Basics of Musculoskeletal Imaging: What Am I looking At?

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Disclosures

- No Financial Disclosures

Introduction

- Importance of Accurate Fracture Description
  - Effective communication among providers
  - Documentation
  - Anticipated associated conditions
  - Formulate treatment plan
  - Predict outcomes and complications
  - Advise patients on expectations

Radiography Concepts

- Patient (Name/ DOB)
- Image (Correct body part)
- Date (Most Recent/ Comparison)
- Joint: x-ray bone above/below
- Fx Bone: x-ray joint above/ below
- X-ray: must get at least 2 views (1 view = no view)

Appropriate Imaging

- X-rays are the 1st step in any joint evaluation
- You cannot describe what you can't see
- At LEAST 2 views of each joint
  - "One view is no view"
  - When in doubt: order weight-bearing radiographs
- Assess the entire bone
- Assess joints above and below fractures
- Don't be afraid to get additional images
- The most commonly missed fracture is the second one!

AO Classification

- Global fracture classification
  - Ascribes numbers to bones
  - Ascribes letters to subtypes
  - Helpful in the research setting
  - Not so helpful in the clinical setting
    - “Hey Doc, I’ve got a 42-B3 down here in the ED”

Eponyms

- Colles
- Smith
- Barton
- Bennett
- Rolando
- Boxers
- Galeazzi
- Monteggia
- Hill-Sachs
- Bankart
- Maisonneuve
- Pellegrini-Steida
- Tilleaux
- Triplane
- Segond
- Lisfranc

Mnemonic: OLD ACID

- O: Open or Closed?
- L: Location of Fracture
- D: Degree (Complete vs Incomplete)

- A: Articular Extension?
- C: Comminution/ Fracture Pattern
- I: Intrinsic Bone Quality
- D: Displacement/ Angulation

Mnemonic: BLT LARD

- B: Bone
- L: Location of Fracture
- T: Fracture Type

- L: Change in Length
- A: Angulation
- R: Rotational Deformity
- D: Degree of Displacement

Radiography Concepts

- Describing a Fracture
  - Body Part and X-ray view (lateral view of L ankle)
  - Skeletally Mature/ Immature (growth plates)
    - Epiphysis/ Metaphysis/ Diaphysis (Salter-Harris)
  - Location (prox./ middle/ distal 1/3)
  - Intra-articular Fracture- joint involvement
  - 2 fragments = simple Multiple fragments = comminuted
  - Direction (transverse, oblique/ spiral/ longitudinal/ impaction/ avulsion/ torus or buckle)
  - Displaced/ Non-displaced (%); Valgus vs Varus

Radiology ABCs

- Alignment
  - General skeletal architecture (size and # of bones)
  - General contour of bone
  - Alignment of adjacent bones
- Bones
  - Bone Density
  - Texture abnormalities (Trabeculae)
  - Local bone changes (Sclerosis, Osteophytes)
  - Fracture- cortical and medullary disruption
  - Osteoarthritis- asymmetric joint space narrowing and osteophytes

Radiology ABCs

- Cartilage Space
  - Joint space height
  - Subchondral bone (smooth surface, sclerosis, cysts)

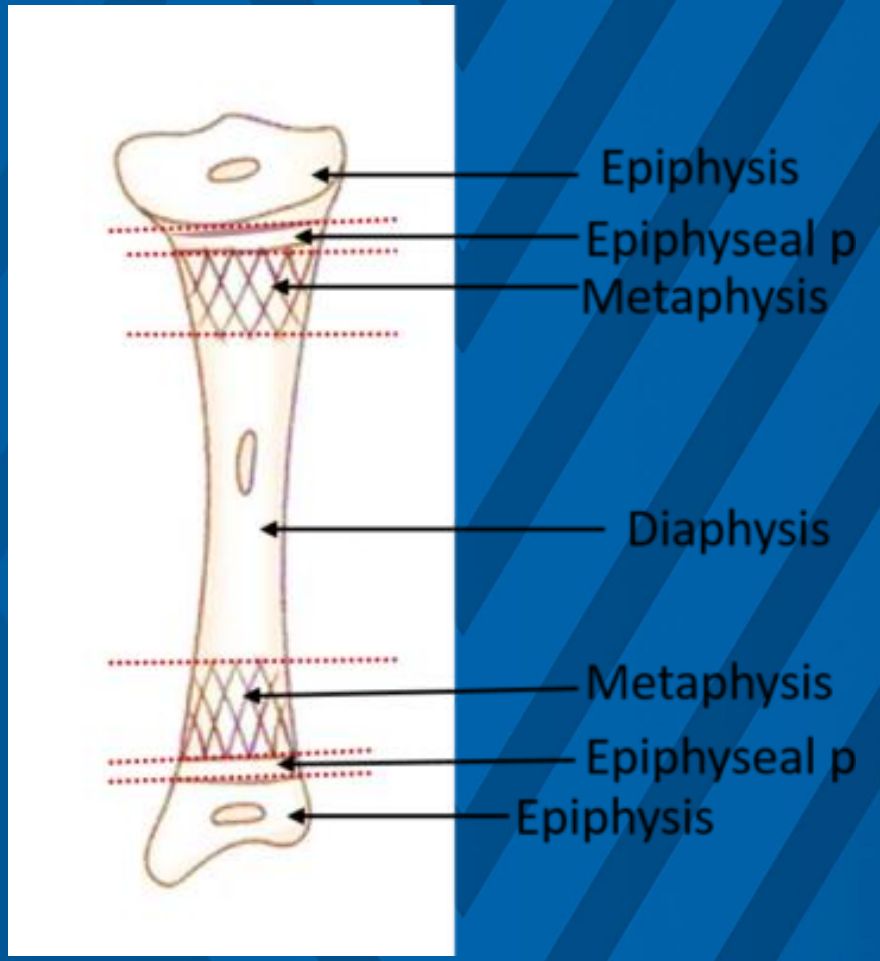
- Soft Tissue
  - Muscles
  - Fat pads/ fat lines
  - Swelling
  - Periosteum
    - Periostitis (fx healing, tumor, infection)

Questions

- Which bone(s) is (are) broken?
- Which part of the bone is broken?
- How many fragments are there?
- What is the fracture pattern?
- Are the ends close to each other?
- Are the fragments anatomically aligned?
- Does the fracture involve a joint surface?
- Is the skin intact?

Which part is broken?

- Use skeletally immature nomenclature
  - Epiphysis
  - Metaphysis
  - Diaphysis
- Divide long bones into thirds
  - Proximal/ Middle/ Distal
- Use anatomic landmarks
  - Head, neck, base, shat, condyle



How many fragments are there?

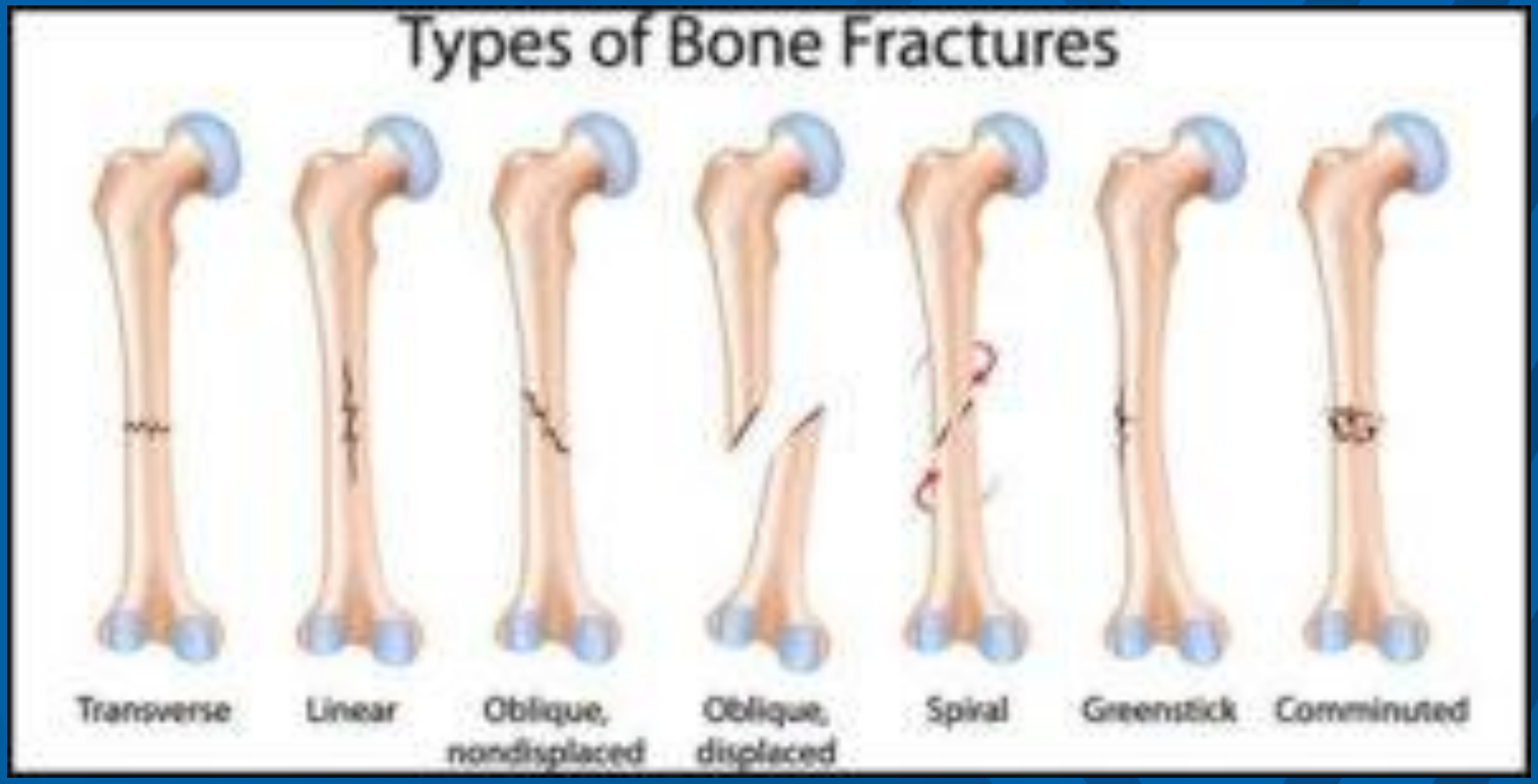
- Two Fragments = Simple
- Multiple Fragments = Comminuted
- Two of more fractures in the same bone = Segmental
- Provides information on degrees of energy

Simple Fracture

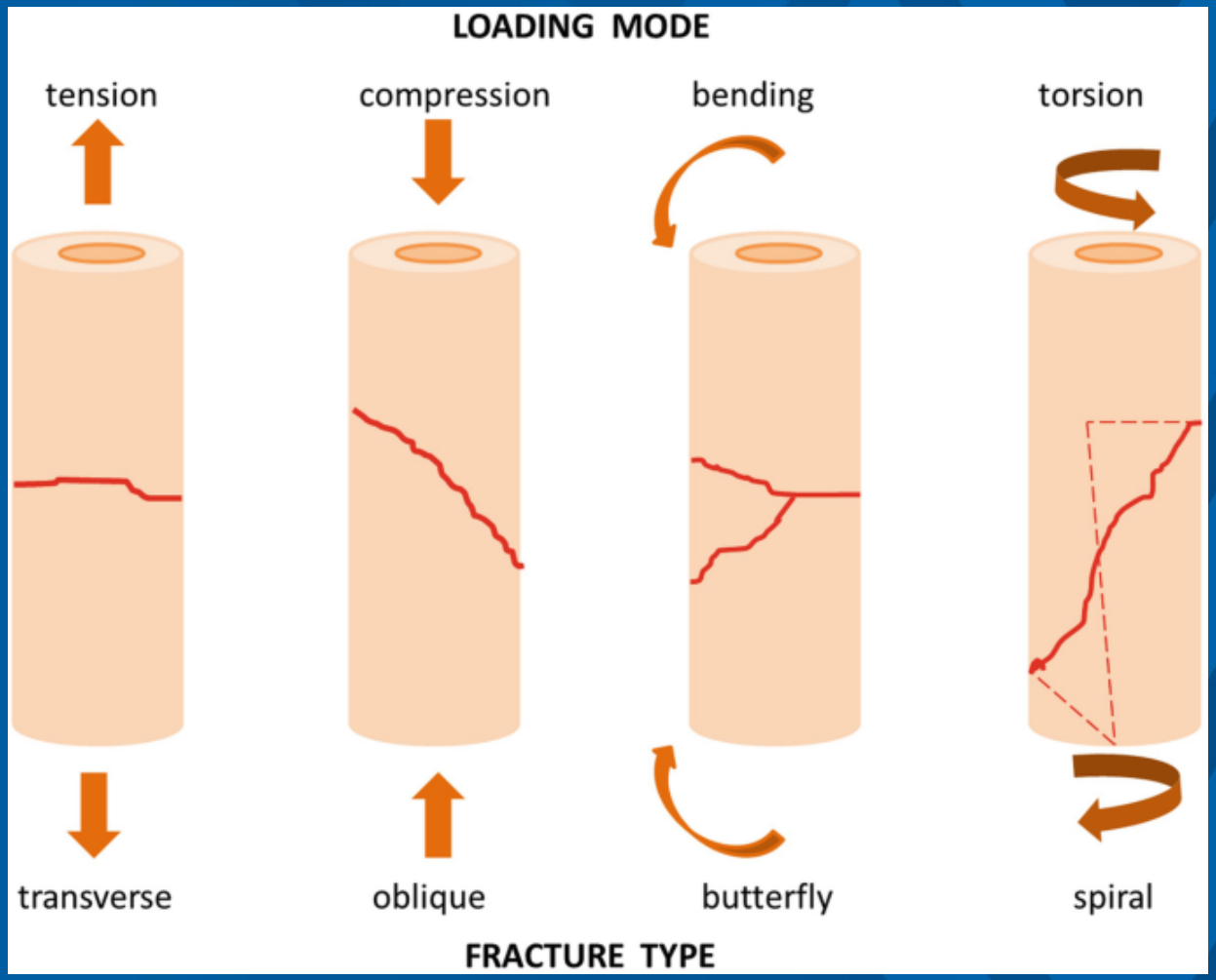
Comminuted Fracture

Segmental Fracture

Fracture Patterns



Fracture Patterns

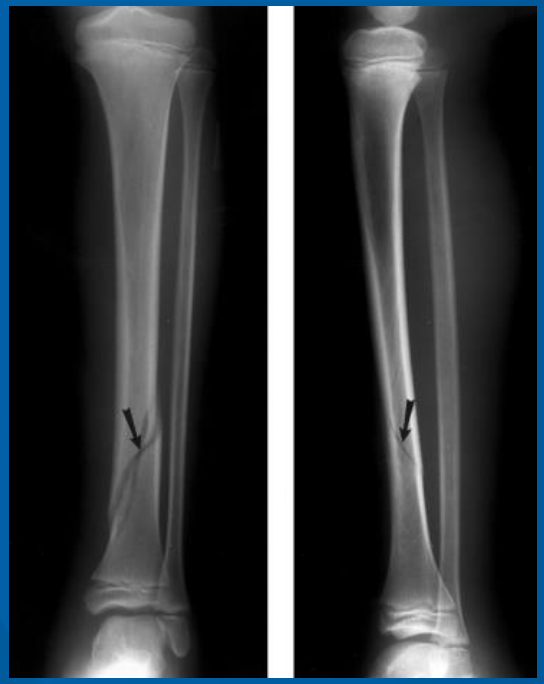


Are the bone ends close to each other?

- Displacement
  - Use percent of long bone width to define
    - 0% = Nondisplaced
    - 100% = Completely displaced
  - Use absolute measurements
    - Especially for intra-articular fractures
    - Other (non-long) bones
  - Describe direction if indicated
    - Distal fragment direction relative to proximal

Fracture Displacement

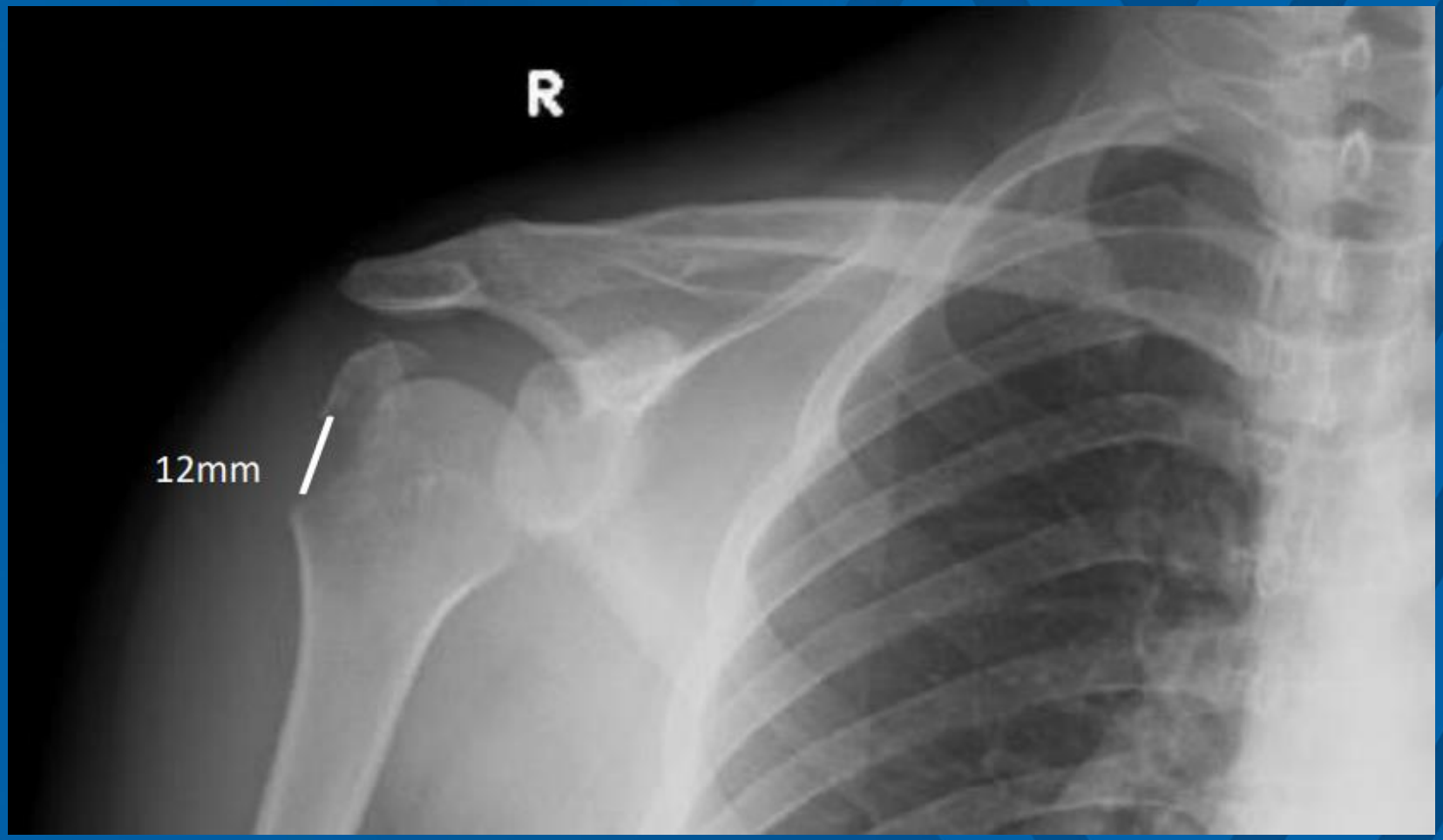
Non-Displaced



50% Displaced

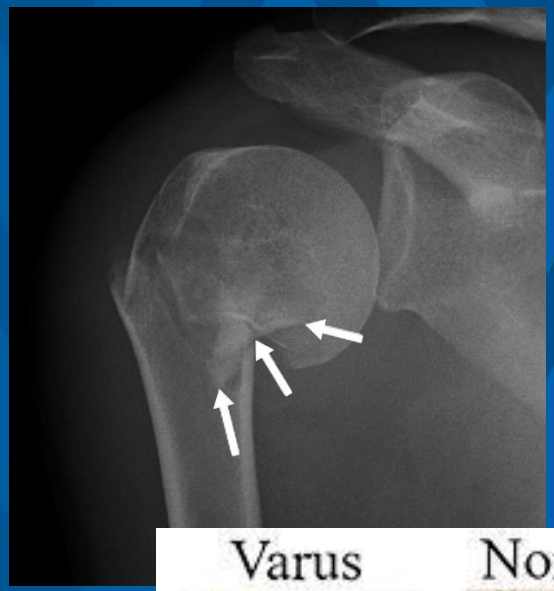
100% Displaced

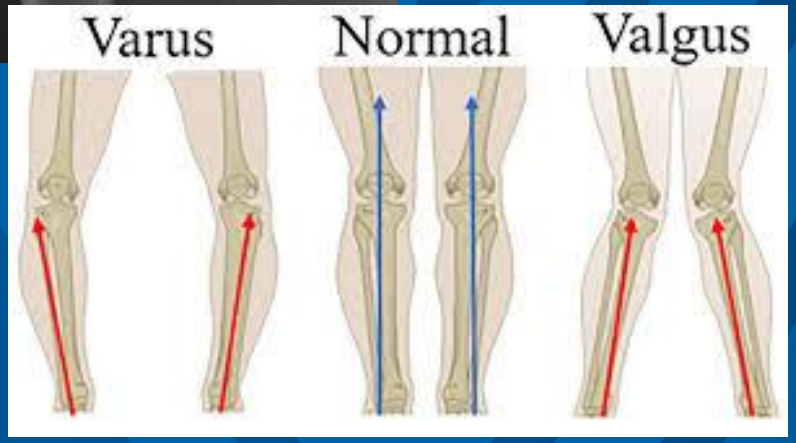
Measured Displacement



Are the fragments aligned?

- Angulation
  - Describe in degrees relative to long axis
  - Generally, 0-90 degrees
  - Define Apex
    - Medial/ Lateral/ Anterior/ Posterior
    - Varus (Medial)/ Valgus (Lateral) angulation

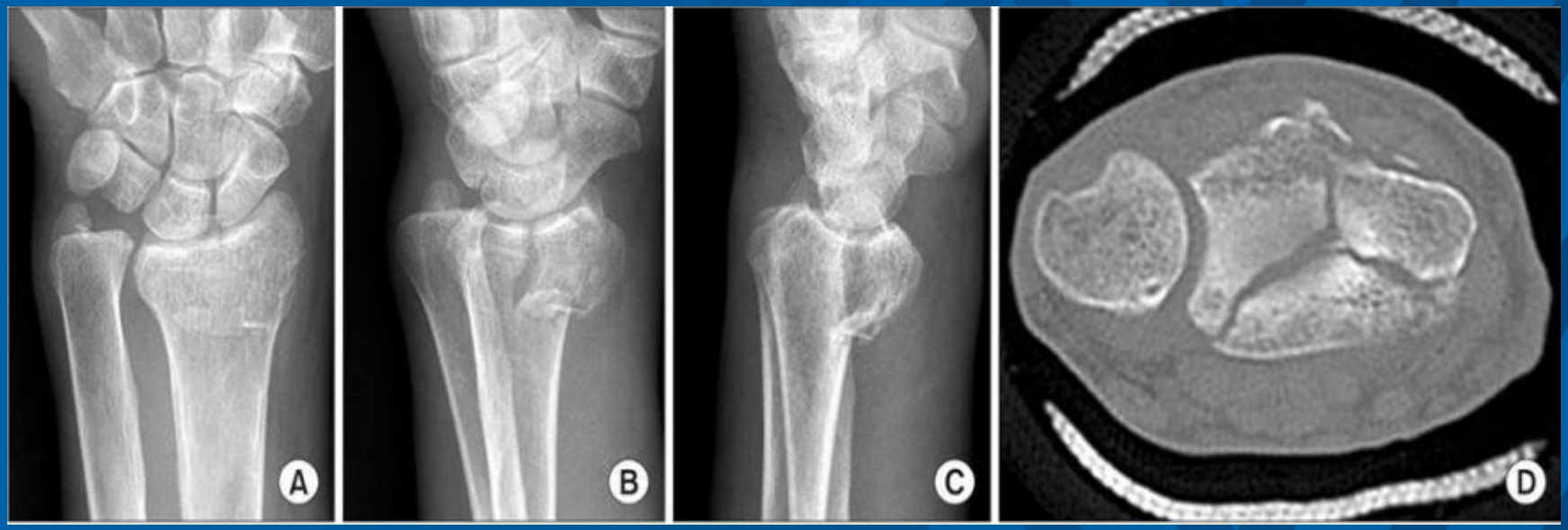




Is a Joint Surface Involved

- Intra-articular Fractures
  - Cross into a joint
  - Involve Articular Cartilage
  - More likely to require surgical management
  - Higher risk of post-traumatic arthritis
  - Generally, more guarded prognosis

Intra-articular Fractures



Is the Skin Intact?

- Closed Fracture
  - Intact skin overlying the fracture
- Open Fracture
  - Loss of skin continuity
  - Protruding bone
  - Small “inside-out” injury
  - Not necessarily directly over the fracture
  - Extensive soft tissue damage

Other Fractures

- Incomplete Fractures
- Pediatric Fractures
- Stress Fractures
- Pathologic Fractures
- Avulsion Fractures

Incomplete Fractures

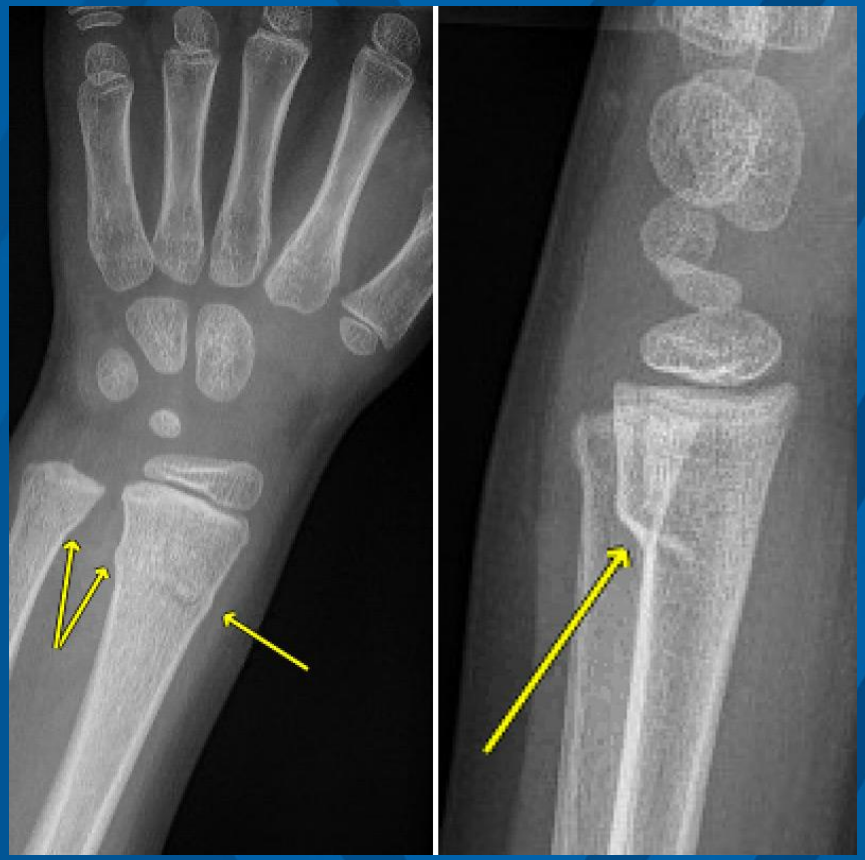
- Partial loss of continuity of bone
- Possible to fracture one cortex
- Low Energy

Greenstick Fracture

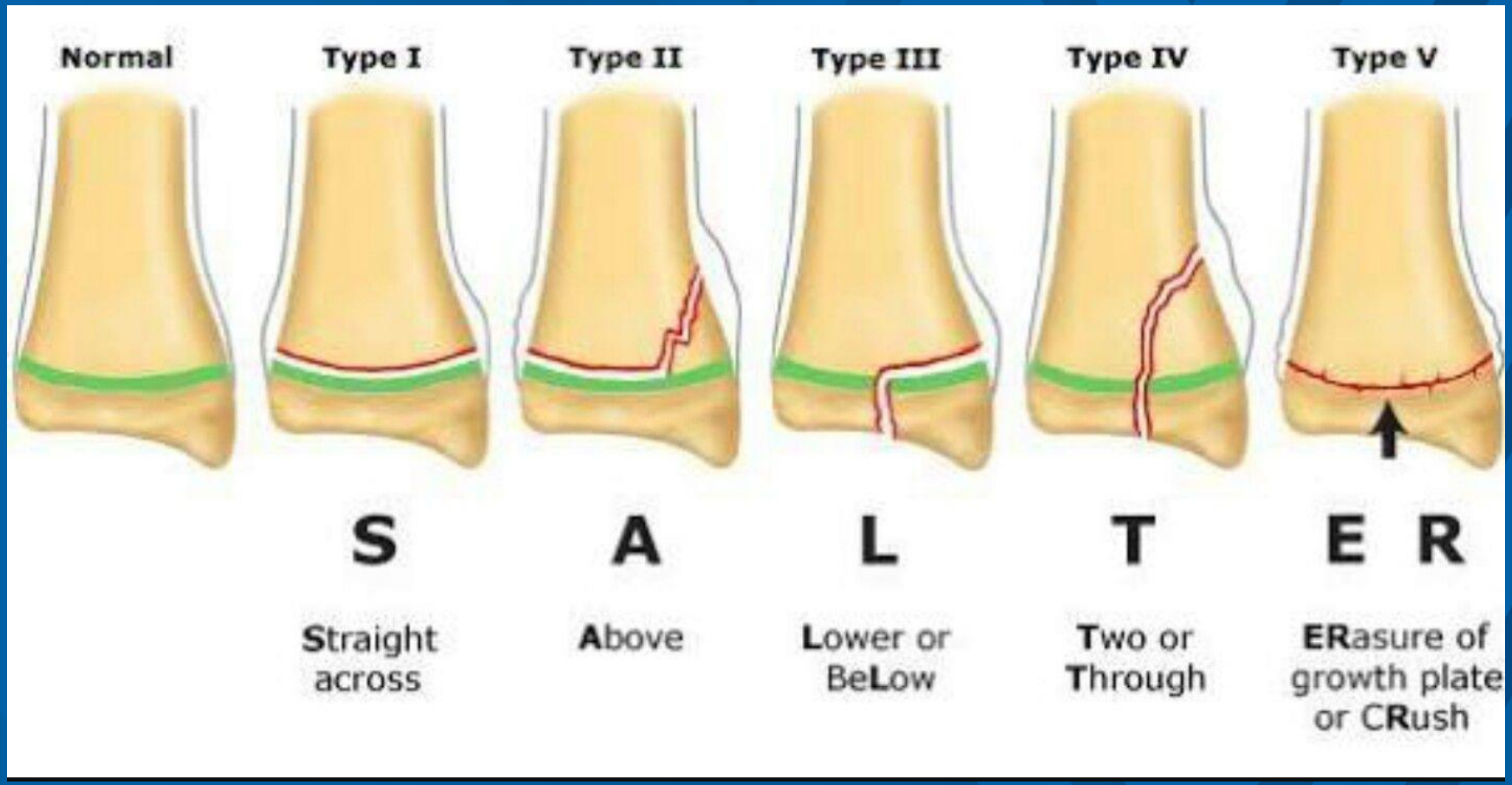
Pediatric Fractures

- Immature bone is not fully mineralized
- More flexible
- Capable of plastic deformity
- “Greenstrick fracture”
- Must recognize growth plates and if they are involved

Buckle Fracture



Pediatric (Growth Plate) Fractures



Pediatric (Growth Plate) Fractures

Corner Fracture- Nonaccidental Trauma

- Orthopaedic providers often the first to evaluate child abuse victims
- Must be vigilant
- 50% will have a fracture
- 85% < 3yo; 70% < 1 yo
- Beware of inconsistent history/ findings
- Fractures in multiple stages of healing
- “Rare” or unusual fractures

Nonaccidental Trauma

Table 2. Specificities Of Radiologic Findings For Physical Abuse

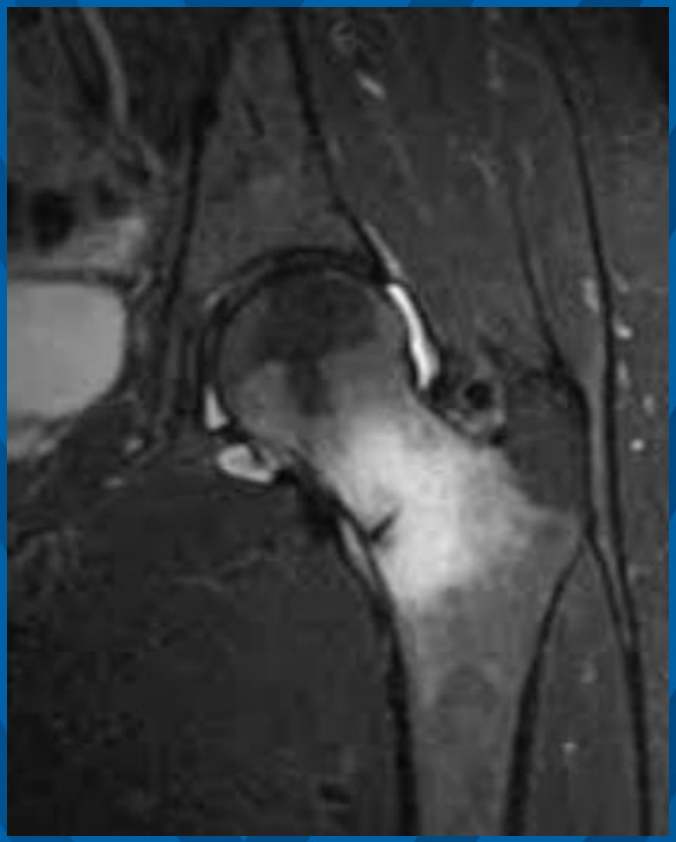
High Specificity	Moderate Specificity	Low Specificity
Classic metaphyseal lesions	Multiple fractures, especially bilateral	Subperiosteal new bone formation
Rib fractures, especially posterior	Fractures of different ages	Clavicle fractures
Scapular fractures	Epiphyseal separations	Long bone shaft fractures
Sternal fractures	Vertebral body fractures and subluxations	Linear skull fractures
Spinous process fractures	Digital fractures	
	Complex skull fractures	

Adapted from Kleinman.[86]

Stress Fractures

- Bone is constantly in state of turnover
- Repetitive stress can result in failure
- “March Fracture”
- Patients often unaware except for pain
- “Dreaded Black Line”
- Treatment depends on location and severity
- Runners: middle 1/3 tibia
- Jumpers: proximal 1/3 tibia

Stress Fractures



Bisphosphonate Fractures

- Bisphosphonate therapy minimizes bone loss and reduces fracture risk
- Associated with typical femoral shaft fractures
- Occur with minimal/ no trauma
- Predominately transverse
- Involves both cortices
- Periosteal reaction

Bisphosphonate Fractures

Pathologic Fractures

- Abnormal bone is more prone to failure
- Neoplastic
  - Most often metastatic (100:1)
  - Most common: Breast, Prostrate, Lung
- Metabolic

Pathologic Fractures

Avulsion Fractures

- Fracture at insertion of tendon or ligament
- Fragment displaced by force of soft tissue
- Degrees of displacement often determines need for operative management

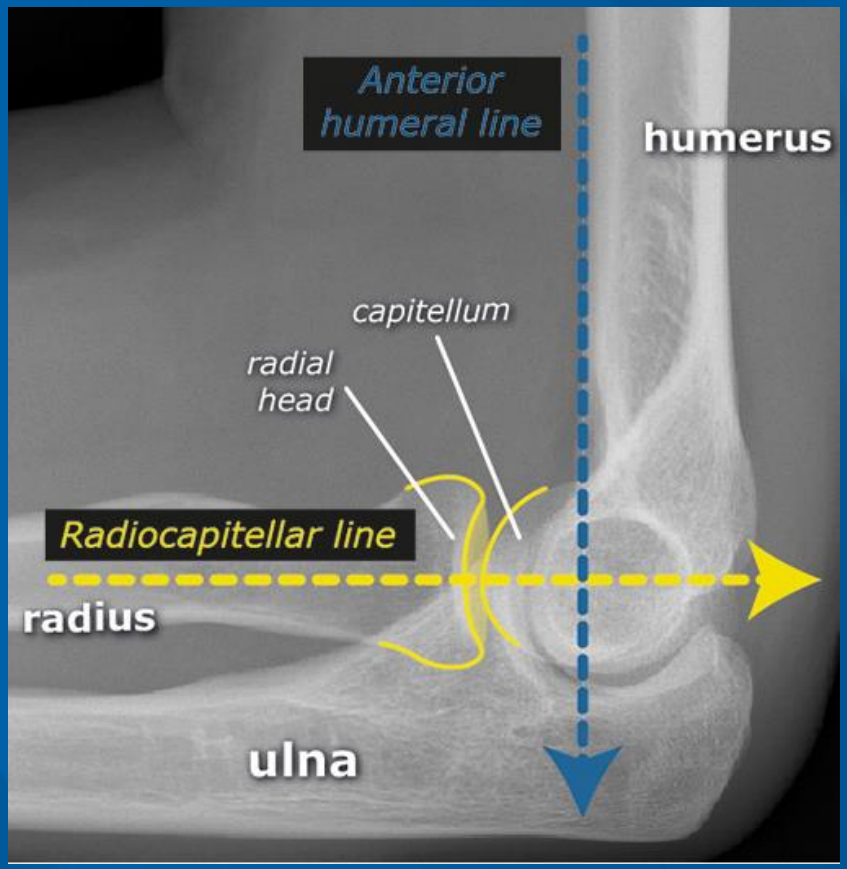
Avulsion Fractures

Other Signs of Fractures

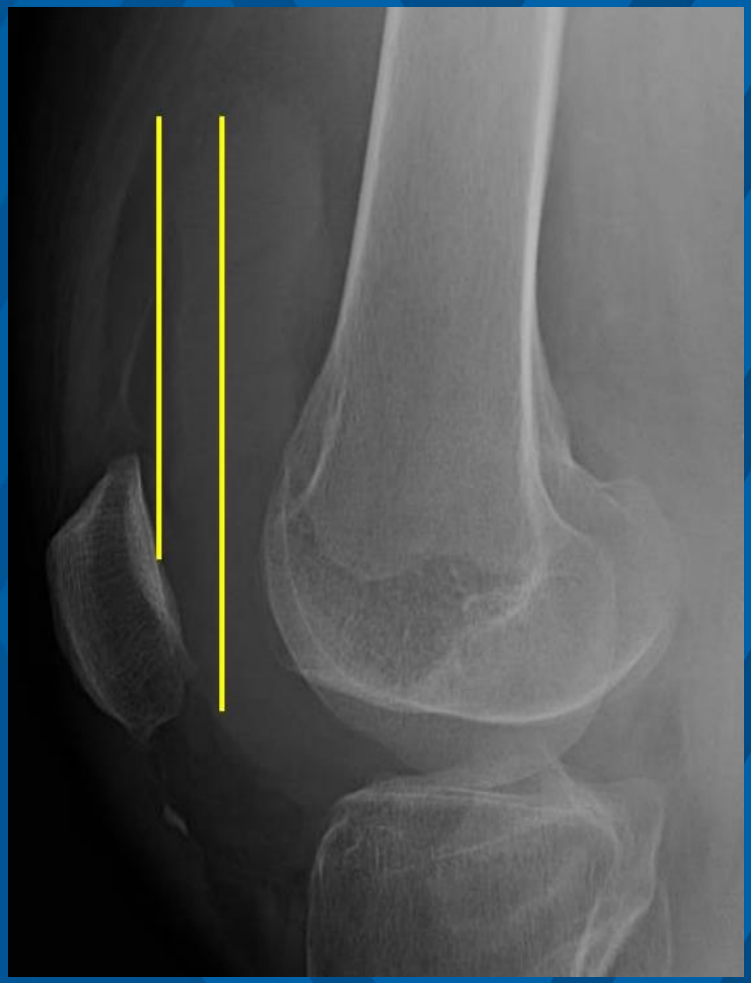
- Callus
- Periosteal Reaction
- Soft Tissue Swelling
- Periarticular fluid “Sail Sign”
- Lipohemarthrosis- accumulation of fat and blood in a joint cavity usually after an intra-articular fracture

Periosteal Reaction

“Sail” Sign


Anterior humeral line
humerus
capitellum
radial head
Radiocapitellar line
radius
ulna

Lipohemarthrosis

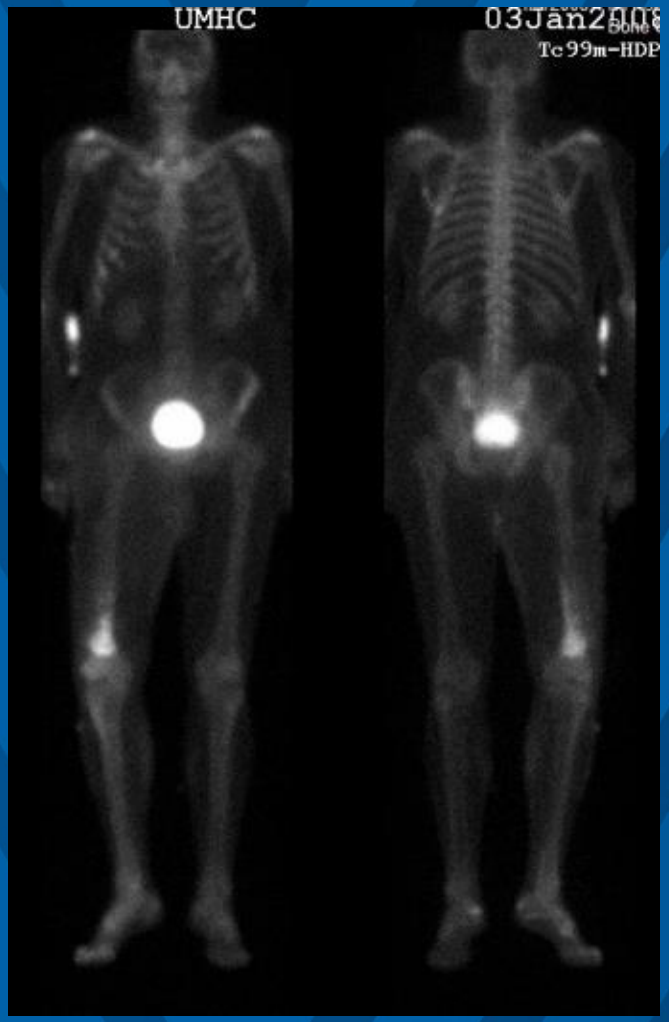


Fabella

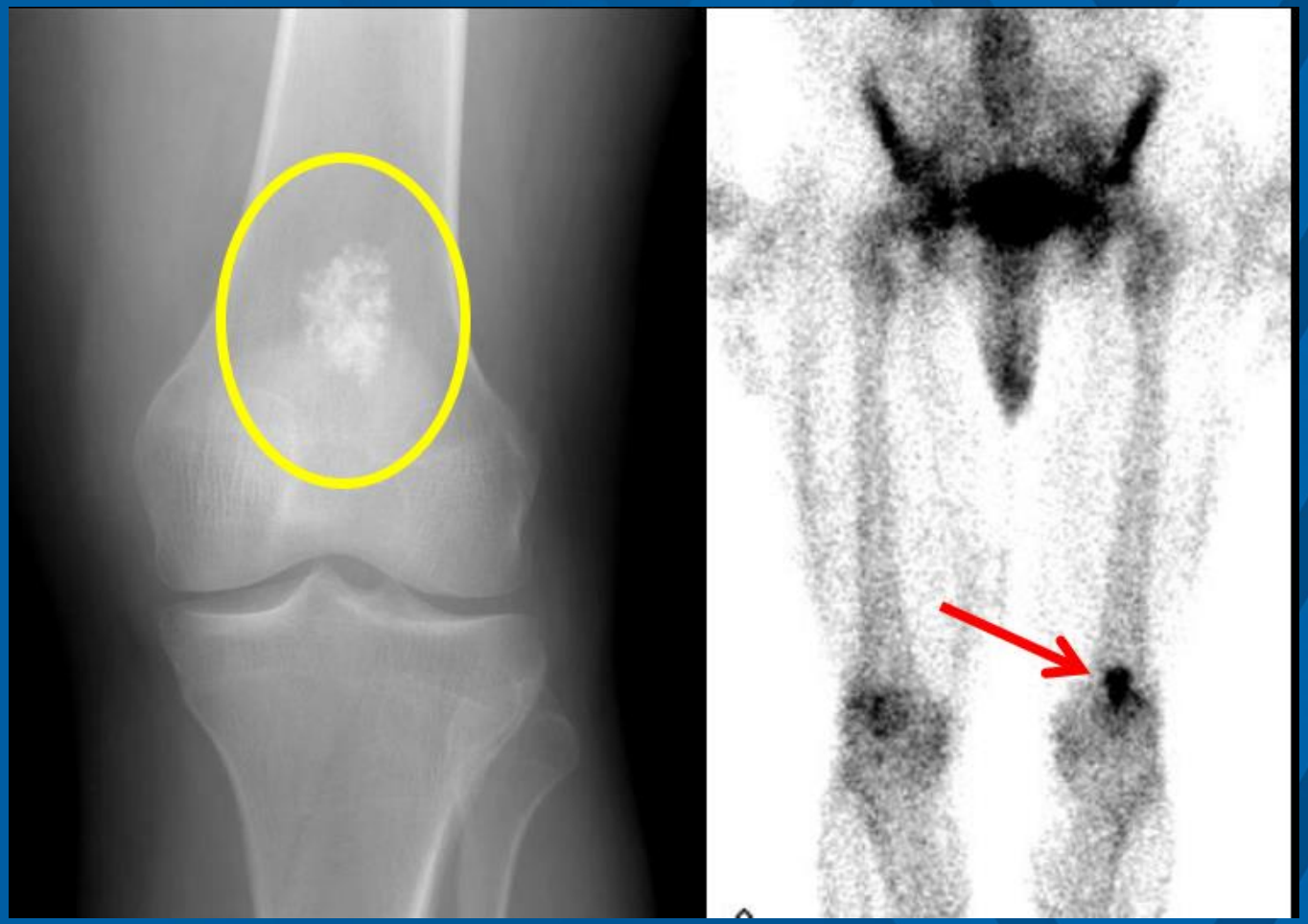
- Lateral view of the knee
- Sesamoid bone located in the lateral gastric tendon sheath
- Normal anatomic variant

Scintigraphy (Bone Scan)

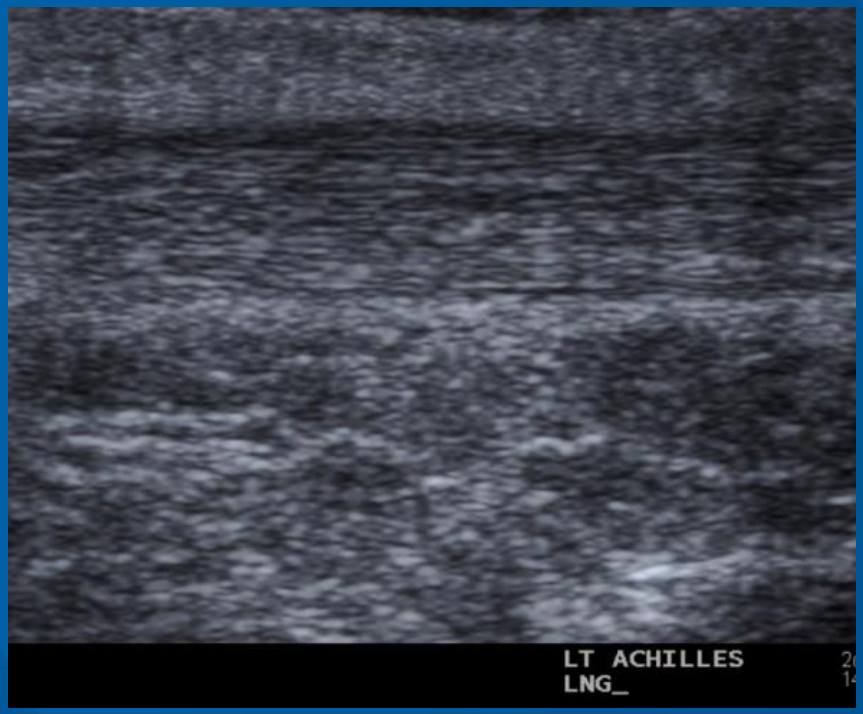
- Uses
  - Cancer screening (metastases)
  - Occult bone disease
    - Fracture vs Infections
- Advantages
  - Very sensitive
  - Low radiation dose
  - Screen Entire Skeleton
- Limitations
  - Non-specific (need 2nd test)
  - Low Resolution
  - Soft Tissues



Scintigraphy (Bone Scan)

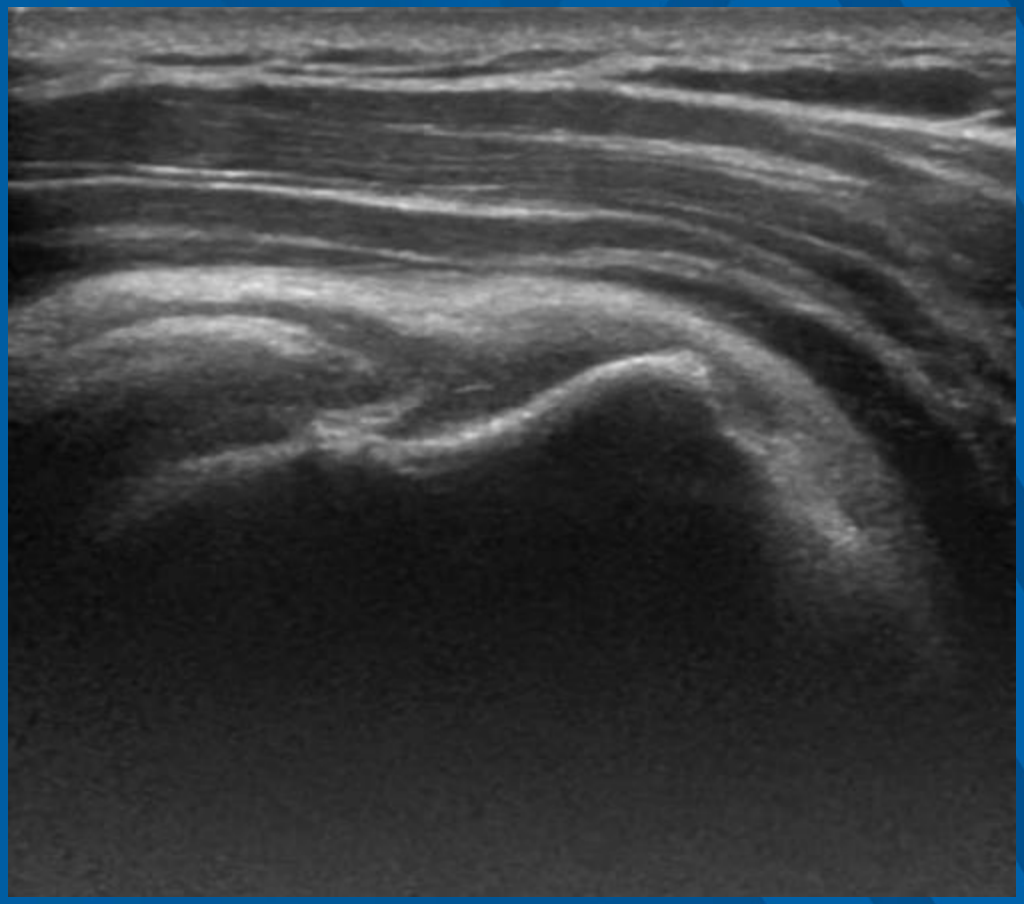


Sonography (Ultrasound)



- Uses
  - Soft tissue Processes
    - Masses/ fluid collection
  - Procedure Guidance
- Advantages
  - No radiation
  - Multiplanar
  - Dynamic
- Limitations
  - Superficial Structures
  - Operator dependent

Sonography (Ultrasound)



Computed Tomography (CT)

- Uses
  - Complex fractures
  - Orthopaedic planning
  - Post-op Imaging
  - MR contraindications
- Advantages
  - Fine bony detail
  - 2D and 3D reconstructions
- Limitations
  - Limited soft tissue detail
  - Radiation dose

Computed Tomography (CT)

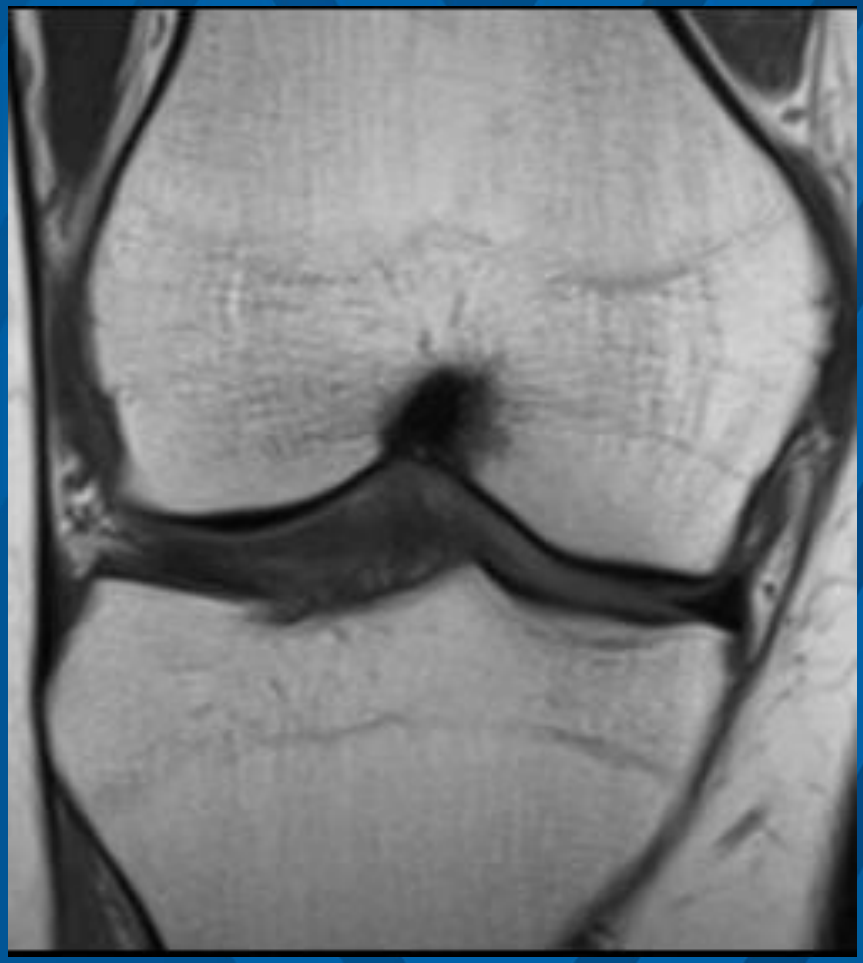
- CT Indications
  - MSK Trauma
  - Fracture anatomy for treatment staging/ planning
  - Intra-articular fragments
  - Assess Healing
  - Characterize skeletal/ soft tissue masses and bone involvement
  - MR Contraindications
    - Post-op Metal artifact
    - Pacemaker/ pumps/ implants
    - Patient Motion

Magnetic Resonance (MRI)

- Uses
  - Advanced bone and soft tissue imaging
- Advantages
  - Supreme sensitivity
  - Anatomic detail
  - Multiplanar imaging
  - No radiation
- Limitations
  - Relatively expensive
  - Lower availability
  - Patient contraindications
  - Single body region
  - Time

Magnetic Resonance (MRI)

- T1 Weighted Image
  - Fluid HYPOintense
  - Looking at anatomy
  - Evaluating Marrow
  - Things that are **BRIGHT**:
    - Melanin
    - Protein
    - Fat
    - Subacute blood
    - Gadolinium



Magnetic Resonance (MRI)

- T2 Weighted Image
  - Fat suppression
  - Fluid HYPERintense
  - Identify pathology
  - Eval ligaments/ tendons
  - Eval cartilage
  - Eval edema pattern
  - Things that are BRIGHT:
    - Fluid (edema, CSF)
    - Neoplasm
    - Fat
    - Gadolinium

Magnetic Resonance (MRI)

- Contrast Enhancement (W/WO)
  - Enhancement is non-specific
- Indications
  - Tumor
    - Differentiation of cyst versus solid lesions
    - Identify biopsy sites
  - Infection
    - Evaluation of viable versus non-viable tissue
  - Inflammatory Arthritis
    - Active Erosions, Synovitis, Tenosynovitis

Magnetic Resonance (MRI)

- Arthrogram- injecting an intra-articular solution to create contrast between the intra-articular structures
- MR
  - Gadolinium based contrast agent (GBCA)
- CT
  - Iodine based contrast agent

- Arthrogram
  - Enhance evaluation of joint anatomy
  - Expose joint pathology

Joint Specific Arthrogram Indications

- Shoulder
  - Labral Tear
  - Glenohumeral Instability
  - Rotator Cuff Tear???
- Elbow
  - UCL Tear
  - RCL, LUCL tear
- Wrist
  - Scapholunate, Lunotriquetral Tear
  - TFCC Tear
- Hip
  - Labral Tear
  - FAI
- Knee
  - Retear of Repaired Meniscus
  - ACL Reconstruction
- Ankle
  - ATFL Tear???
- ALL Joints
  - Osteochondral Lesion
  - Loose Body

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