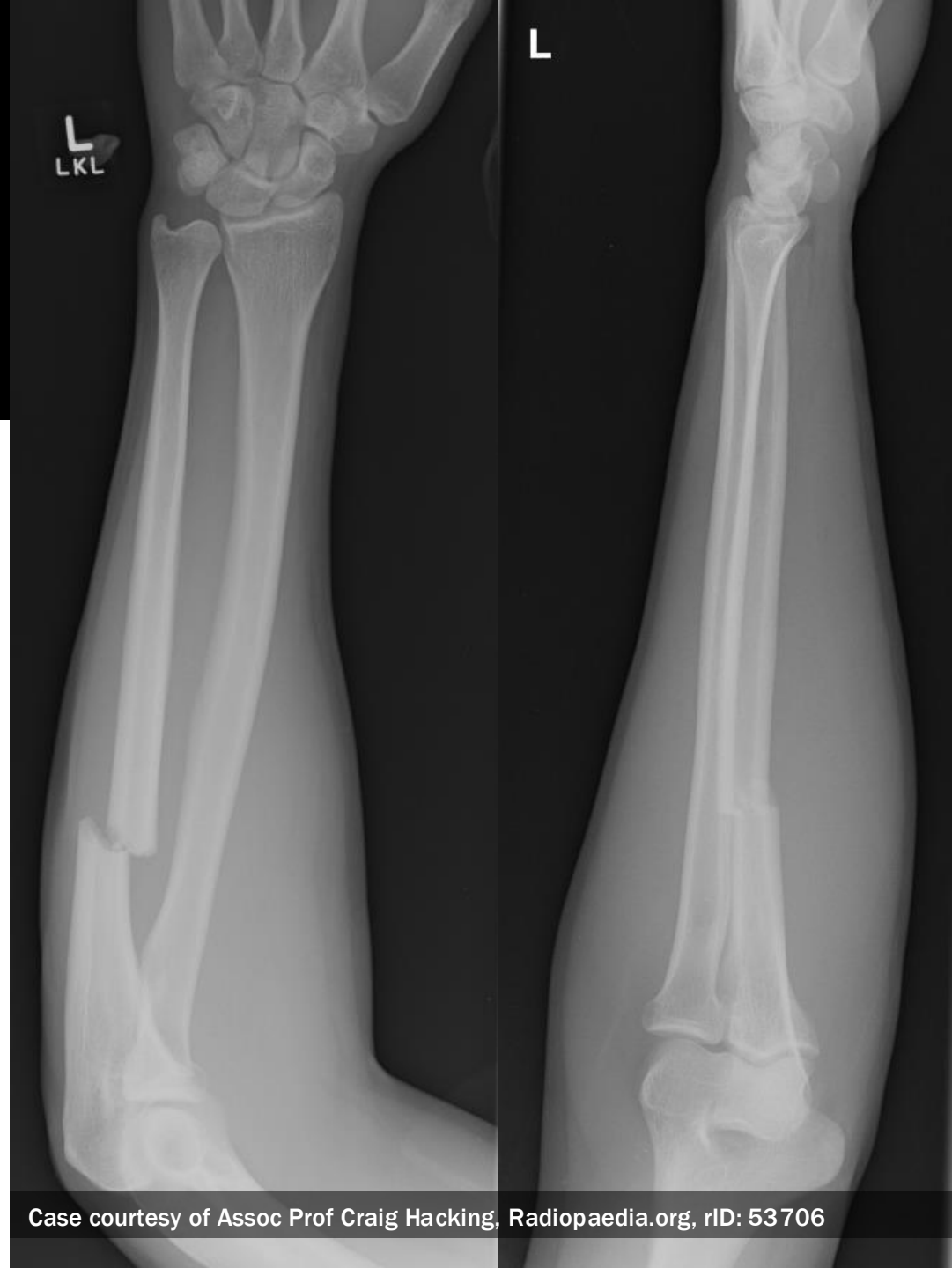
Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 80

Nightstick Fracture

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

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

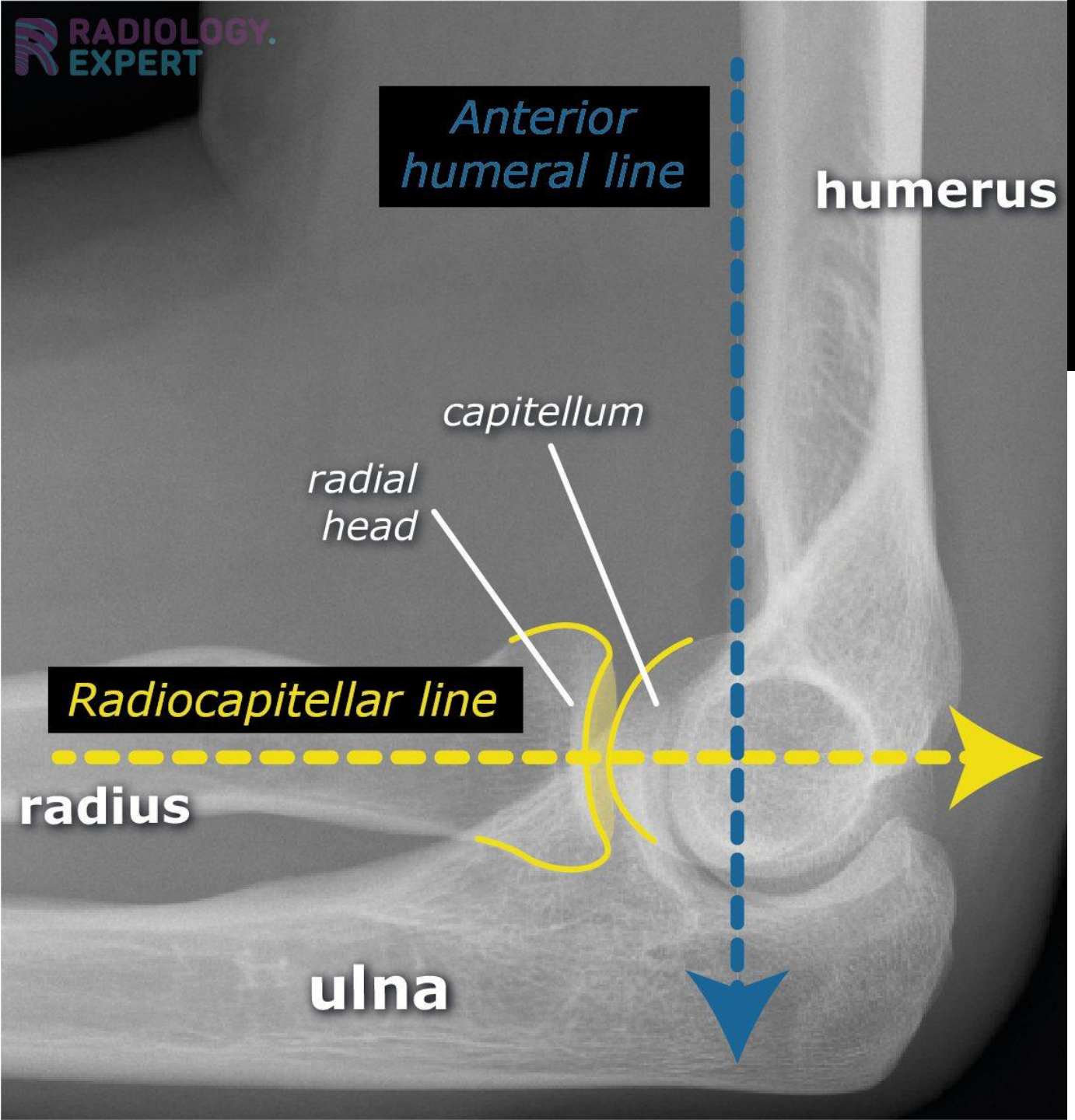
Rare in kids: consider Galeazzi equivalent

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

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

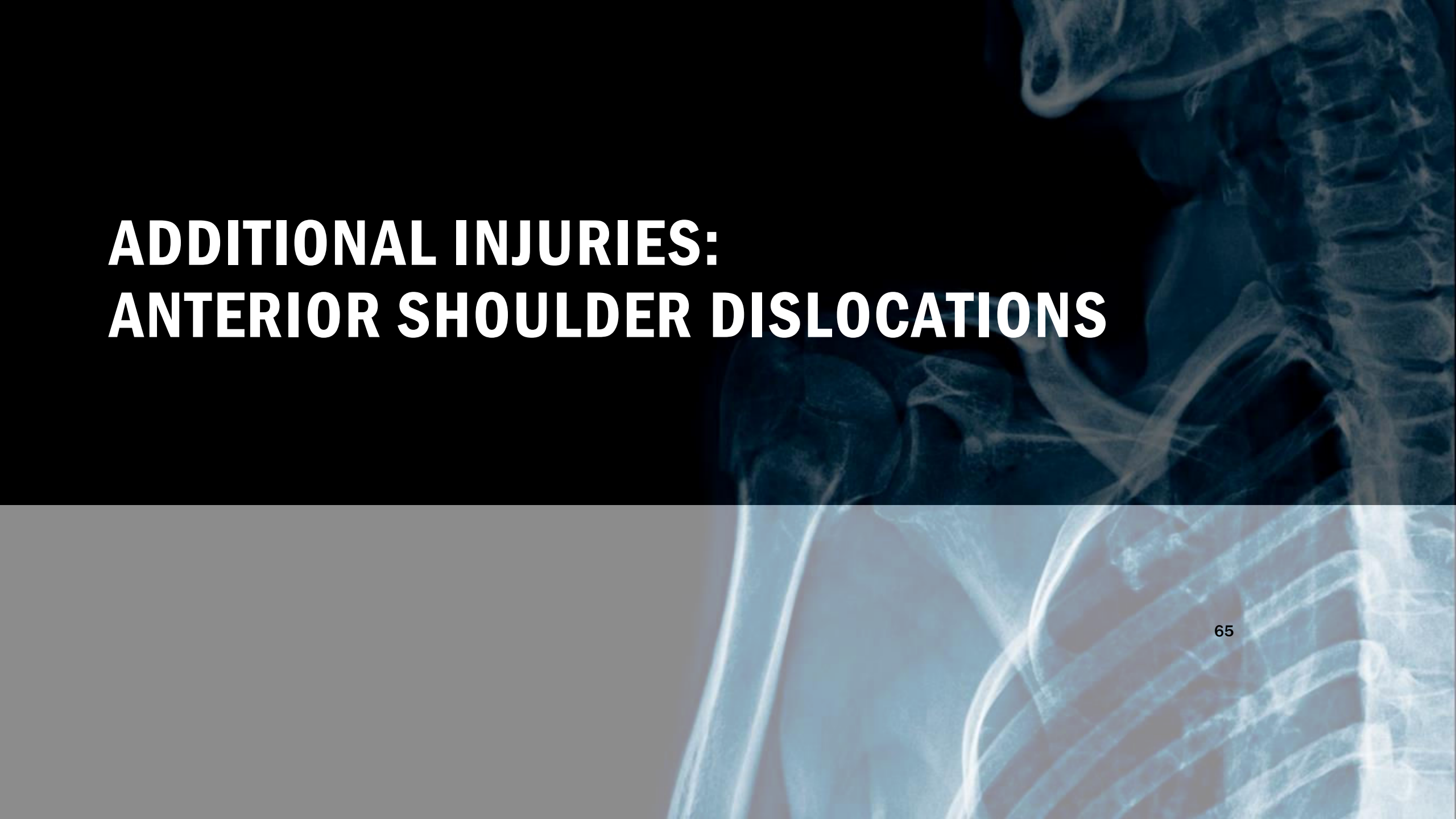
FOREARM FRACTURES: PEARLS TO AVOID PITFALLS

- 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

HILL SACHS DEFECT

- Pattern: impaction fracture of the posterolateral humeral head
- MOI: Anterior shoulder dislocations
  - Impaction- 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

COMMONLY ASSOCIATED WITH WHAT OTHER EPONYM?

BANKART LESION

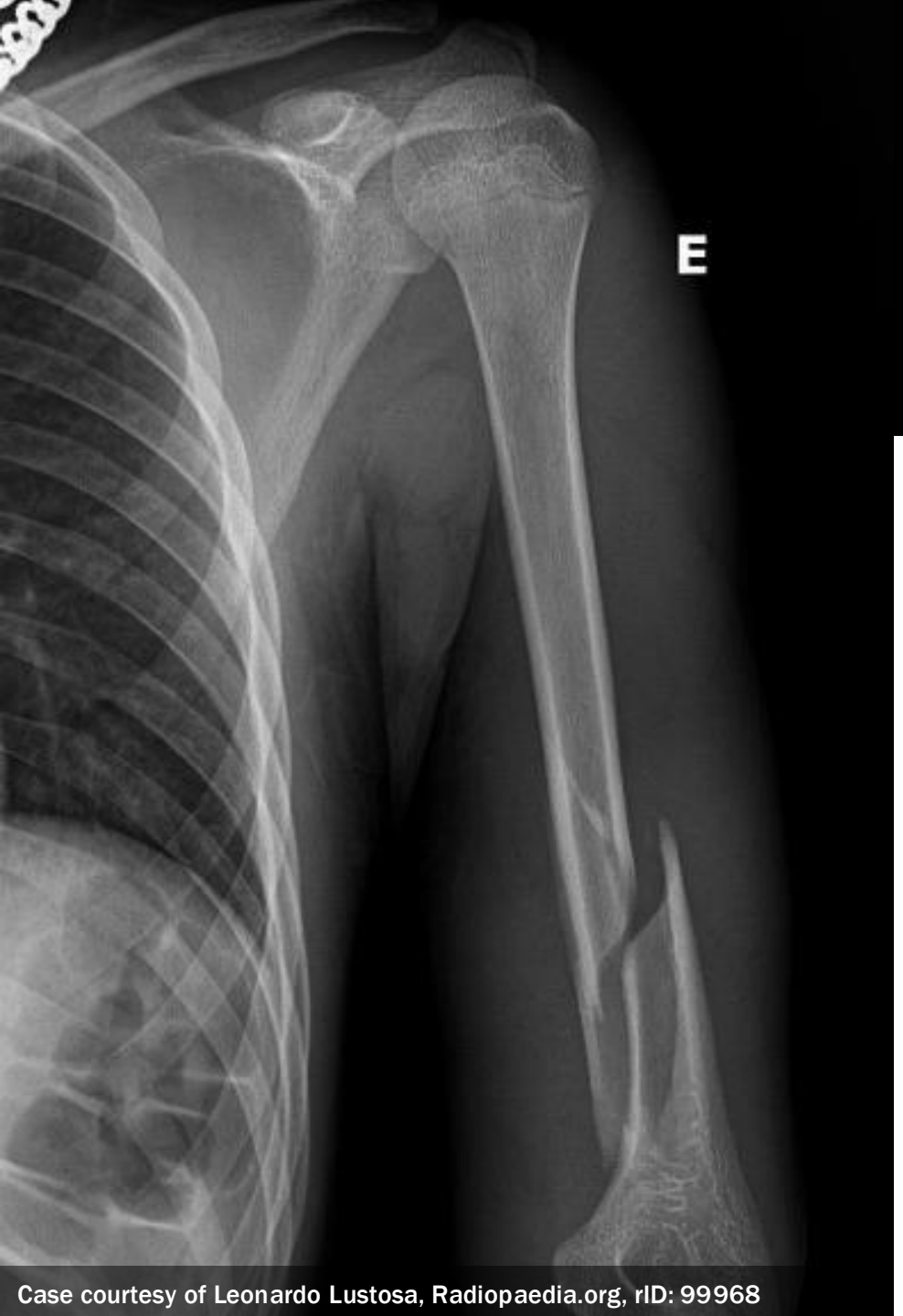
BANKART LESION

- 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

WHAT ADDITIONAL INJURY IS ASSOCIATED WITH THIS FRACTURE PATTERN?



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

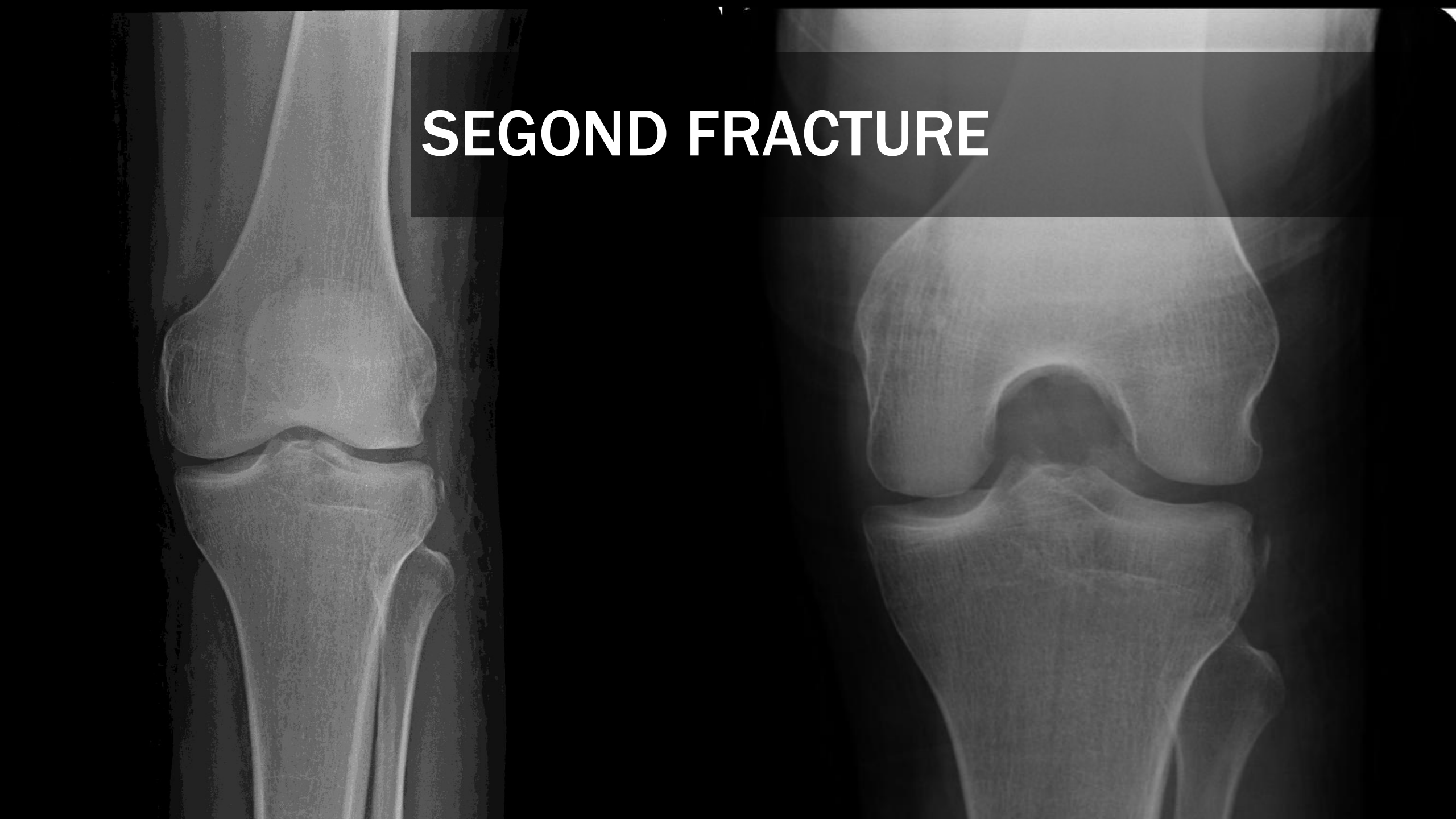
HOLSTEIN-LEWIS FRACTURE

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

*Increased risk of radial nerve palsy

LOWER EXTREMITY: ASSOCIATED INJURIES

SEGOND FRACTURE



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

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

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

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

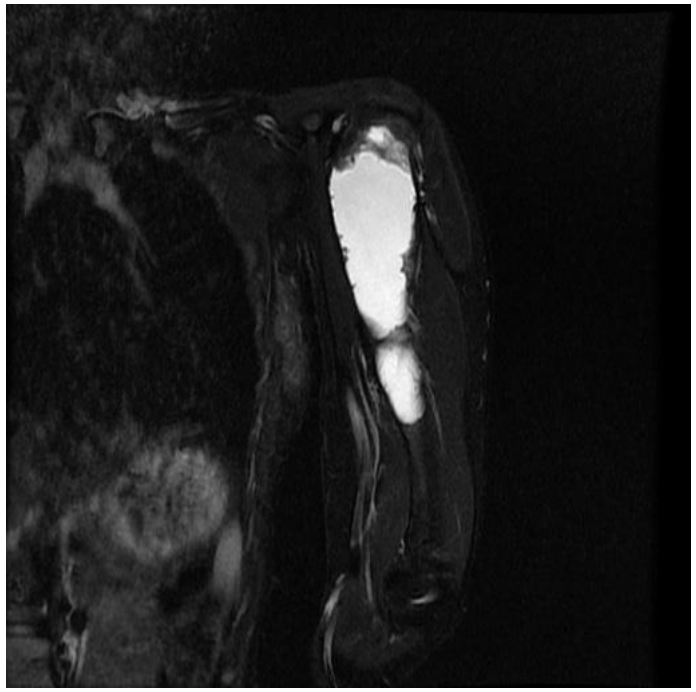
CASES WITH CONCERNING FEATURES ON IMAGING

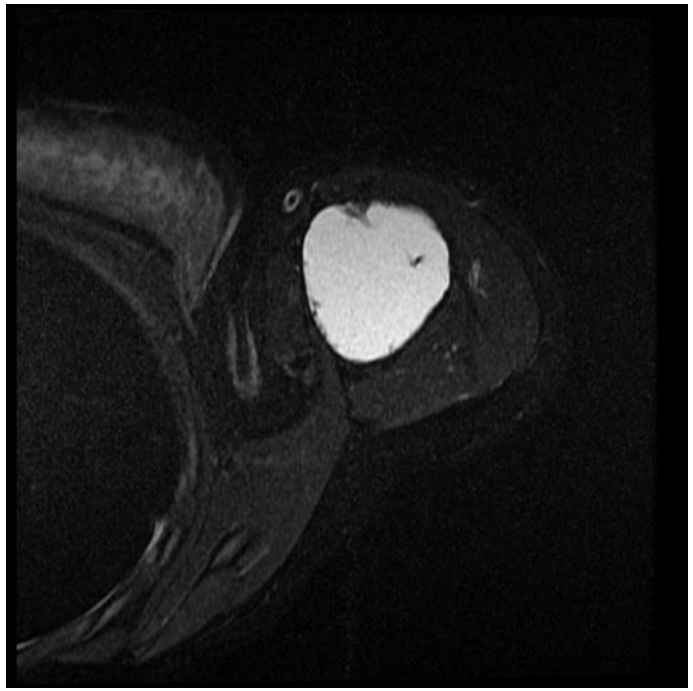
Images courtesy of Henk Jan van der Woude and Robin Smithuis and Radiology Assistant

UNICAMERAL BONE CYST (UBC)

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

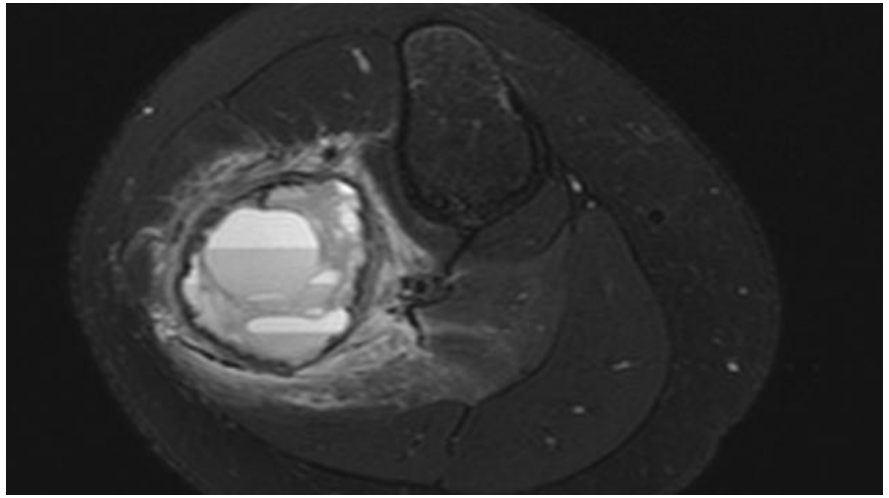
MRI: UBC





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

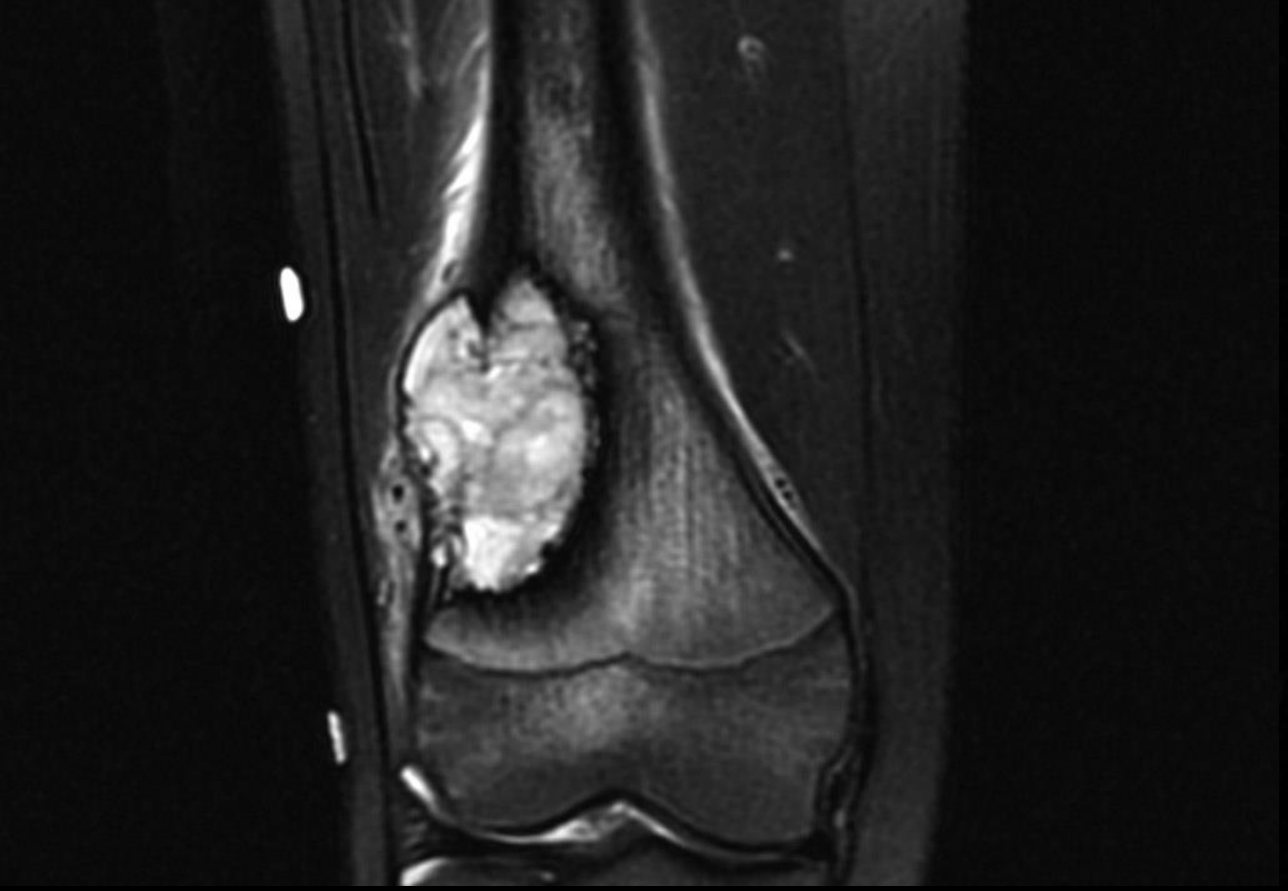
Bone Scan (Technetium Tc 99m): Sensitive for new bone formation

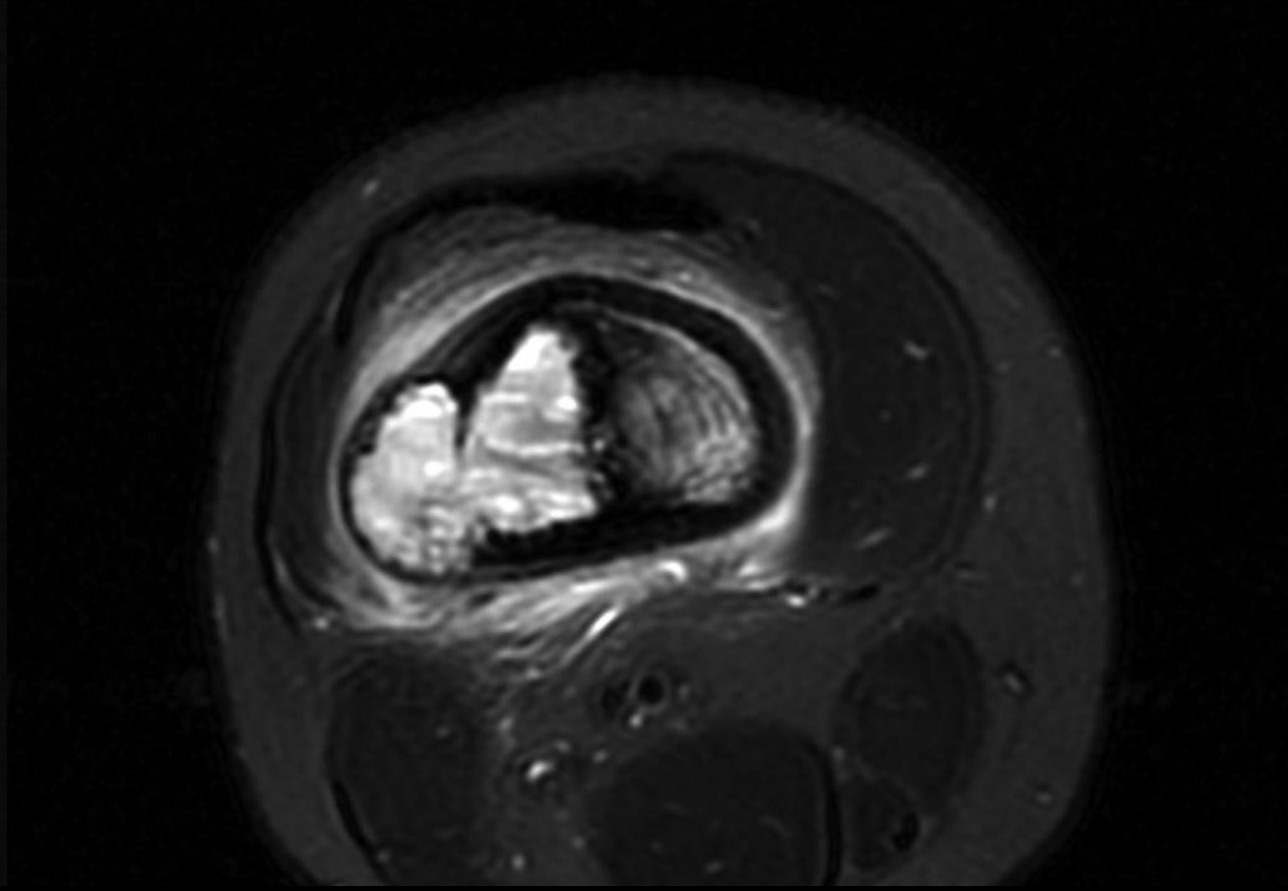
BONE TUMORS AND LESIONS

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

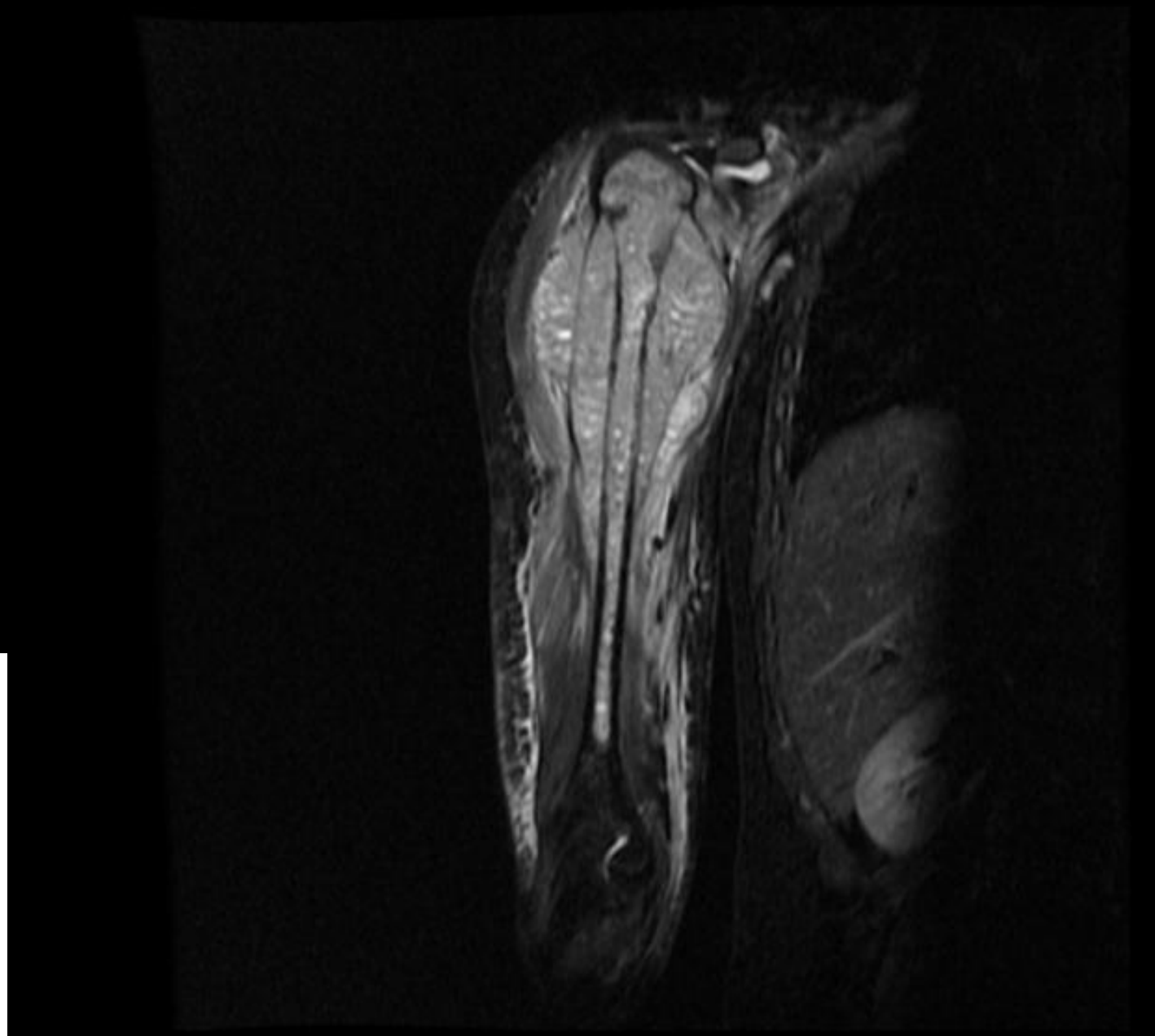
ILL-DEFINED, WIDE ZONE OF TRANSITION

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

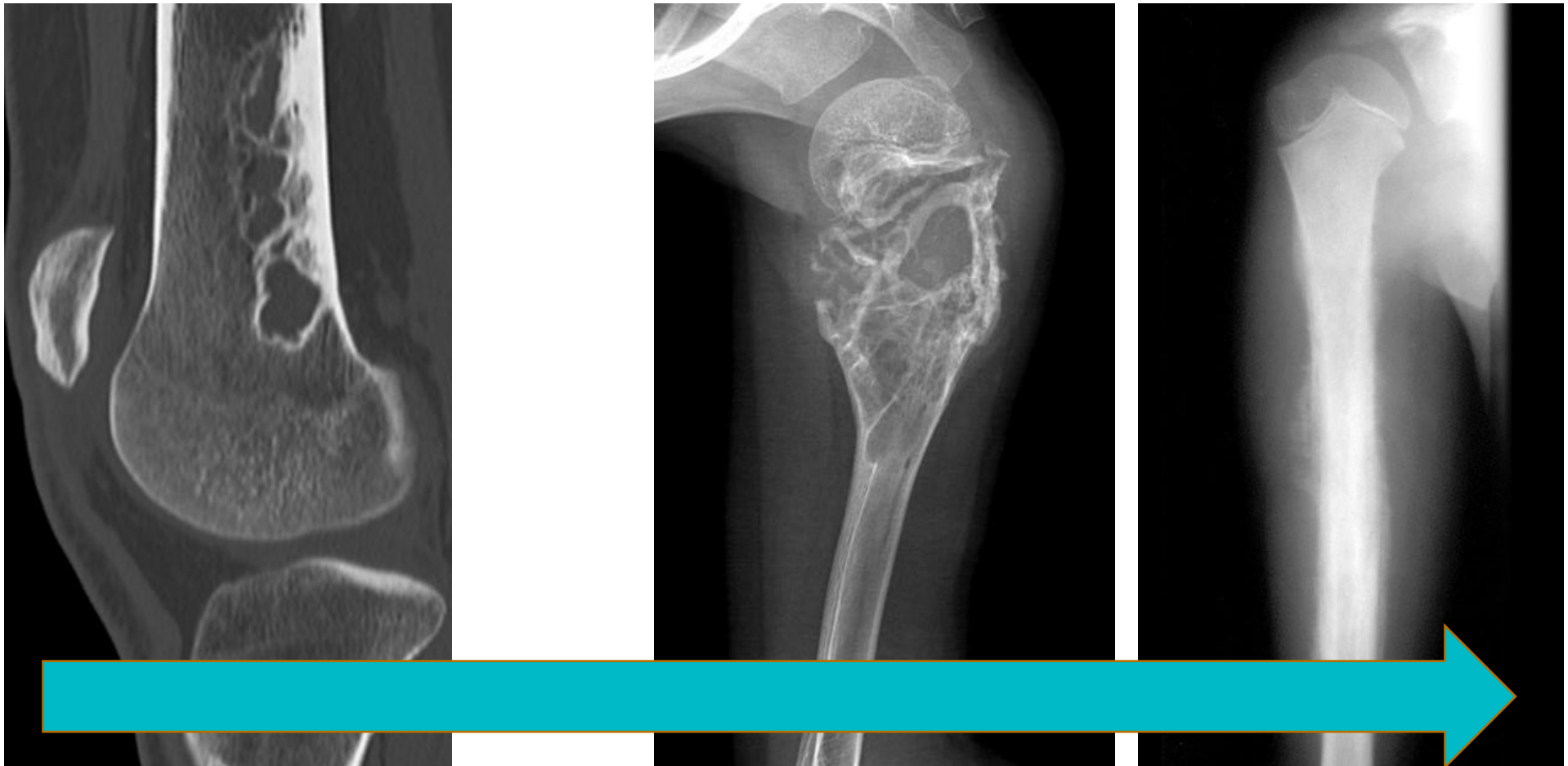


Case courtesy of Dr Hani Salam, Radiopaedia.org, rID: 8024

BONE DESTRUCTION

CONFINED: GEOGRAPHIC

INFILTRATIVE: MOTH-EATEN/PERMEATIVE

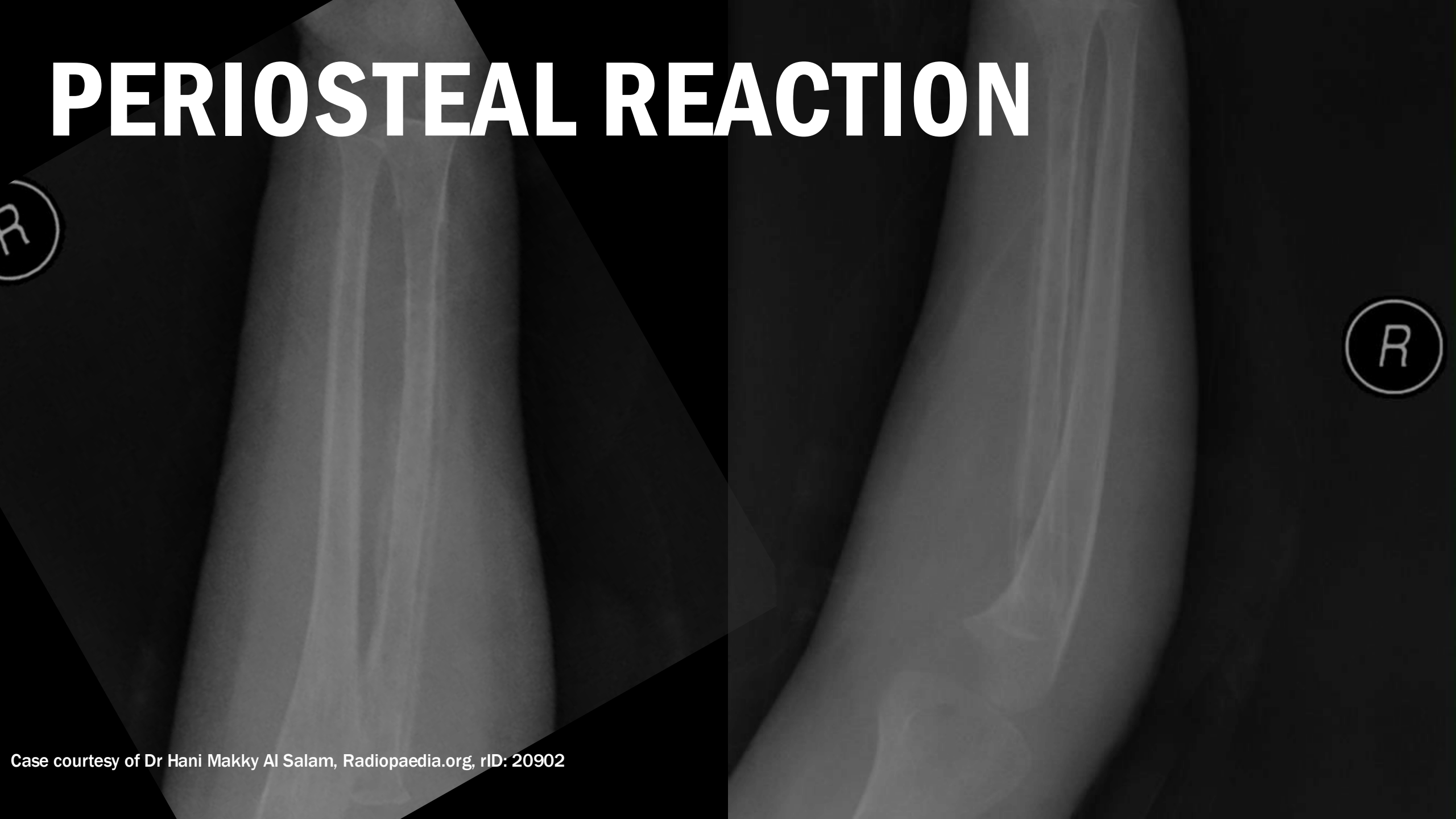


Case courtesy of Dr Roberto Schubert, Radiopaedia.org, rID: 14173

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

WHEN FRACTURES BECOME RED FLAGS

NON-ACCIDENTAL TRAUMA

Suspected Physical Abuse (SPA)

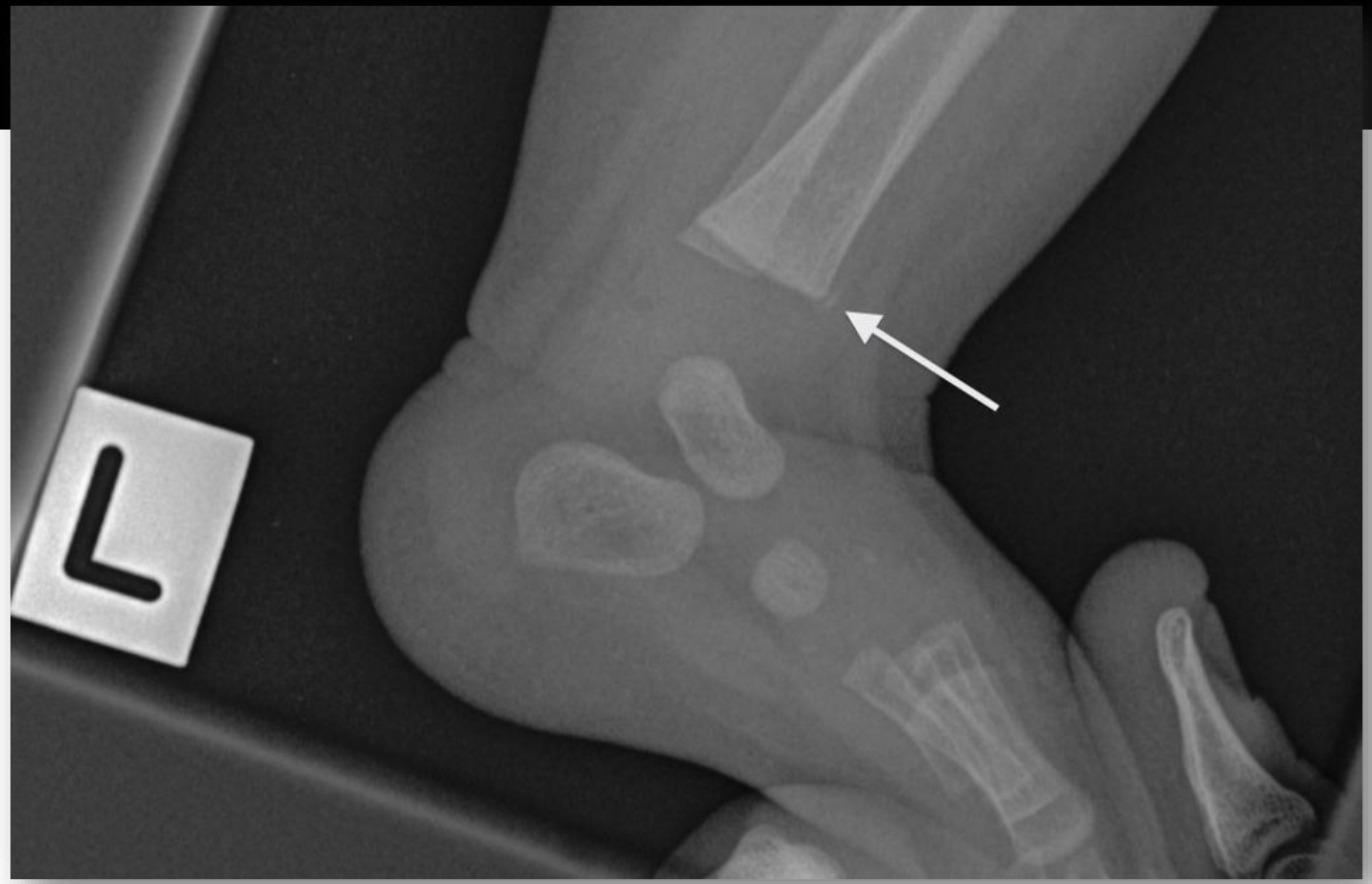
Inflicted Injury (II)

Always Concerning:

- Posterior rib, skull, sternum, scapula fractures
- Non-ambulatory injuries
- Bucket handle/corner metaphyseal fx

BUCKET HANDLE OR CORNER FRACTURE

Case courtesy of Dr Hani Makky Al Salam, Radiopaedia.org, rID: 13614



Case courtesy of Dr Jan Frank Gerstenmaier, Radiopaedia.org, rID: 22589

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, Steinback LS

Basics of Musculoskeletal Imaging

- Tehranzadeh J

Handbook of Fractures

- Egol KA, Koval KJ, Zuckerman JD