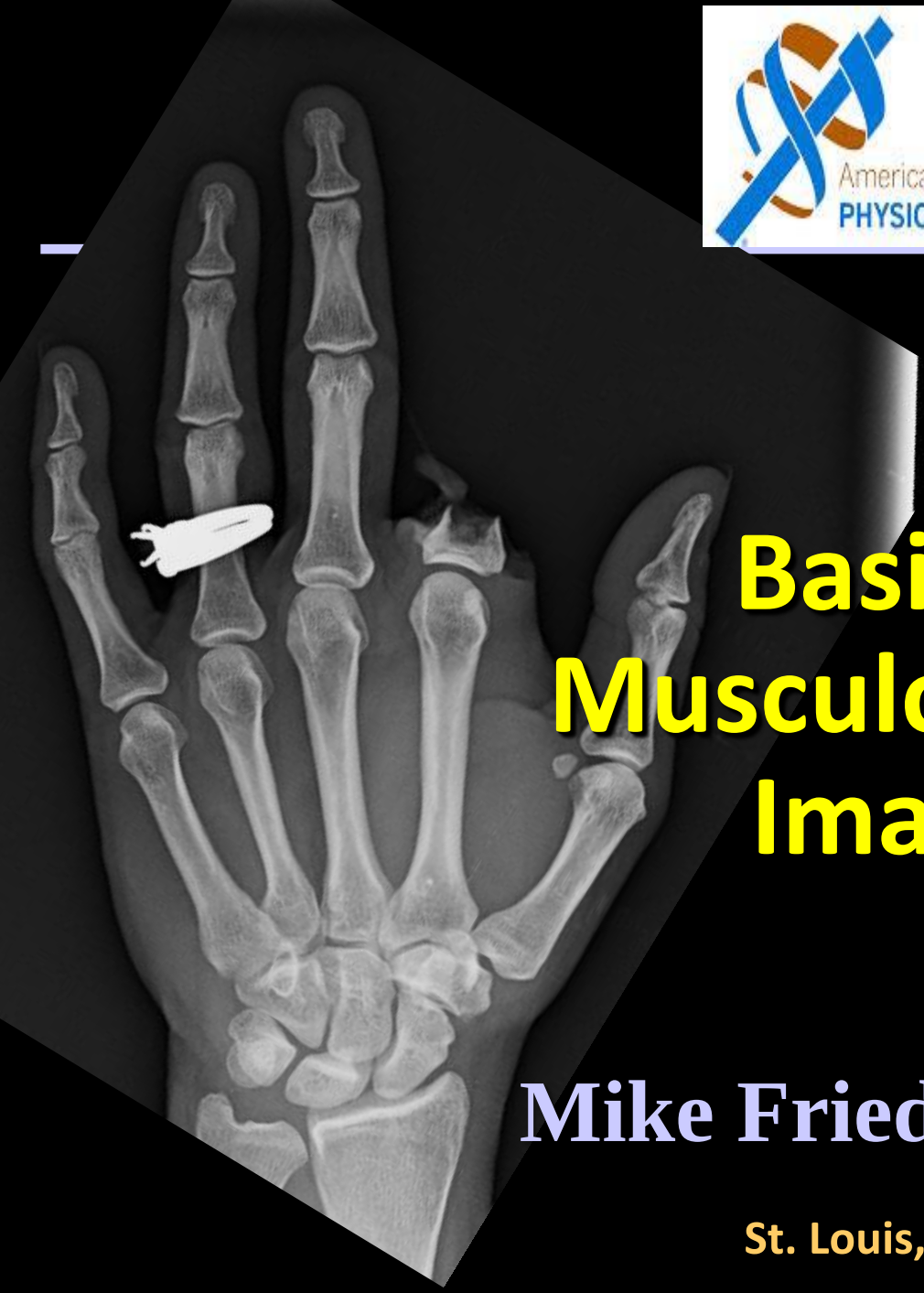


American Academy of PHYSICIAN ASSISTANTS

AAOS
American Academy of Orthopaedic Surgeons

Basics of Musculoskeletal Imaging

Mike Friedman, MD

St. Louis, MO

Disclosures

I have no financial disclosures

Introduction

Available modalities

What can I order?

An imaging strategy

What should I order?

Clinical scenarios

[Nothing]

Radiographs

(X-rays)

Bone scan

Ultrasound

CT

MRI

Imaging Modalities

Radiographs (Plain films)

- Uses
- Advantages
- Limitations

Radiographs (Plain films)

Uses

Advantages

Limitations

Bone & joint disease

- Trauma
- Infections
- Tumors
- Arthritis

Radiographs (Plain films)

Uses

Advantages

Limitations

Inexpensive

Widely available

Portable

Radiographs (Plain films)

Uses

Advantages

Limitations

Radiation

Early disease

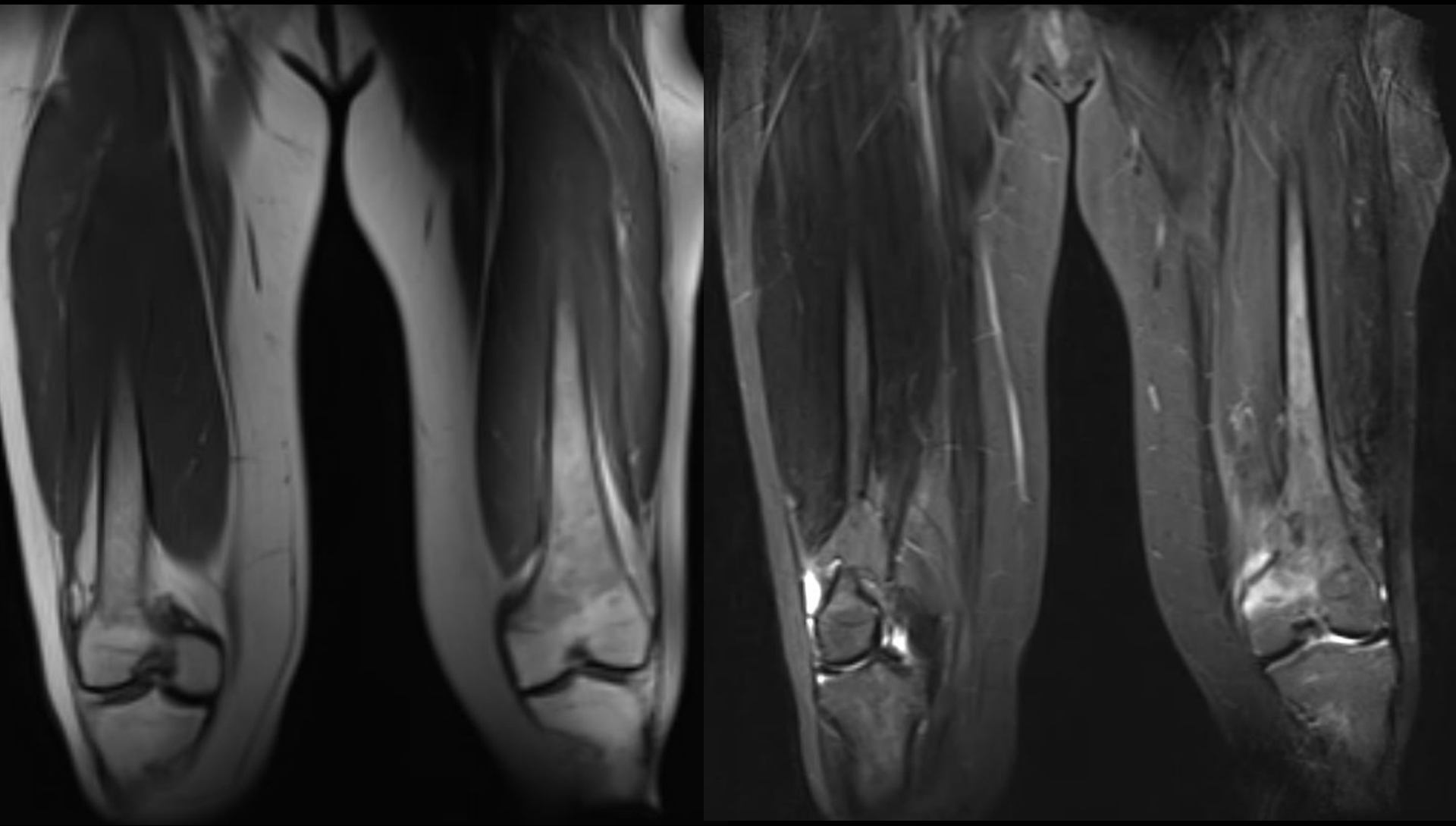
Soft tissues

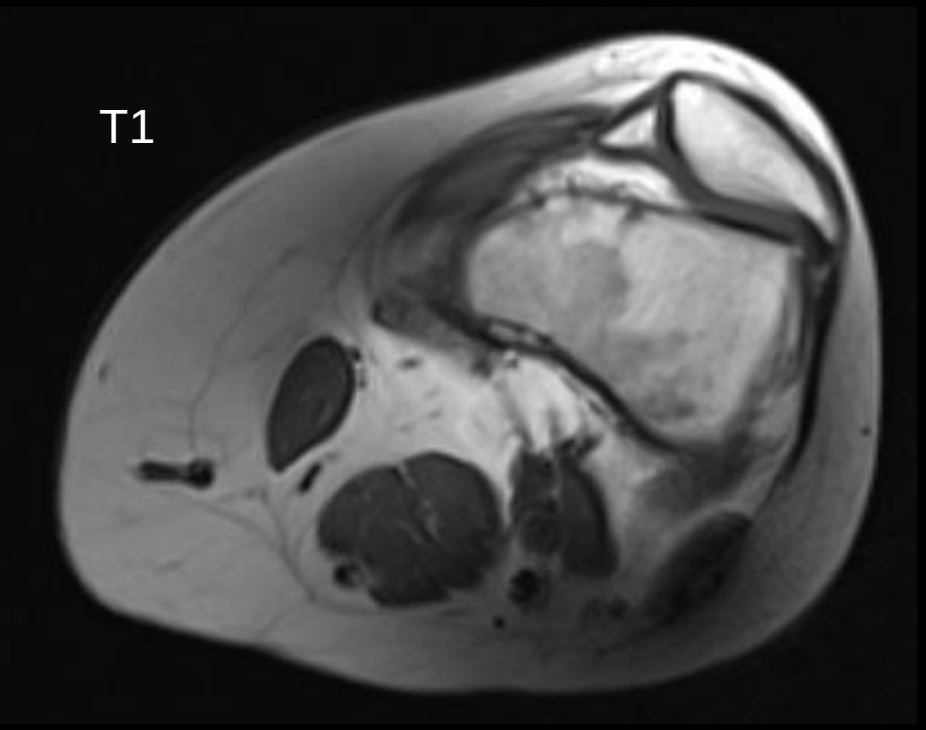
Generalized Principals

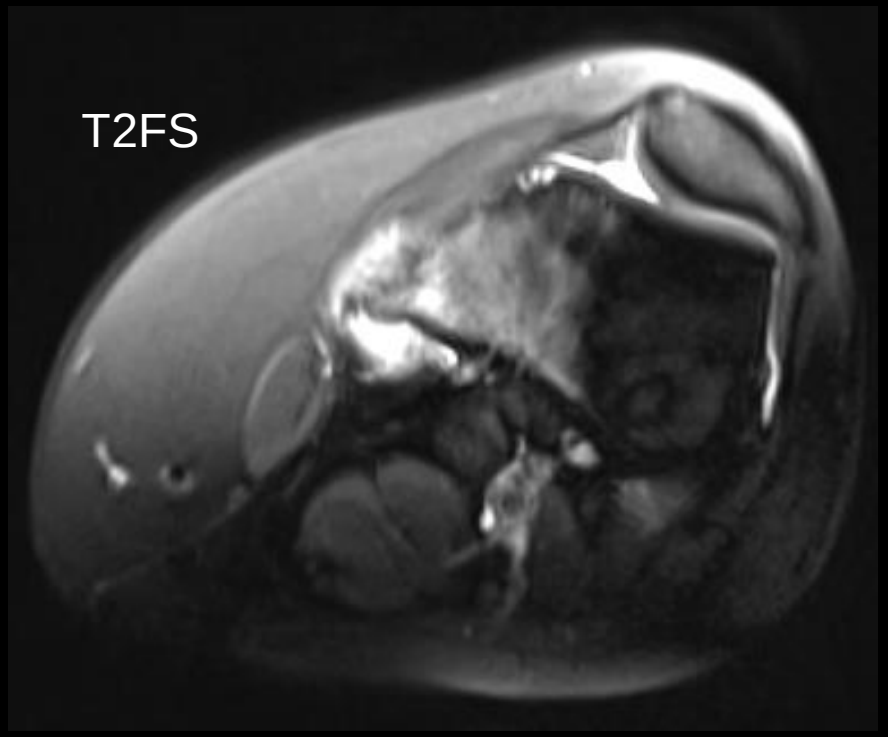
1. Xrays are the 1st step in any joint evaluation
   - Most efficient means of seeing bone/joint abnormality

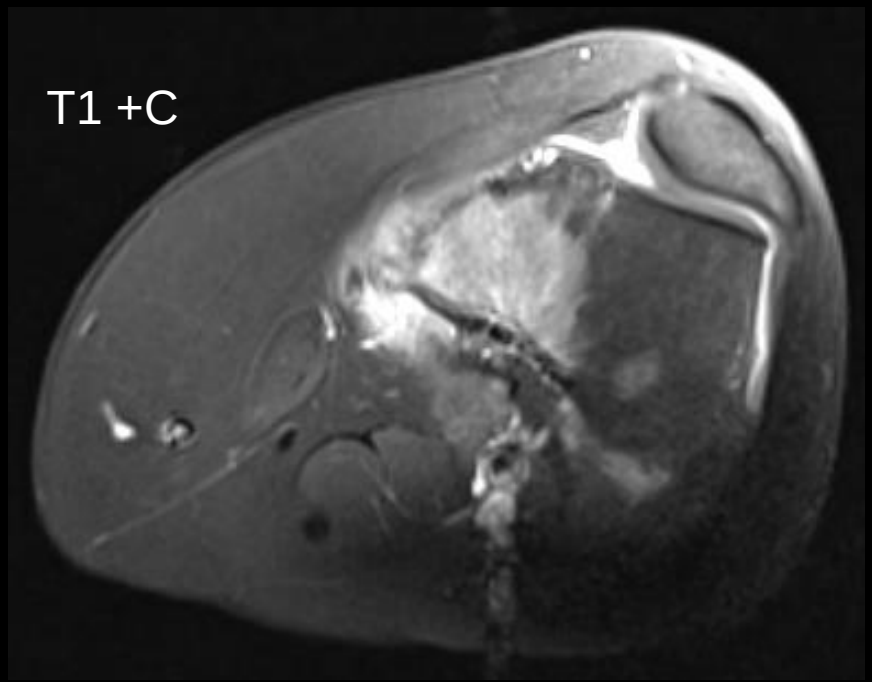
Case

- 32 yof
- 3-4 wks of non-traumatic distal left thigh pain.
  - Hx of prior humerus osteomyelitis 2 years ago
  - Elevated WBC, ESR, CRP
- R/O Osteomyelitis




T1


T2FS


T1 +C

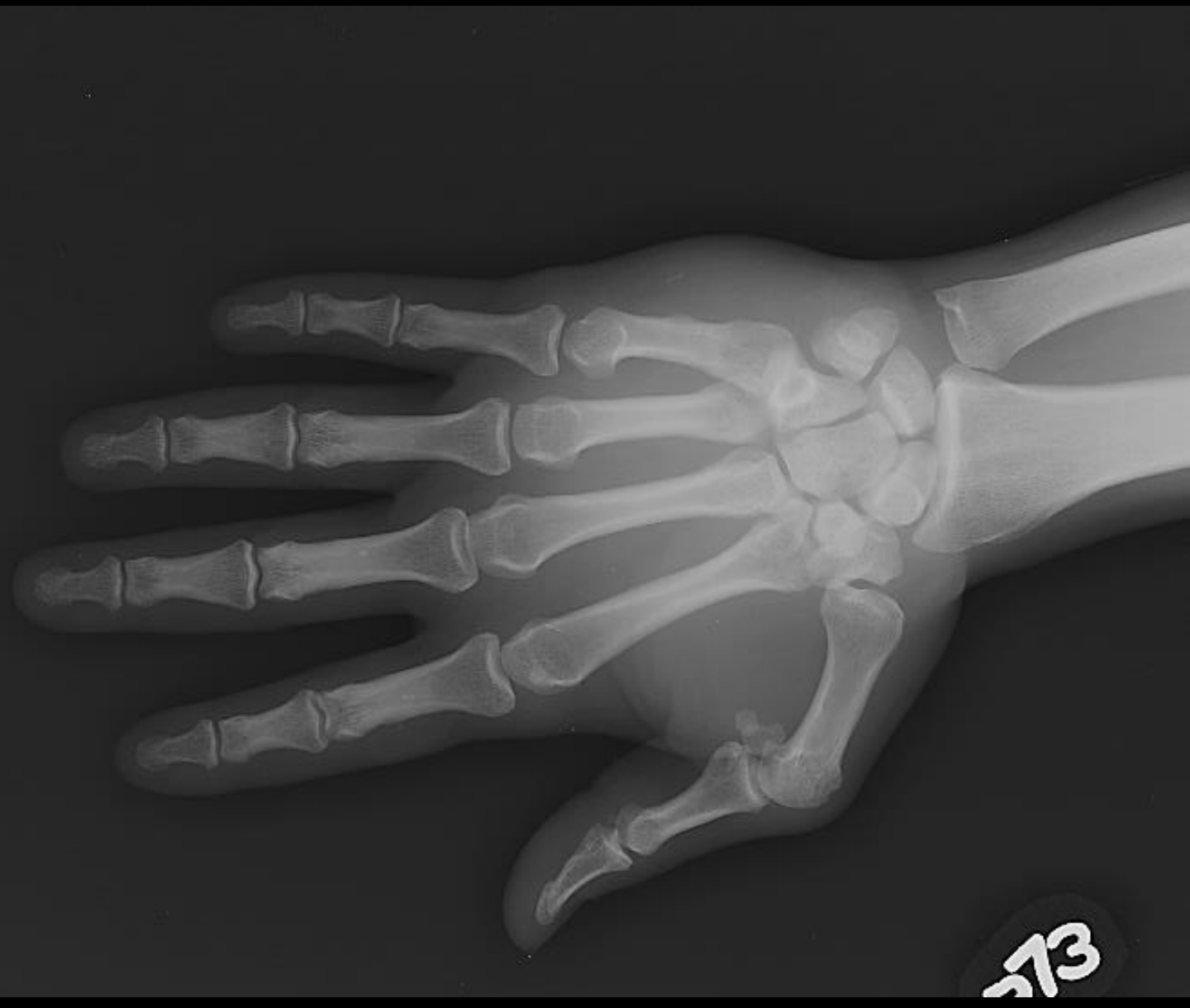
Generalized Principals

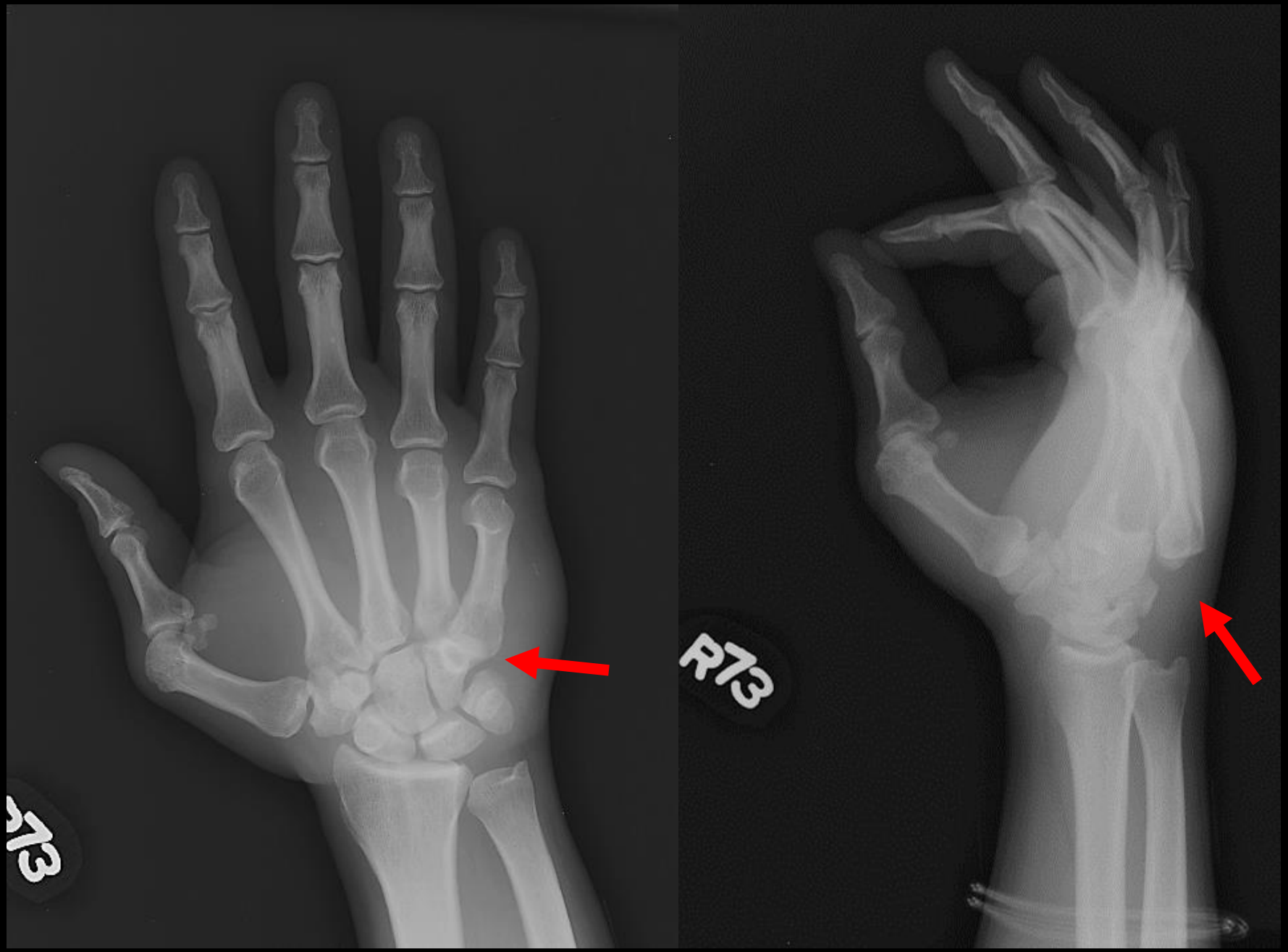
1. Xrays are the 1st step in any joint evaluation
   - Most efficient means of seeing bone/joint abnormality

2. At LEAST 2 views of each joint
   - Study type should be tailored to the clinical question
   - When in doubt:
     - Order weight-bearing radiographs

Case

- 26 yom
- Hand pain after a fight




R73

Case

- 17 yom

- High school football stud
- Signed letter of Intent to D-1 school

- “Pop” with right midfoot pain after a game

Non weight-bearing

Weight-bearing

Companion


JE


WB
R
JEH

Generalized Principals

1. Xrays are the 1st step in any joint evaluation
   - Most efficient means of seeing bone/joint abnormality

2. At LEAST 2 views of each joint
   - Study type should be tailored to the clinical question
   - When in doubt:
     - Order weight-bearing radiographs
     - Order the most views
       - ? Cost to patient

3. If still in doubt:
   - Consult your friendly radiologist


X-RAY
IN USE

Evaluating the X-ray

- Evaluation
  - Establish a consistent pattern of viewing & assessing
  - ABCs
    - Alignment
    - Bones
    - Cartilage spaces
    - Soft tissues

ABCs: Alignment

- General skeletal architecture
  - Size and # of bones
- General contour of bone
  - Smooth & continuous cortical lines
- Alignment of adjacent bones
  - Joint articulations

Case

Radiographs: Arthritis

ABCs: Bones

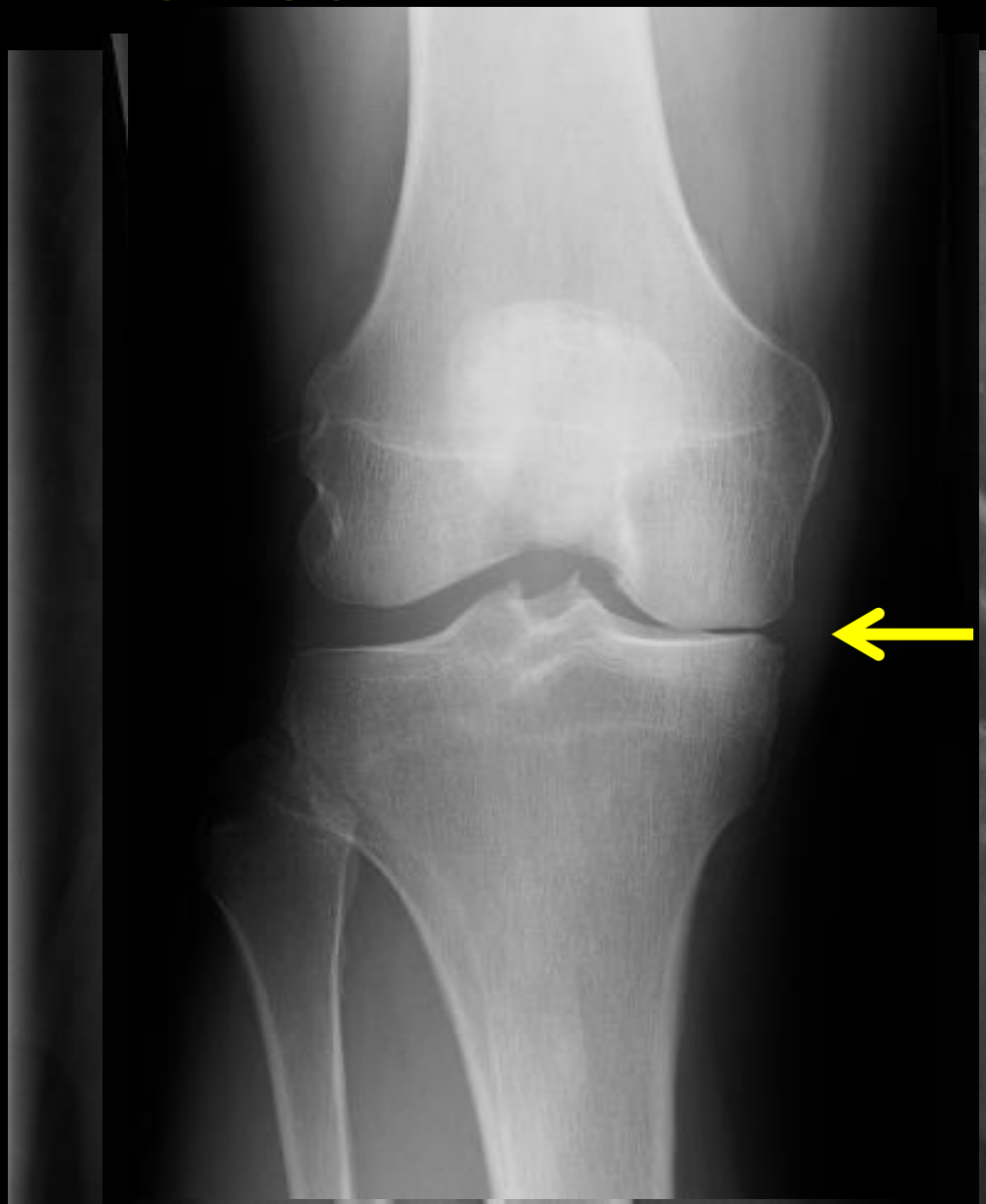
- Bone Density
- Texture abnormalities
  - Trabeculae
- Local bone changes
  - Sclerosis, osteophytes

Fracture

- Cortical and medullary disruption

Osteoarthritis

- Asymmetric joint space narrowing
- Osteophytes



Case

Radiographs: Tumor

ABCs: Cartilage Space

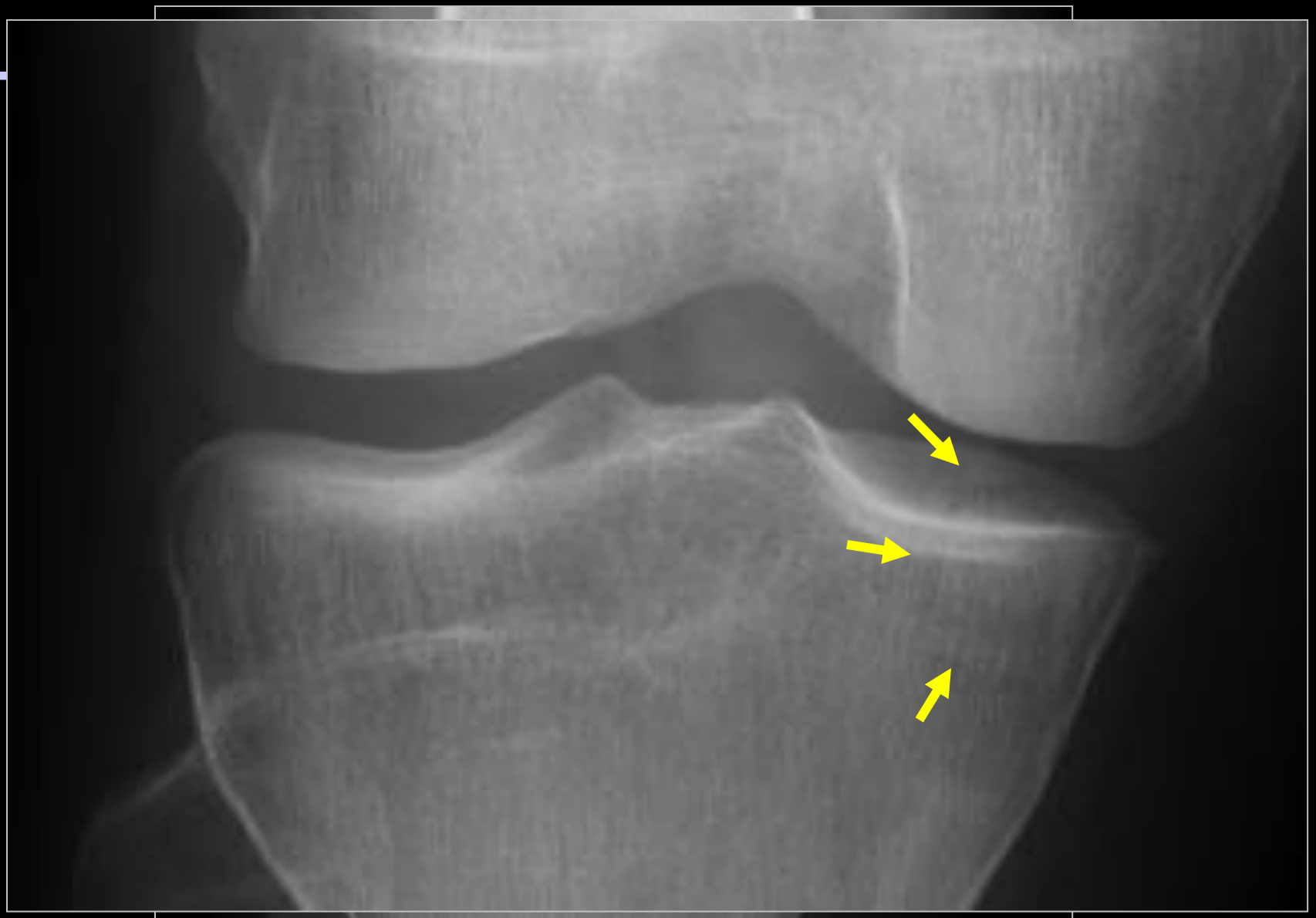
- Joint space height
- Subchondral bone
  - Smooth surface, sclerosis, cysts

ABCs: Soft Tissue

- Muscles
- Fat pads/fat lines
- Swelling
- Periosteum
  - Periostitis (fx healing, tumor, infxn)
- Miscellaneous findings

Case

Radiographs: Lipohemarthrosis



Case

Radiographs (Plain films)

Use

Workhorse of Bone and Joint radiology

Low cost / radiation

Available

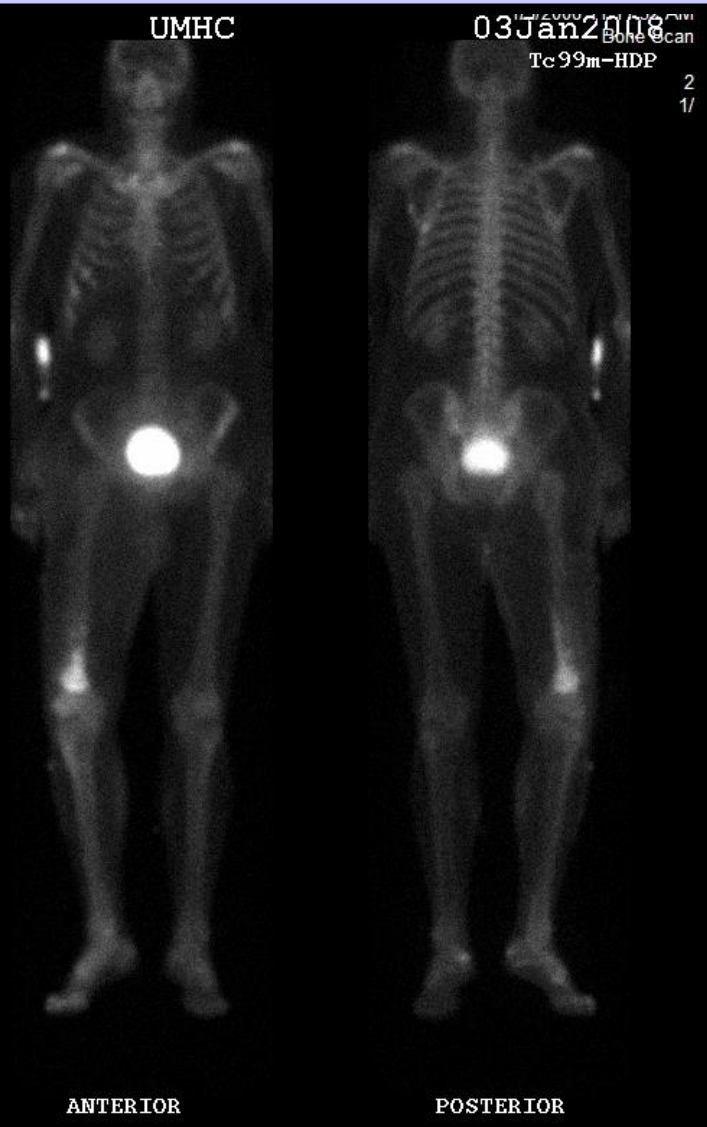
ABCs

Limits

Soft tissues

Scintigraphy (Bone scan)

- Uses
- Advantages
- Limitations



Scintigraphy (Bone scan)

Uses

Advantages

Limitations

Cancer screening

metastases

Occult bone disease

fractures

infections

Scintigraphy (Bone scan)

Uses

Advantages

Limitations

Very sensitive

Low radiation dose

Screen entire skeleton

Scintigraphy (Bone scan)

Uses

Advantages

Limitations

Non-specific

need 2nd test

Low resolution

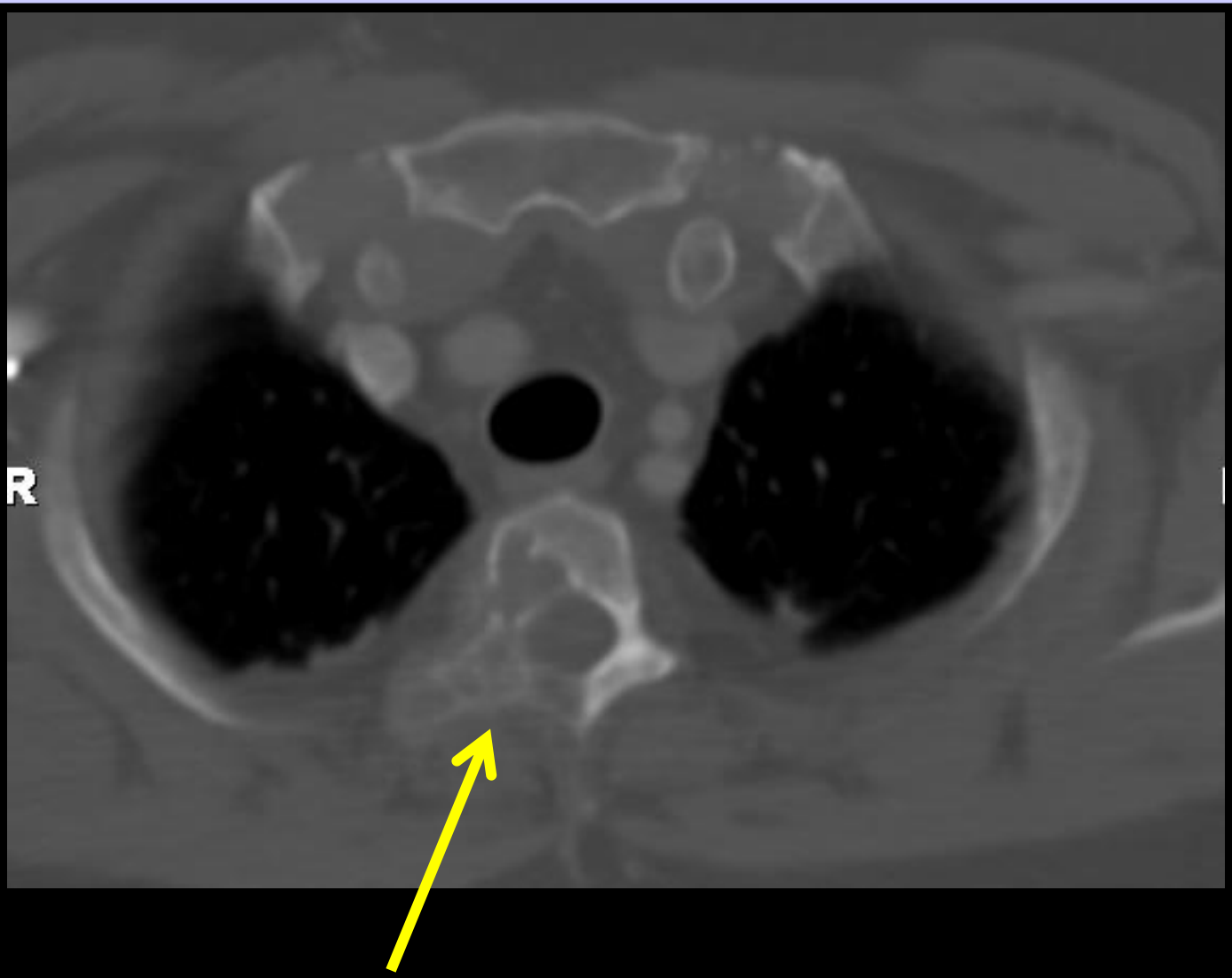
Soft tissues

Case

Case

Case

Scintigraphy: Metastasis



Scintigraphy: Metastasis

Case – Triple phase bone scan

Dx?

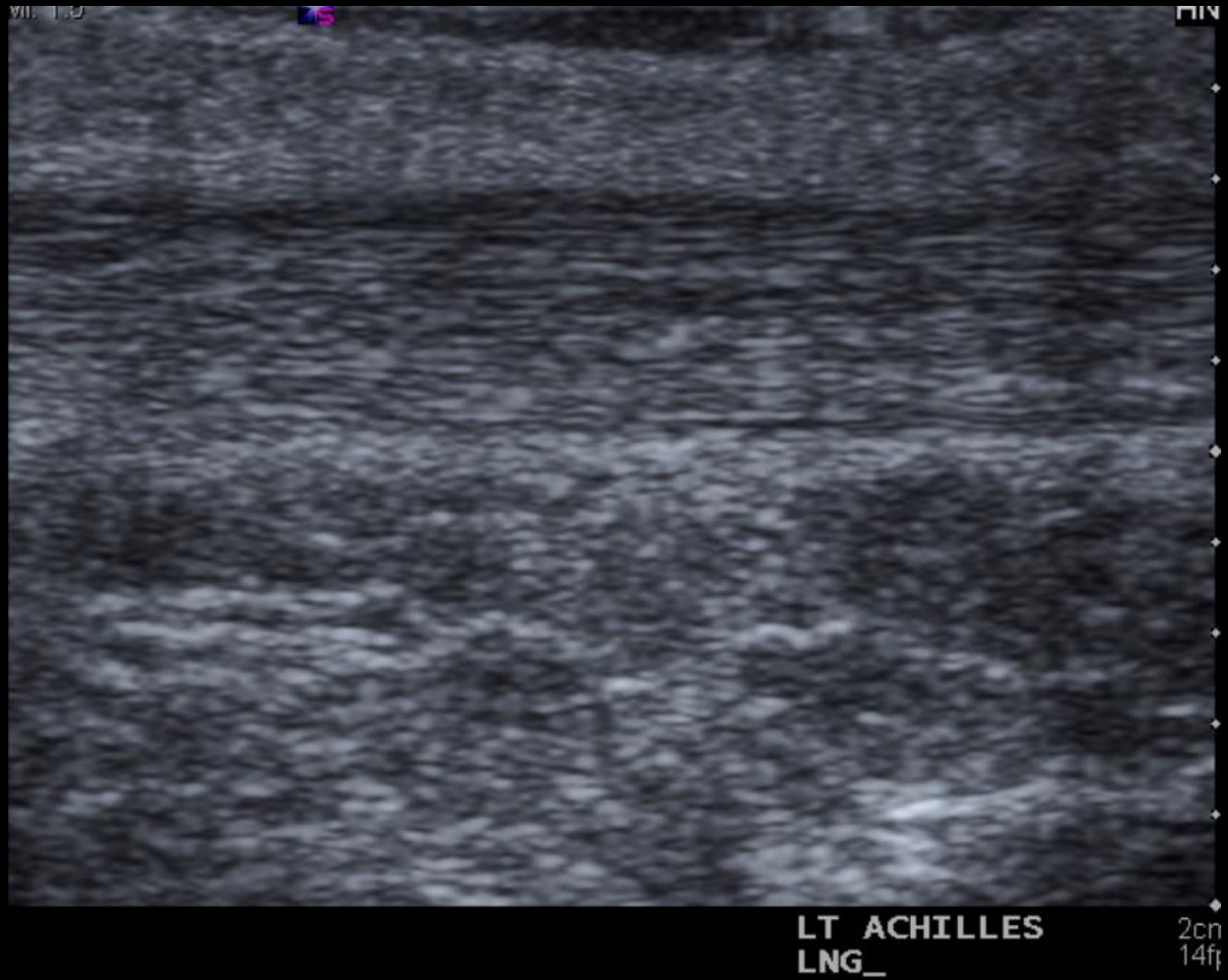
Aseptic loosening vs infection
Now what?

No abnormal WBC accumulation, Now what?

Arthrocentesis

Sonography (Ultrasound)

- Uses
- Advantages
- Limitations



Sonography (Ultrasound)

Uses

Advantages

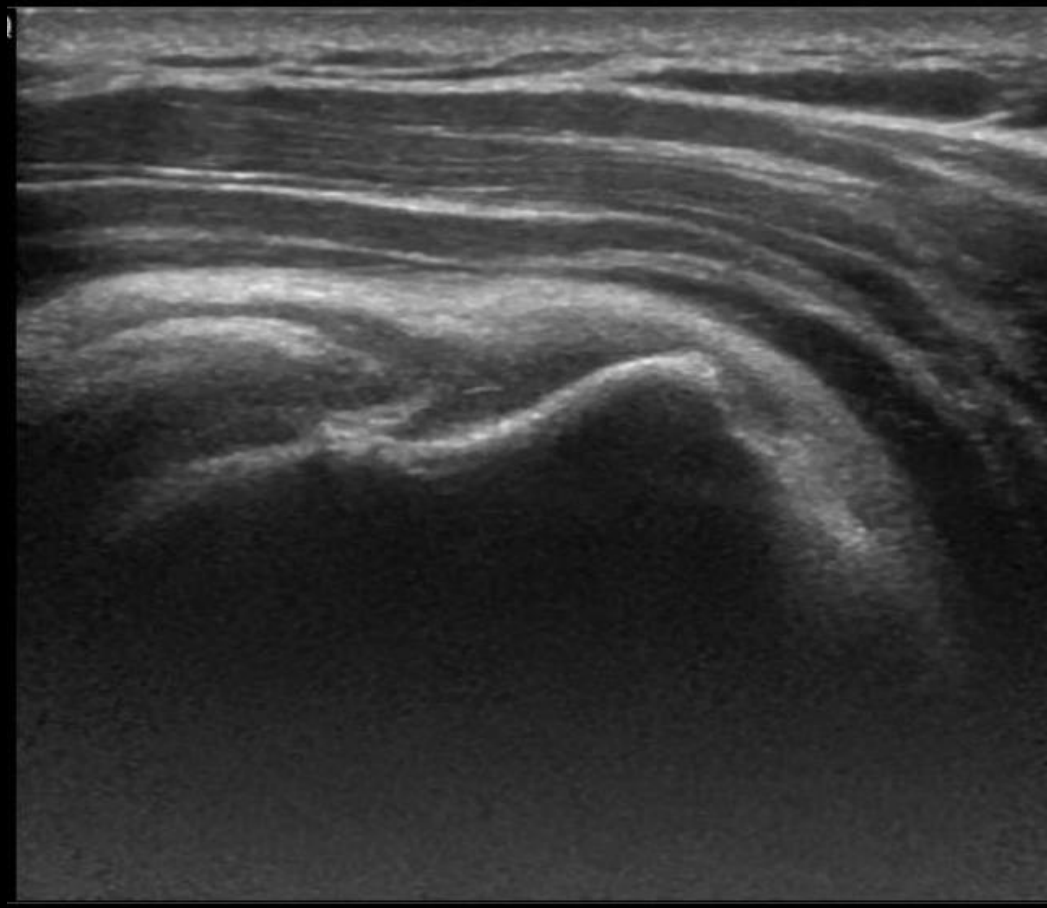
Limitations

Soft tissue processes

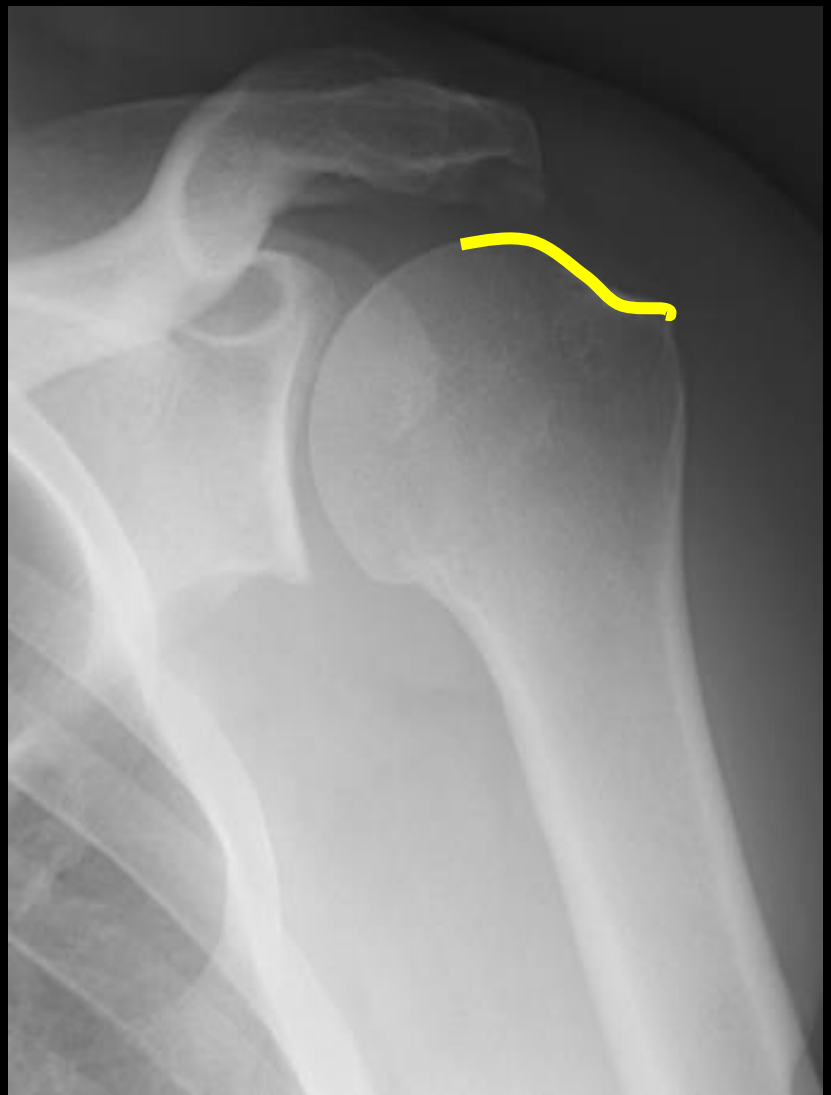
- masses
- tendon disease
- fluid collections

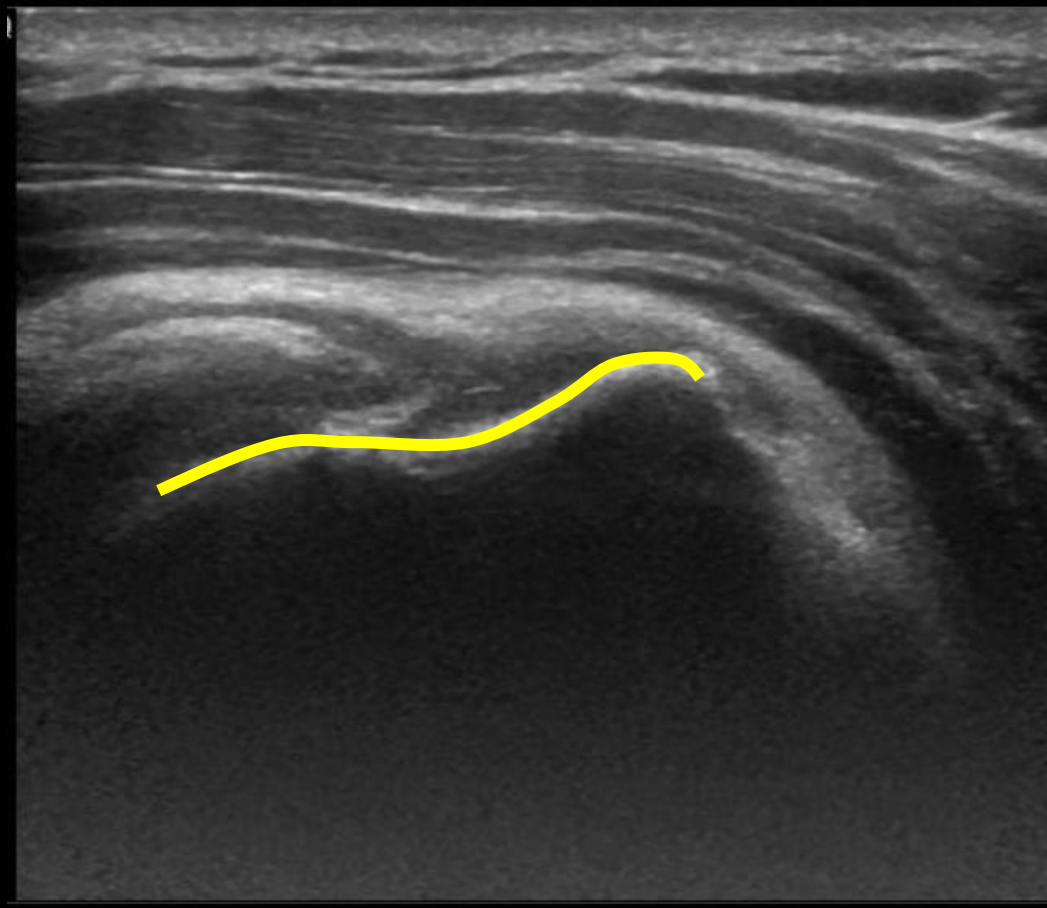
Procedure guidance

Case

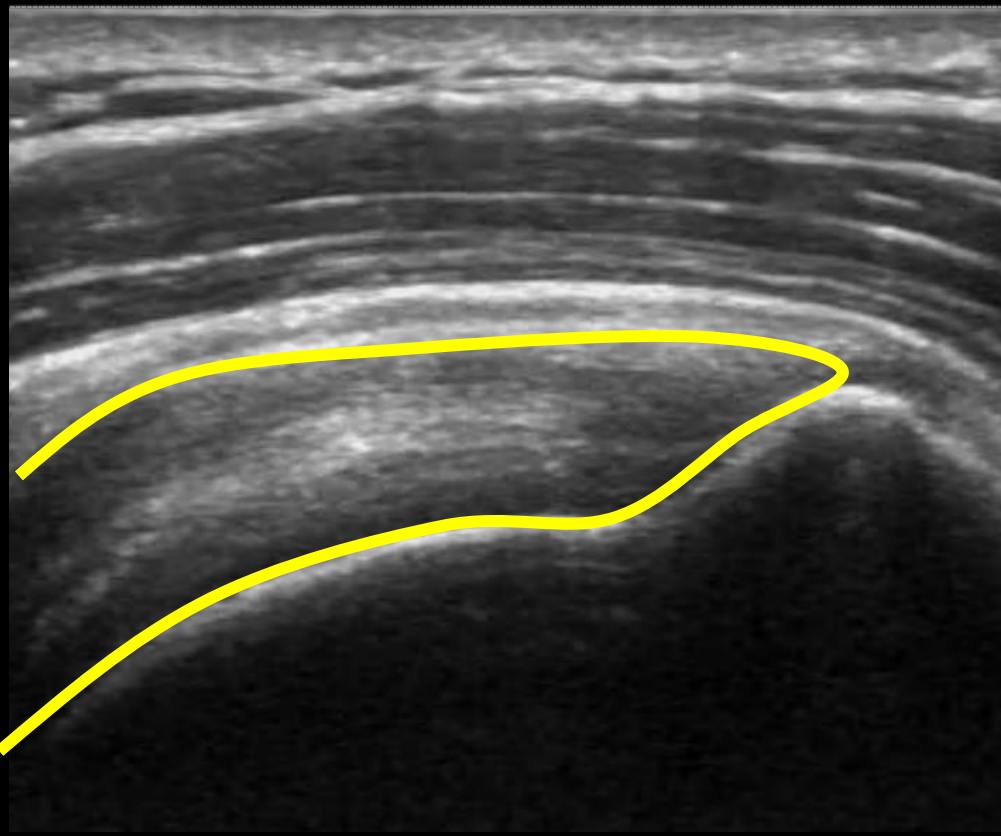


Sonography: Rotator Cuff Tear

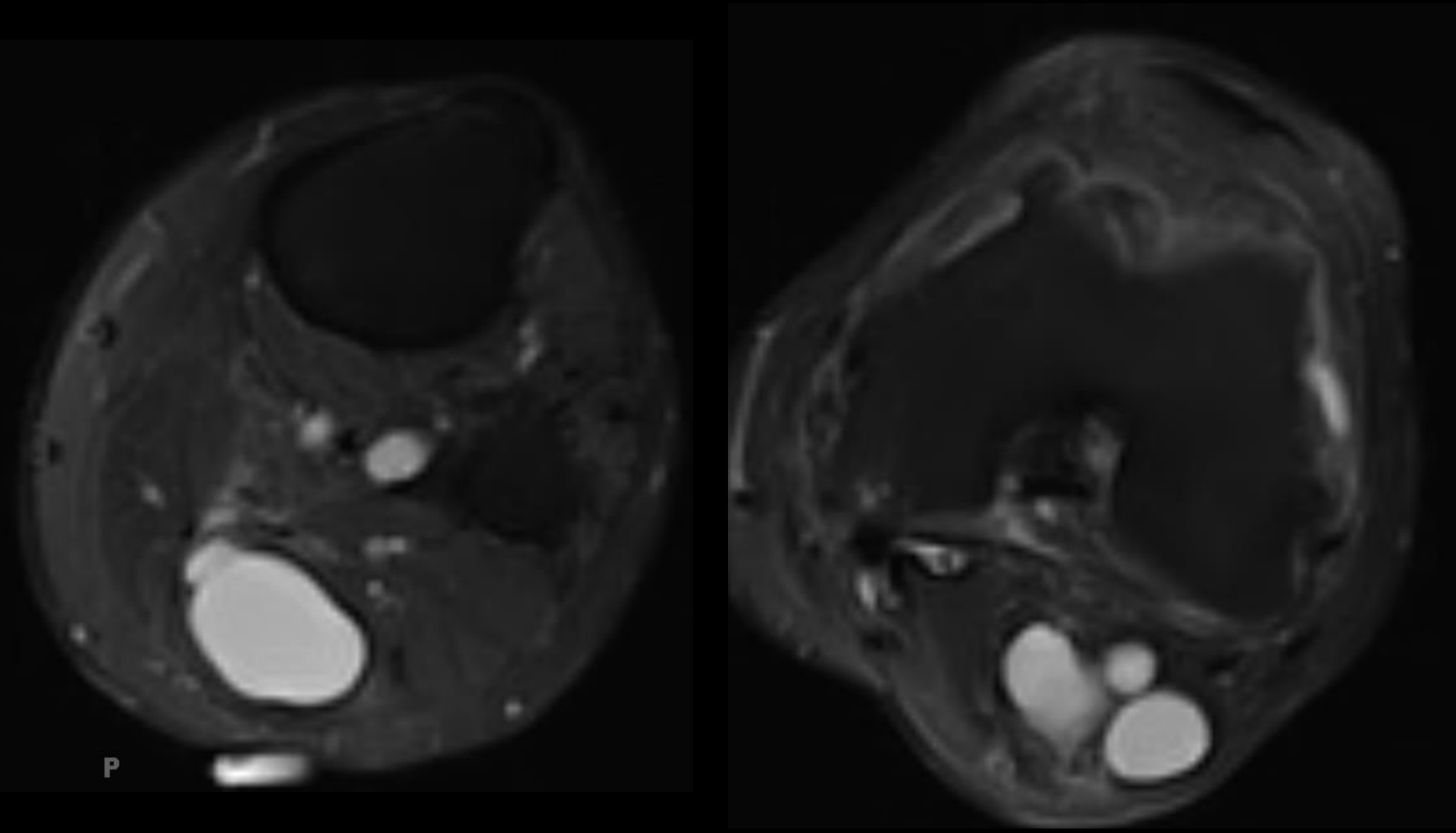




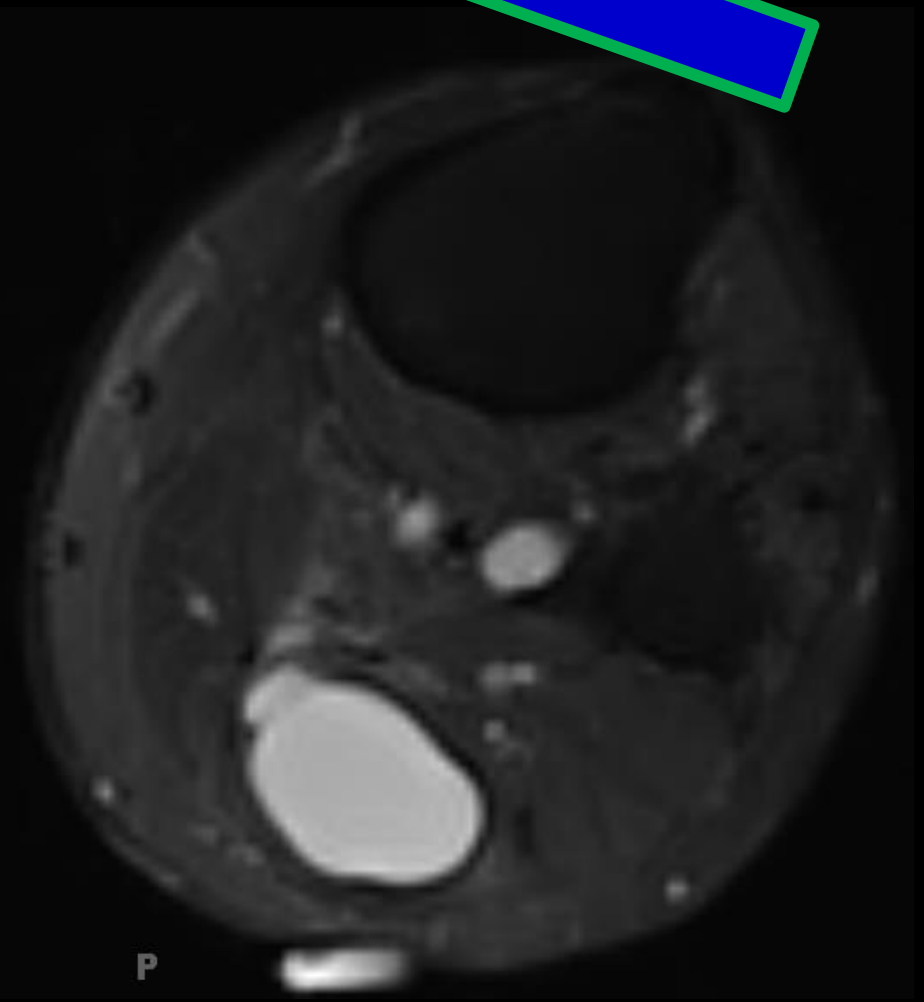
Sonography: Rotator Cuff Tear

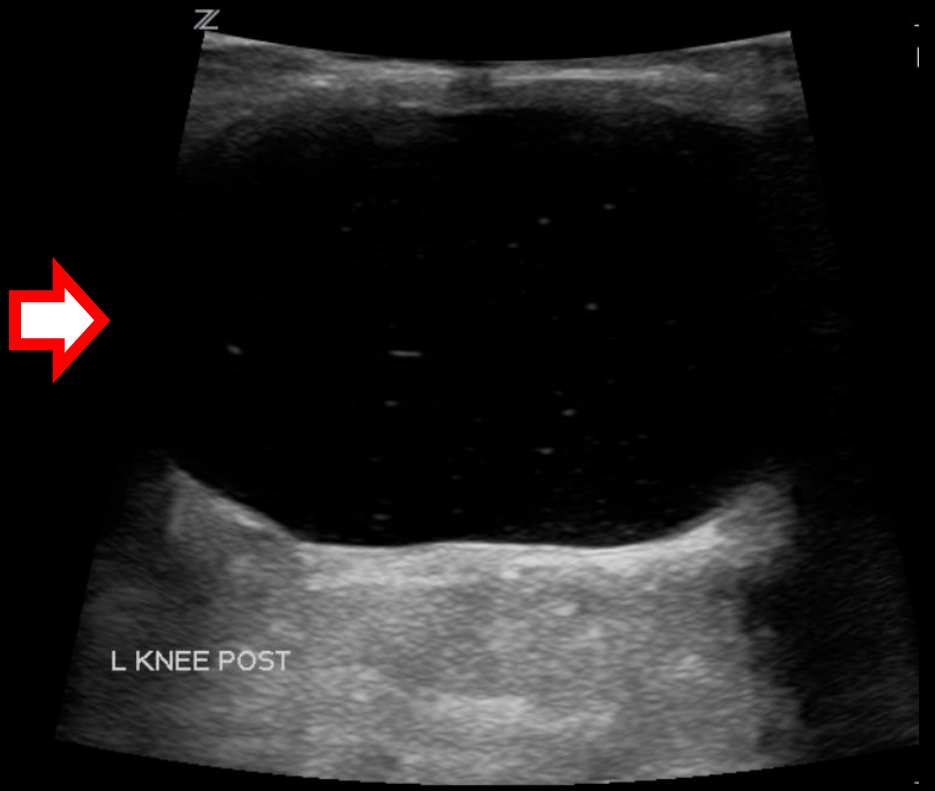


Case

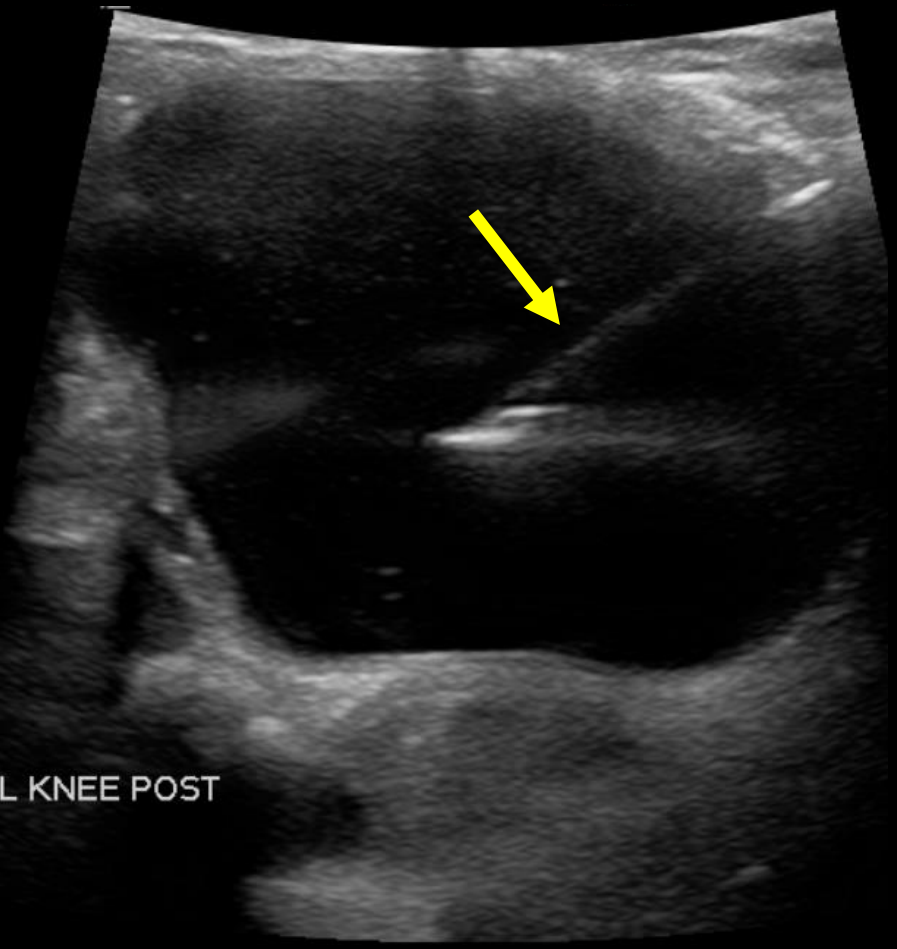


Sonograp Knee baker's cyst





Sonography: Knee baker's cyst



Sonography (Ultrasound)

Uses

Advantages

Limitations

No radiation

Multiplanar

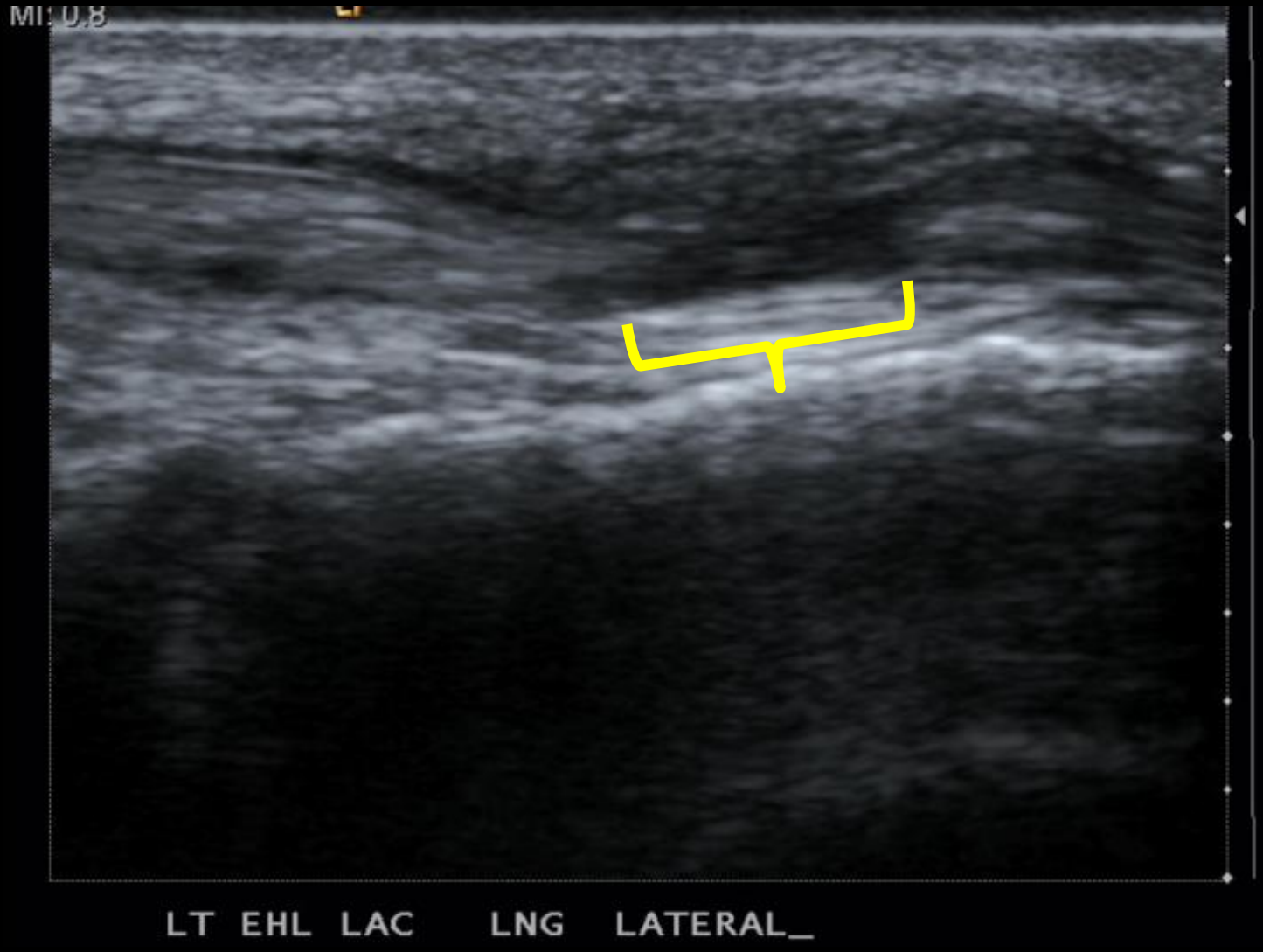
Dynamic

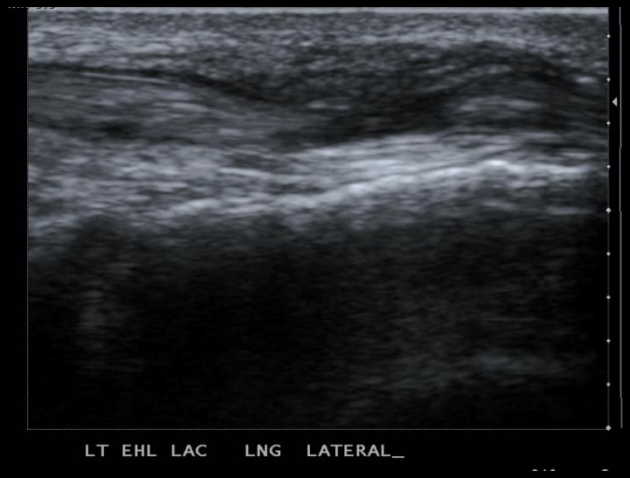
Case

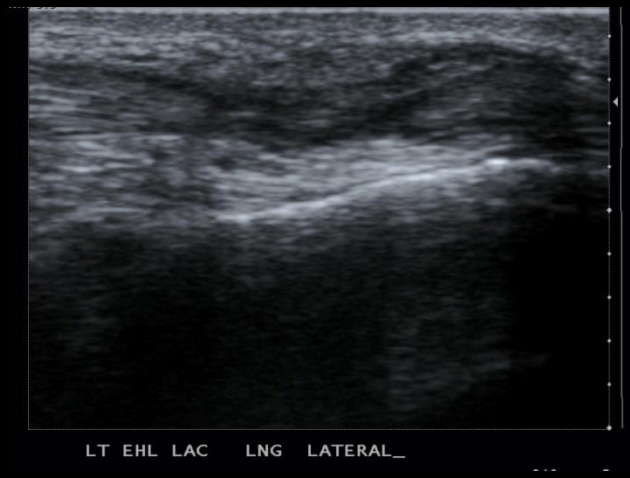
19 yof

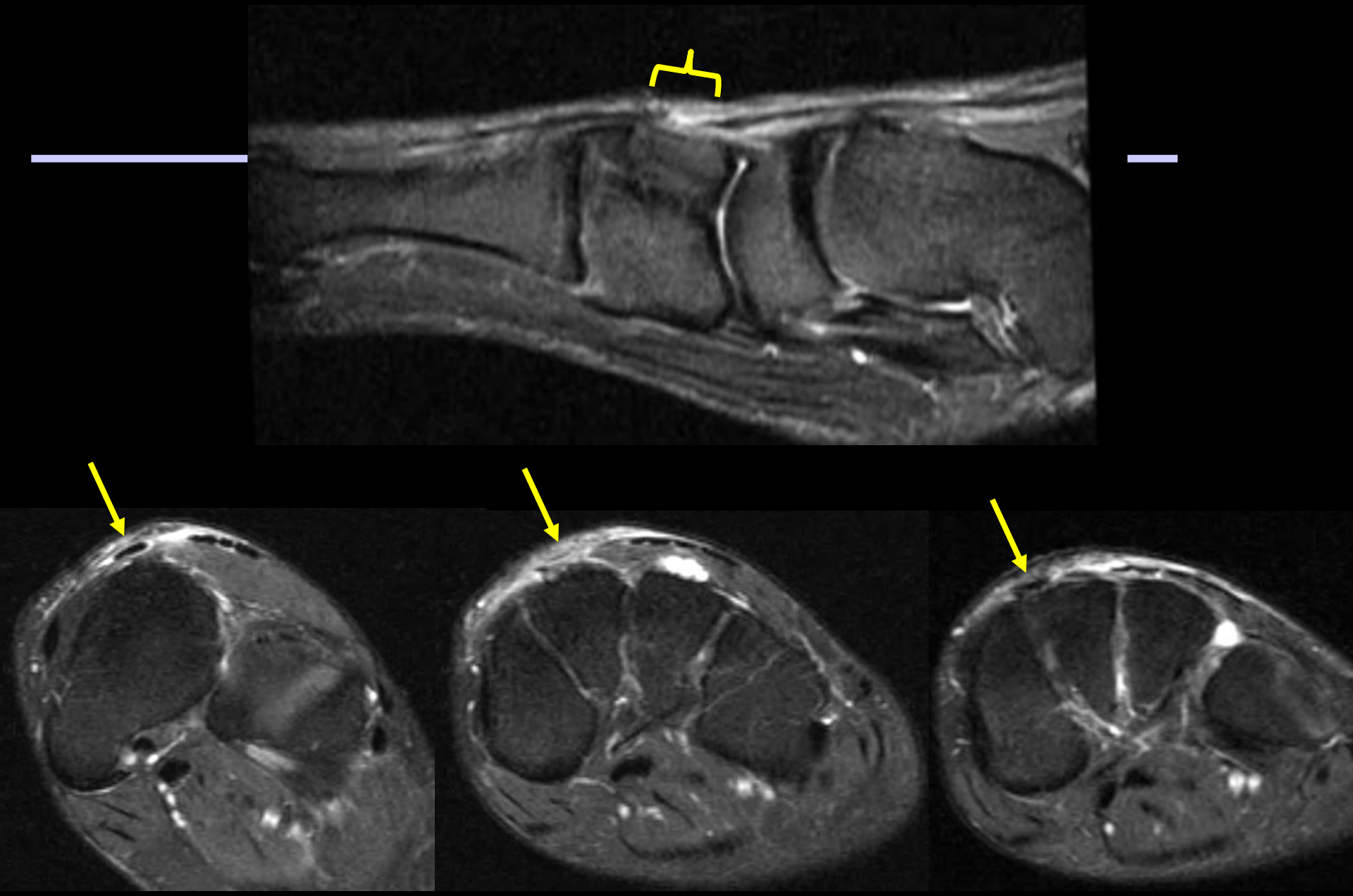
Dropped picture frame on the top of her foot

Cannot extend great toe


LT EHL LAC LNG LATERAL_


LT EHL LAC LNG LATERAL_


LT EHL LAC LNG LATERAL_



Sonography (Ultrasound)

Uses

Advantages

Limitations

- Superficial structures
- Extremely operator dependent

Ultrasound

Use

Soft tissues

Procedure guidance

Dynamic

No Radiation

Limits

Superficial limits

Operator dependent

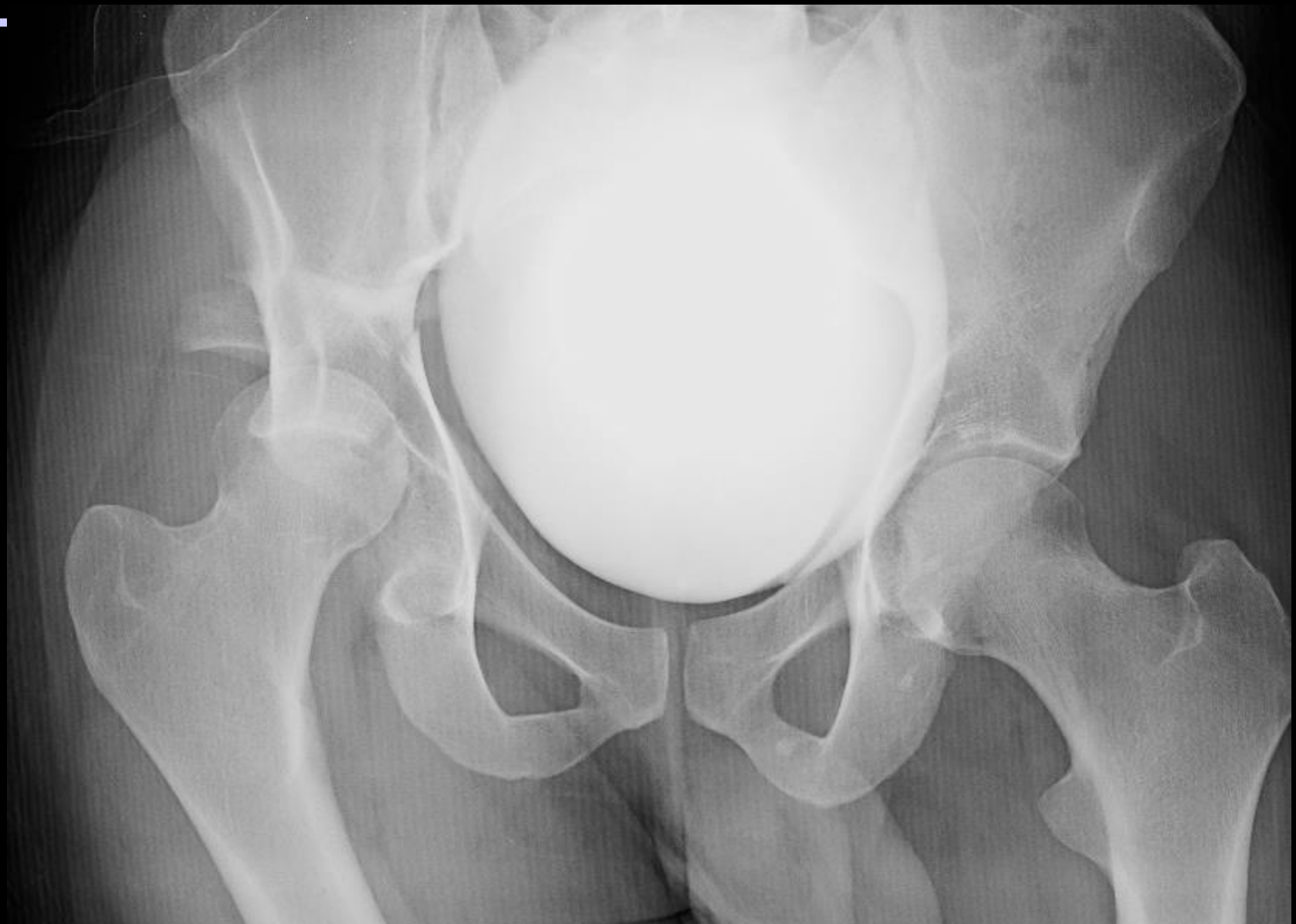
Computed Tomography (CT)

- Uses
- Advantages
- Limitations

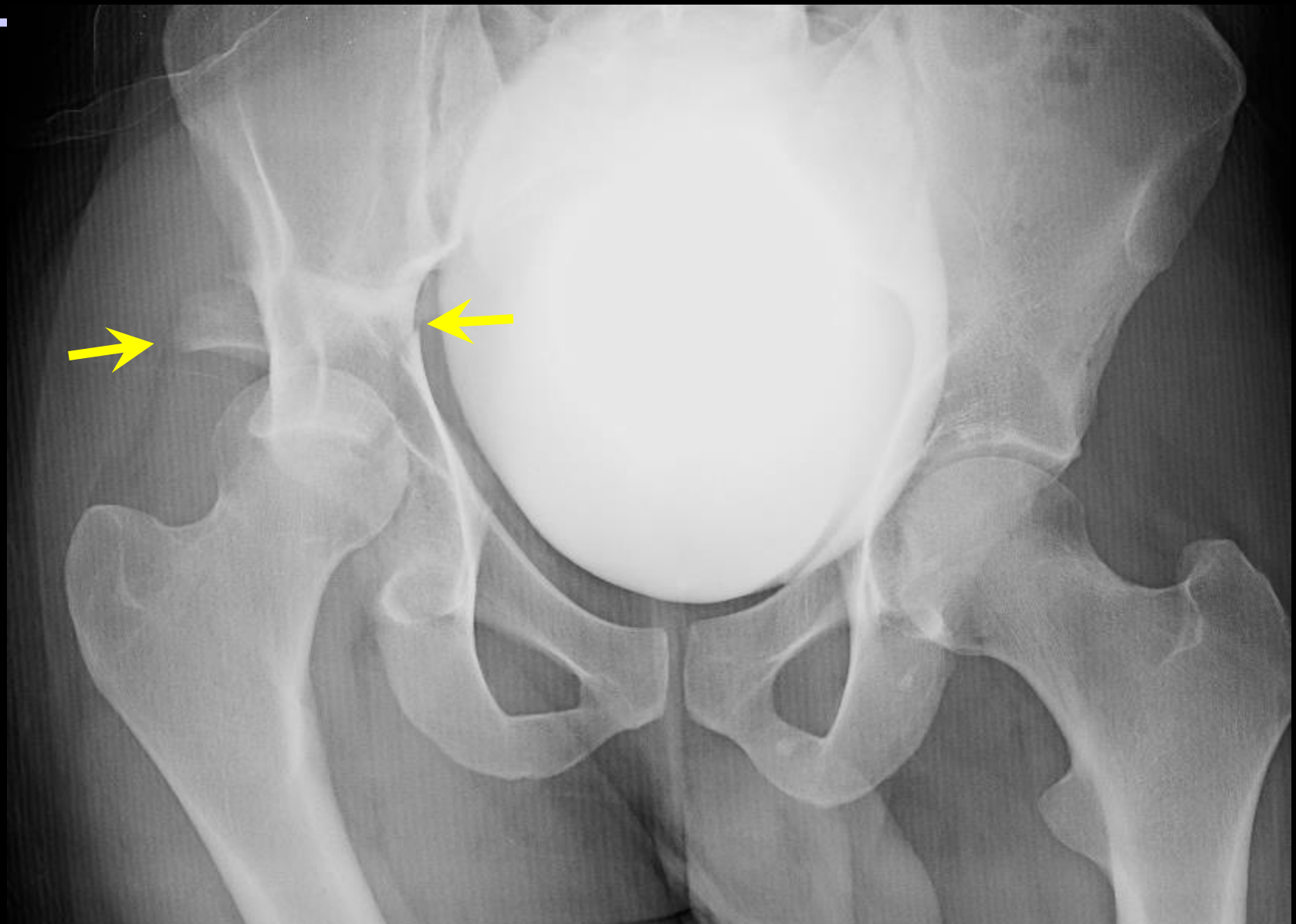
Computed Tomography (CT)

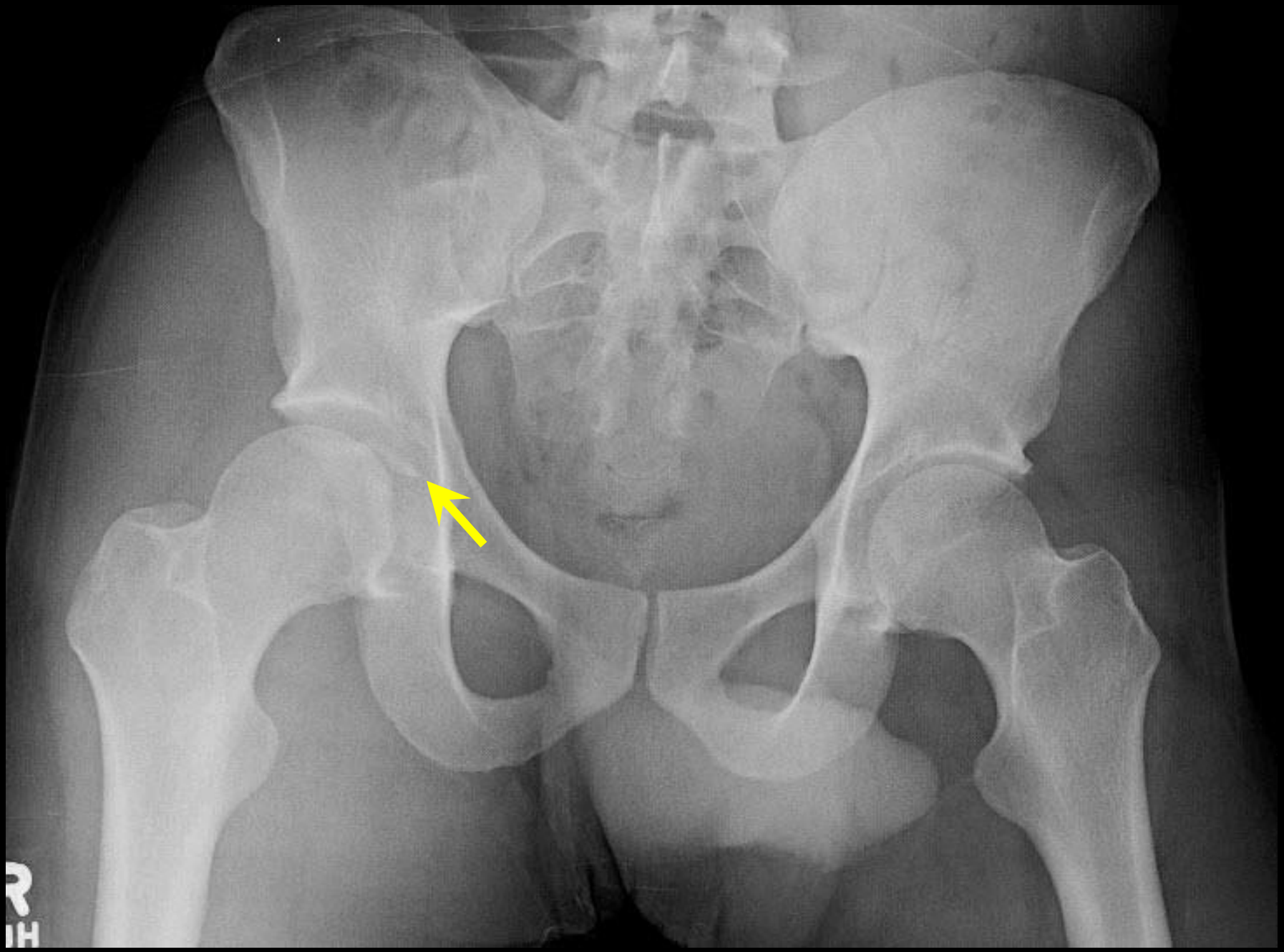
- Uses
  - Complex fractures
  - Orthopedic planning
  - Postoperative imaging
  - MR contraindications
- Advantages
- Limitations

Case



Case

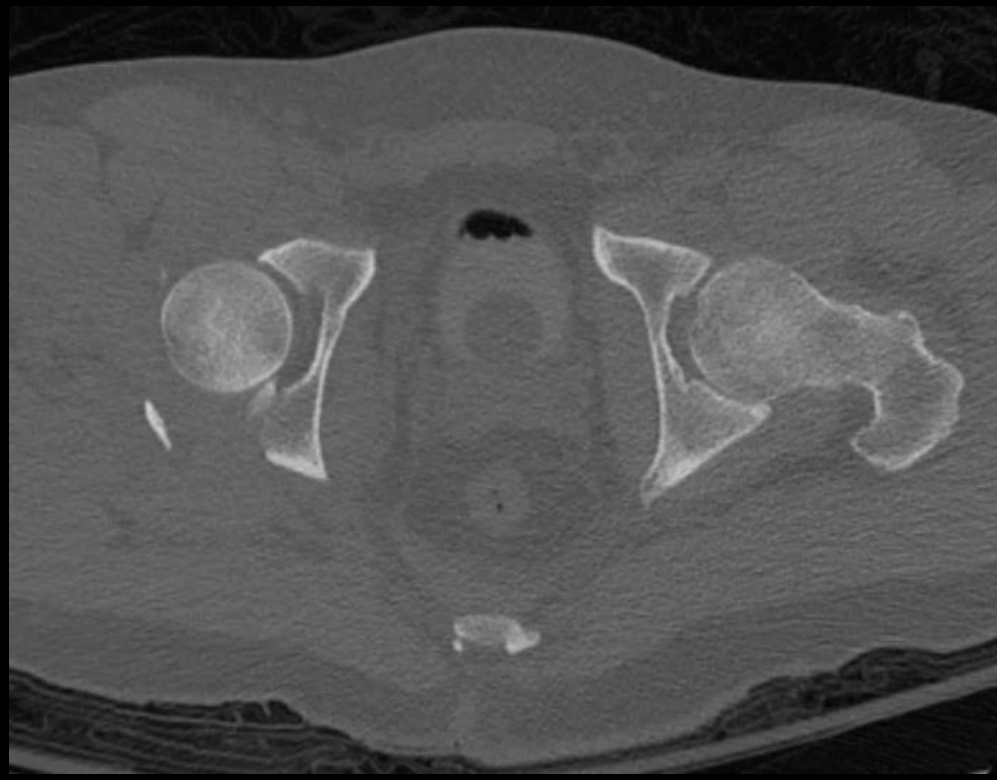




CT Indications

MSK Trauma

- Fracture anatomy paramount for treatment staging / planning
  - Pediatrics – physes
- Intra-articular fragments
- Healing

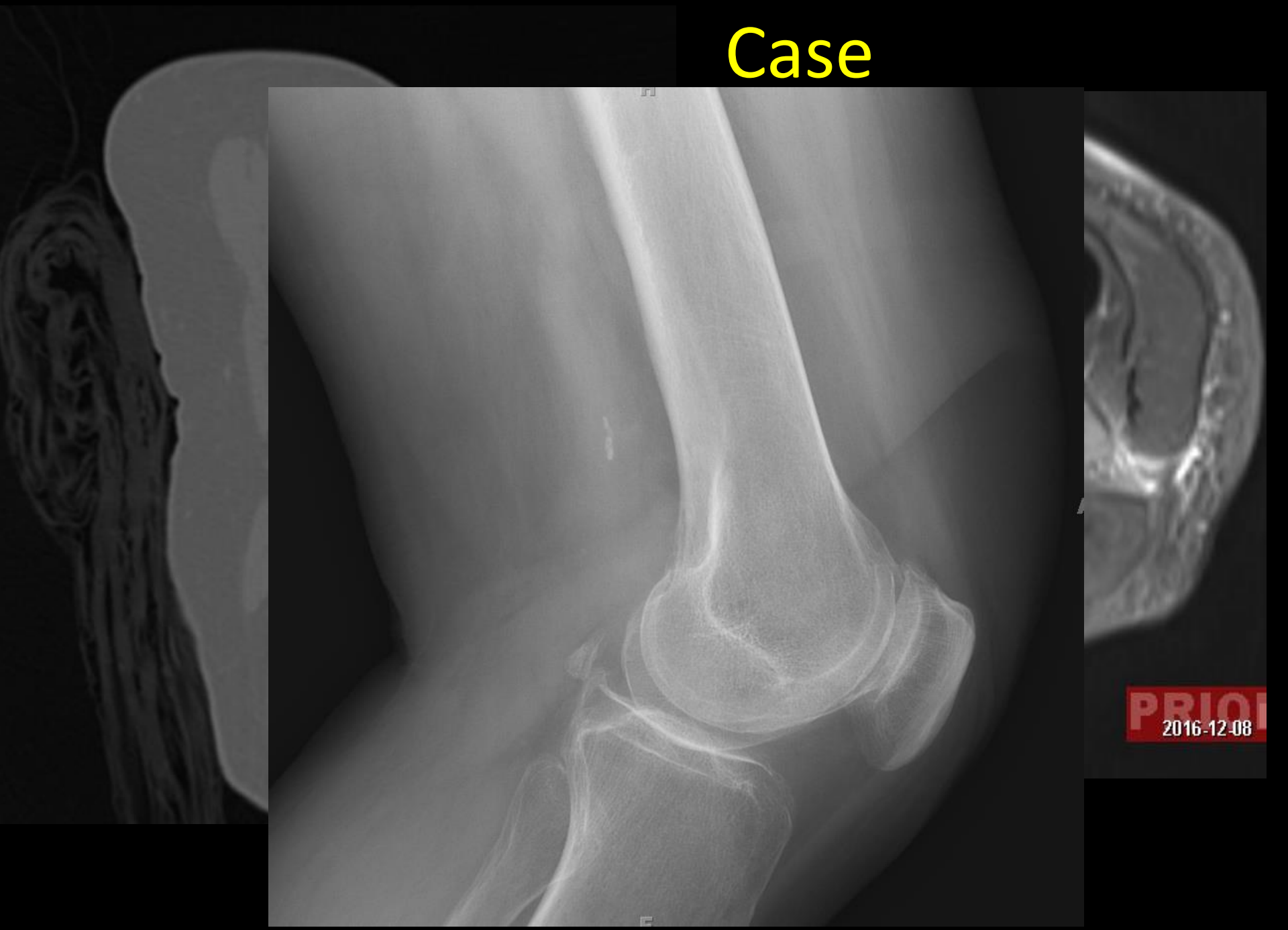


CT Indications

Skeletal/Soft Tissue Masses

- Characterization
  - Matrix
    - Chondroid/osteoid
  - Myositis Ossificans
  - Periosteal Reaction
- Osseous involvement
  - Pathologic fracture risk
- Osteoid Osteomas

Case



CT Indications

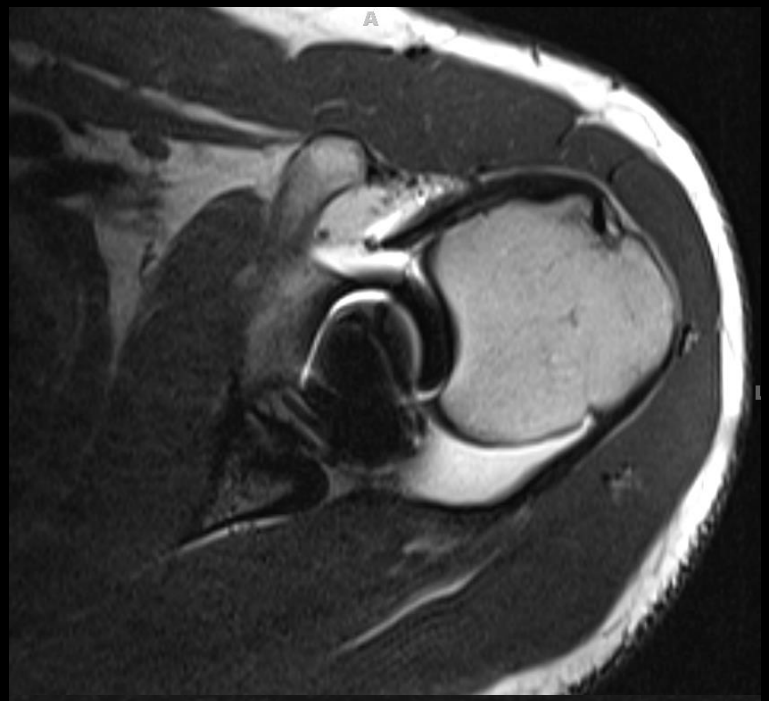
MR Contraindications

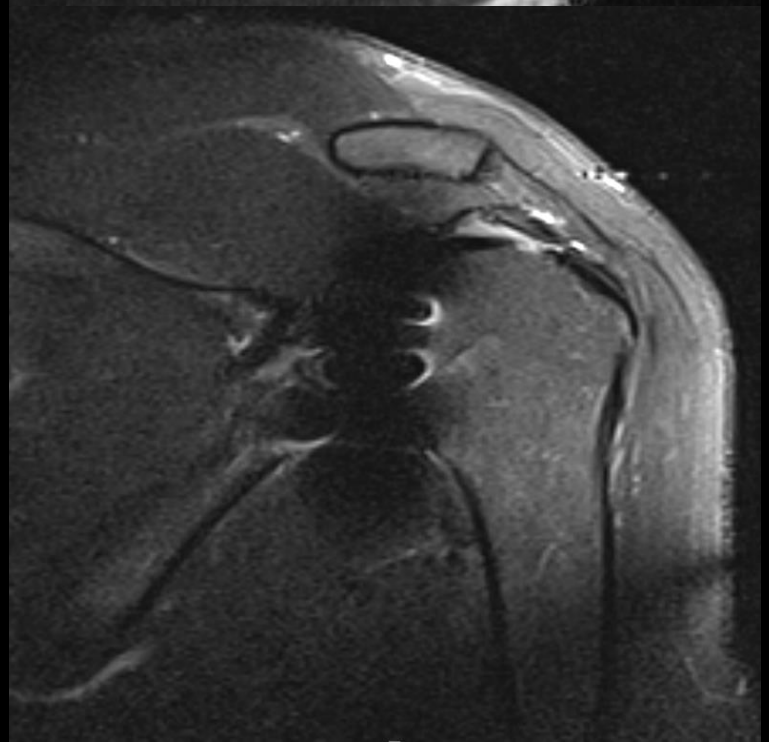
- Postoperative
  - Metal artifact
- Pacemaker / Pumps / Implants
  - Myelogram
- Patient Motion

Further Eval of MR Findings

- Pseudoarthrosis
- Coalition

Case





Computed Tomography (CT)

Uses

Advantages

Limitations

Fine bony detail

2D and 3D reconstructions

Computed Tomography (CT)

Uses

Advantages

Limitations

Limited soft tissue detail

Radiation dose

Computed Tomography (CT)

Use

Surgical planning

Fine bony detail

Fast

Limits

Radiation

Magnetic Resonance (MR)

- Uses
- Advantages
- Limitations

Magnetic Resonance (MR)

Uses

Advantages

Limitations

Advanced bone and soft tissue imaging

- Tendon / ligt injuries
- diagnosis / exclusion
- local staging
- treatment planning
- prognostication

Magnetic Resonance (MR)

Uses

Advantages

Limitations

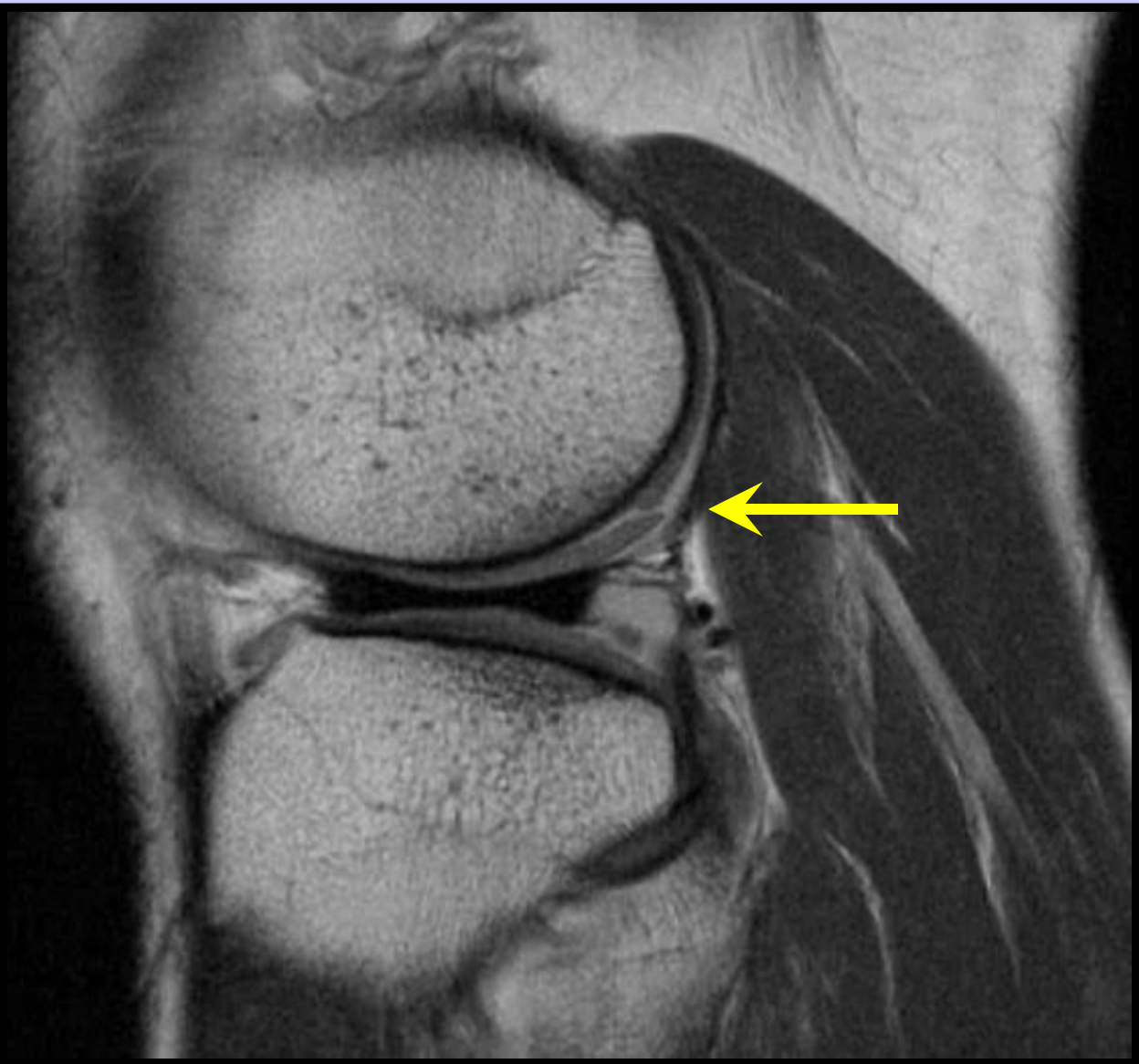
Supreme sensitivity

Exquisite anatomic detail

Multiplanar imaging

No Radiation

Case

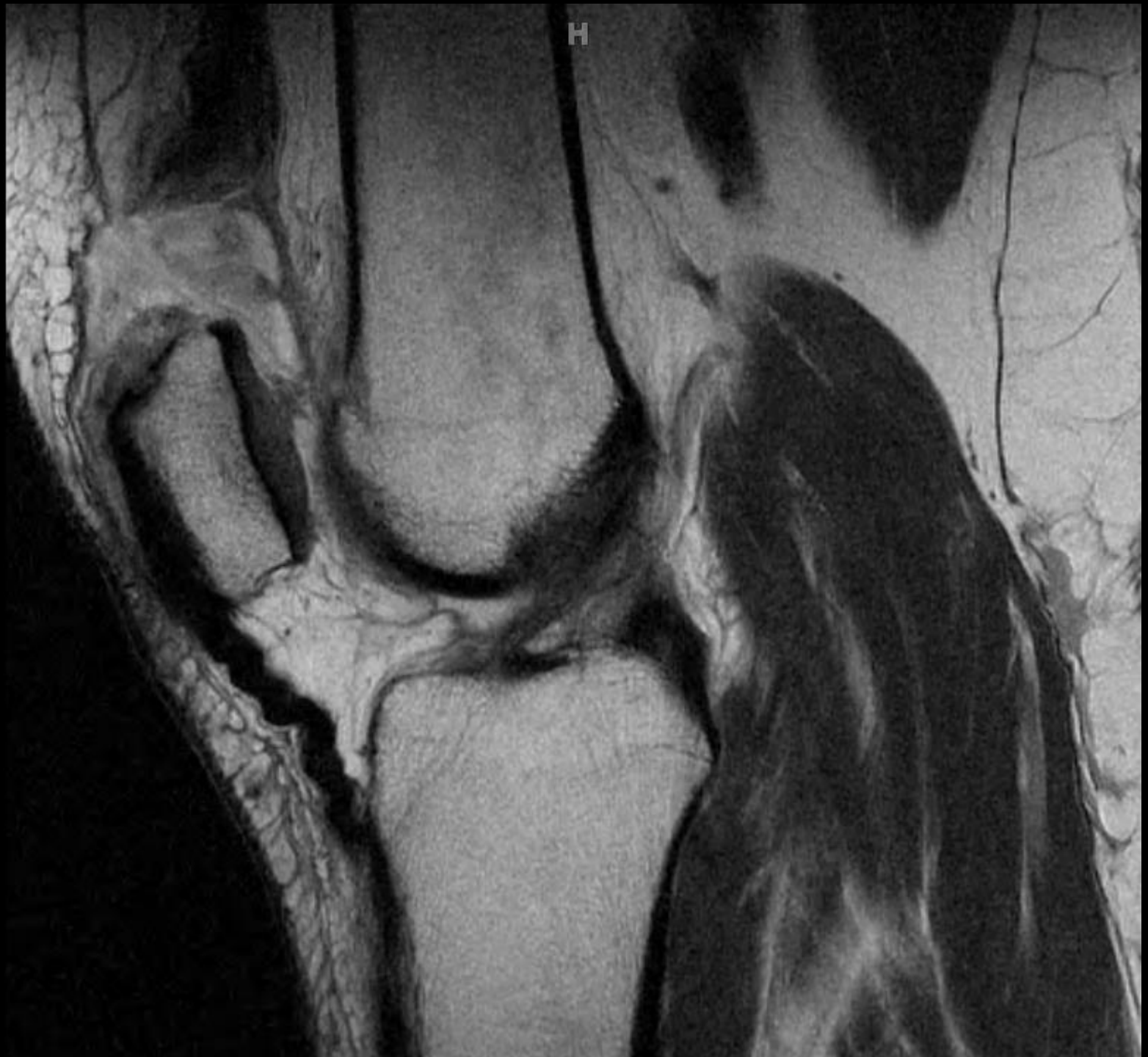


MR: Articular Cartilage

Normal meniscus

Case

Case


H

MR: Quadriceps Tear


H

Magnetic Resonance (MR)

Uses

Advantages

Limitations

- Relatively expensive
- Lower availability
- Patient contraindications
- Single body region
  - not survey test
- Time

MR Contraindications

Absolute

Implantable Pediatric Sternum Device

Metallic Foreign Body in the Eye

"Triggerfish" Contact Lens

Gastric Reflux Device

Insulin Pumps

Temporary Transvenous Pacing Leads

Relative

Shrapnel

Pregnancy

Implantable Drug Infusion Pumps

Epidural Catheters

Feeding Tubes

Recent prosthesis

Relative

Spinal Fixation Hardware

Halo

Neuro-Stimulation Systems

Bone Fusion (Spinal) Stimulator

Cochlear Implants

Intra-Cranial Vascular Clips

EEG Electrodes

Ventricular Catheters

Breast Tissue Expanders

Prosthetic Heart Valves

Pacemakers, ICDs, Pacing Wires and Loop Recorders

Penile Implants

Foley Catheter with Temperature Probe

Magnetic Resonance (MR)

Uses

Excellent/sensitive soft tissue imaging

Anatomy

No Radiation

Limits

Expensive

Time consuming

Contraindications

Basic MRI Review

- Typical MSK imaging exams will include around 4 to 6 pulse sequences in various anatomical planes (usually 2 to 4).

- The workhorse sequences utilized are
  - T1 weighted
    - (with FS if contrast is used)
  - T2 weighted
    - (with or without fat suppression)
  - STIR
  - PD weighted
  - GRE

Basic MRI Review

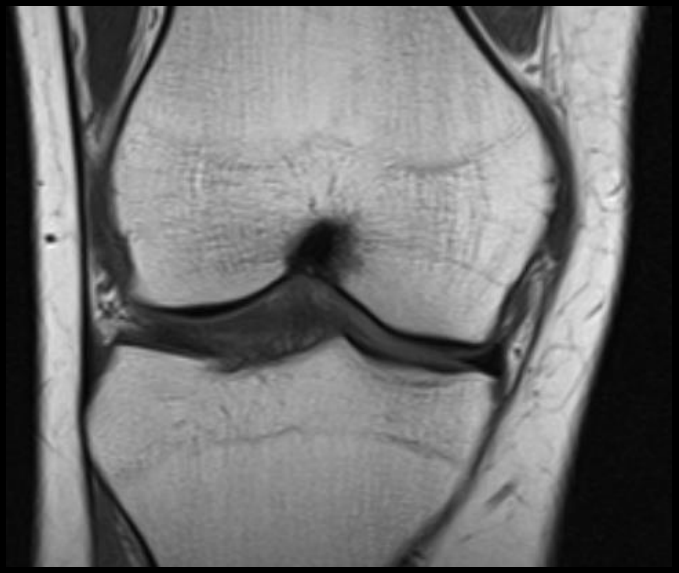
- Basic Protocols used for MSK imaging:
  - T1
    - Fluid hypointense
  - T2
    - Fat suppression
    - Fluid hyperintense
  - STIR
    - Looks much like a T2 FS image
    - More homogeneous fat suppression

Basic MRI Review:
Things **Bright** on T1 and T2

T1	T2
Melanin	Fluid (edema, CSF)
Protein	Neoplasm
Fat	Fat (esp. w/ FSE)
Subacute blood	Subacute blood
Gadolinium	Gadolinium

Basic MRI Review: General Points

- T1 -- Looking at anatomy
  -- Evaluating Marrow



- T2 -- Identifying pathology
  -- Evaluating ligaments & tendons
  -- Evaluating cartilage
  -- Evaluating edema pattern

Basic MRI Review: General Points

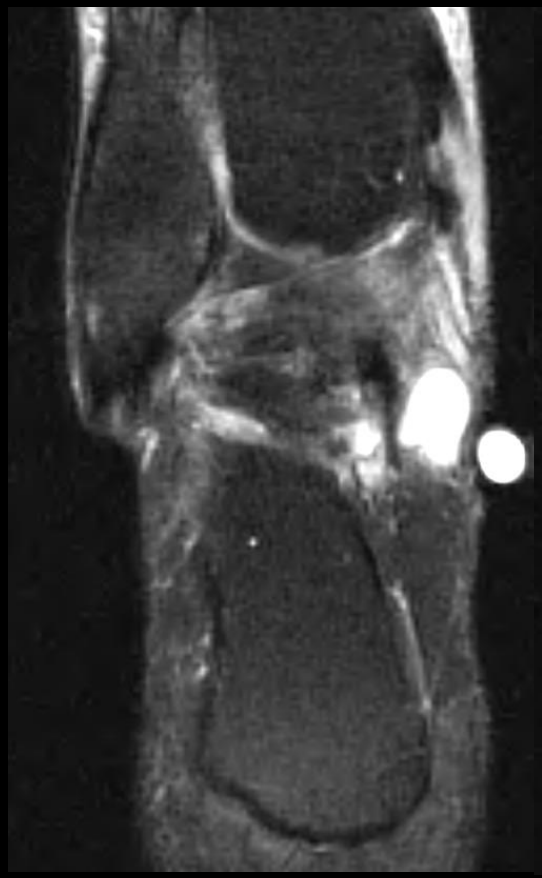
- MRI without contrast
  - Most joint evaluations
- MRI with contrast
  - Arthrograms
- MRI with and without contrast
  - 3 main reasons
  - Spine

Basic MRI Review

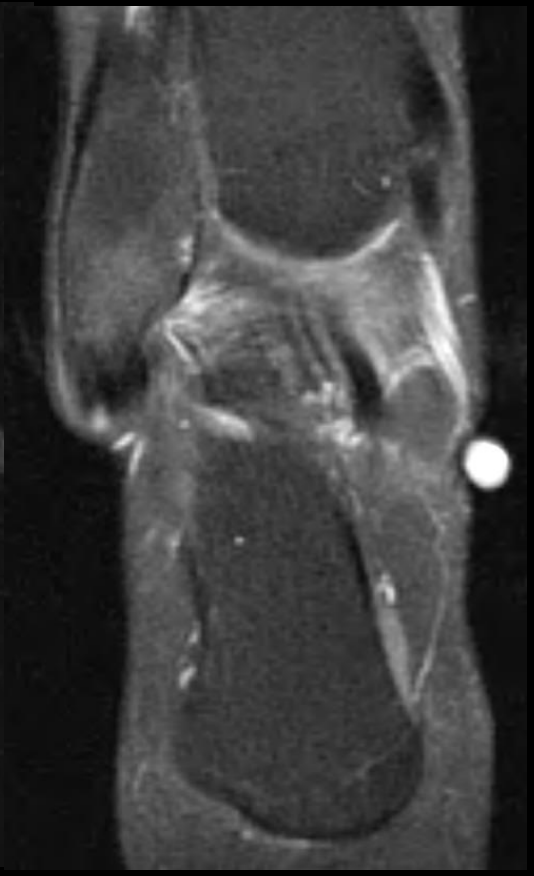
Contrast Enhancement (CE)

- Enhancement is non-specific

- Indications:
  - Tumor
    - Differentiation of cyst versus solid lesions
    - Identify biopsy sites

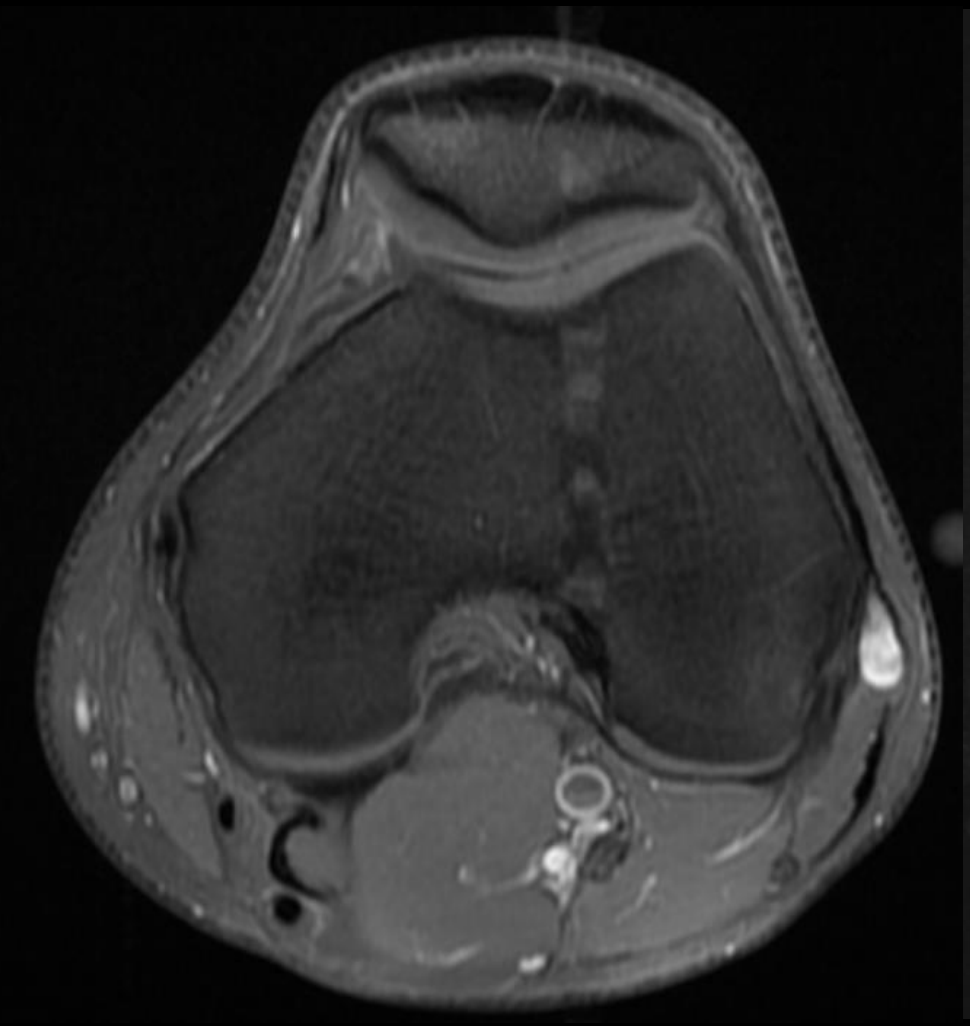


T2 FS



T1 FS +Gd

Case



T1+C

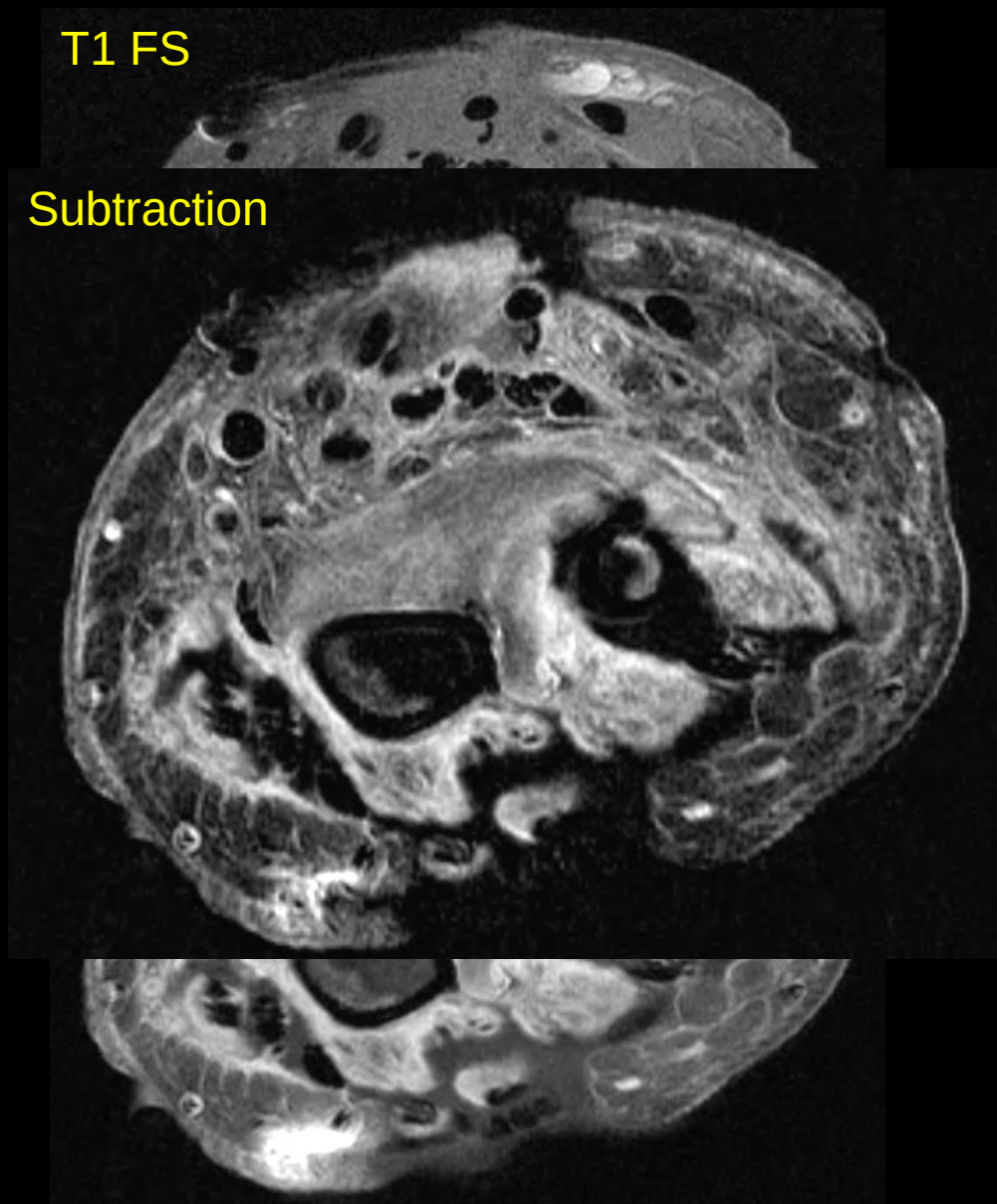
T2FS

Basic MRI Review

Contrast Enhancement (CE)

- Enhancement is non-specific

- Indications:
  - Tumor
    - Differentiation of cyst versus solid lesions
    - Identify biopsy sites
  - Infection
    - Evaluation of viable versus non viable tissue



Basic MRI Review

Contrast Enhancement (CE)

- 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

MRI Protocols

- IMPORTANT:
  - Every examination is tailored to the specific clinical question
  - History is crucial
    - An order with history listed as “pain” is worthless to the reading radiologist
    - Will get a much better tailored examination when a complete history is presented to the radiologist
    - When in doubt, speak directly to an MSK radiologist

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

Rational

- Arthrogram
  - Enhance evaluation of joint anatomy
  - Expose joint pathology
- Joint distension
  - Expose apposed structures

Joint Specific Arthrogram Indications

Shoulder
- Labral Tear
- Glenohumeral Instability
- ?? Rotator Cuff tear

Elbow
- UCL tear
- RCL, LUCL ligt tear

Wrist
- Scapholunate, lunotriquetral tear
- TFCC tear

Hip
- Labral Tear
- FAI

Knee
- Retear repaired meniscus
- ACL reconstruction

Ankle
- ?? ATFL tear

All Joints
- Osteochondral Lesion
- Loose Body

Summary

CT

- Acute trauma
- Fracture classification
- Surgical Planning
- Post operative
- Some tumor evaluation
- MR contraindications

MRI

- Intraarticular pathology
- Soft tissue infection
- Tumor staging/evaluation

Summary

1. Imaging modalities used in MSK imaging
    1. XR, CT, MRI, US Bone scintigraphy
2. **ALWAYS** begin with plain films
3. Whenever possible order standard examination (always at least 2 views)
4. MR exams are time-consuming, expensive, and can be difficult to tolerate
    1. MR should be a **FOCUSED** exam

Summary

5. MRI vs CT

6. MRI ordering
    - Without contrast
        - Most joint evaluations
    - With contrast
        - Arthrograms
    - With and without contrast
        - 3 main reasons
            - » TUMOR
            - » INFECTION
            - » Inflammatory Arthritis

Thank You!!

friedmanm@clinicalradiologist.com