

Imaging of Musculoskeletal Infection

Jon A. Jacobson, MD
FACR, FSRU, FAIUM, RMSK

*Musculoskeletal Radiologist
Lenox Hill Radiology, NYC*

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Disclosures

- Book Royalties: Elsevier
- Consultant: Bioclinica
- Advisory Board: Philips
- Contractor: POCUSPRO
- Not relevant to this talk

Syllabus on line and other educational material:
www.jacobsonmuskus.com

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Objectives:

1. Understand mechanism of musculoskeletal infection
2. Recognize imaging findings of musculoskeletal infection
3. Differentiate osteomyelitis from neuropathic joint

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Outline:

- Mechanisms
- Soft tissue infection
- Septic arthritis
- Osteomyelitis
 - Neuropathic joint
 - Discitis

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Mechanisms:

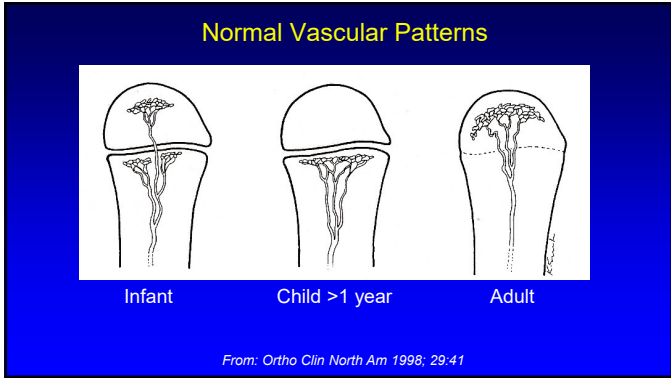
- Hematogenous
 - Children, intravenous drug abusers
- Contiguous source
 - Diabetic ulcer
- Direct implantation
 - Penetrating injury
 - Surgery

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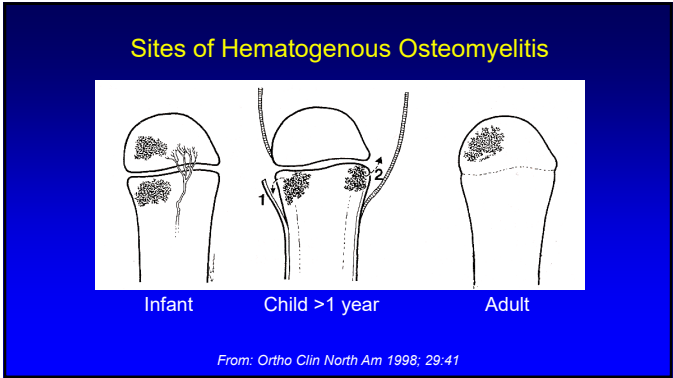
Infection: hematogenous

- Abscess (pyomyositis)
- Septic bursitis
- Septic arthritis
 - Acromioclavicular, sternoclavicular
 - Sacroiliac
- Osteomyelitis
 - Vascular patterns differ with age

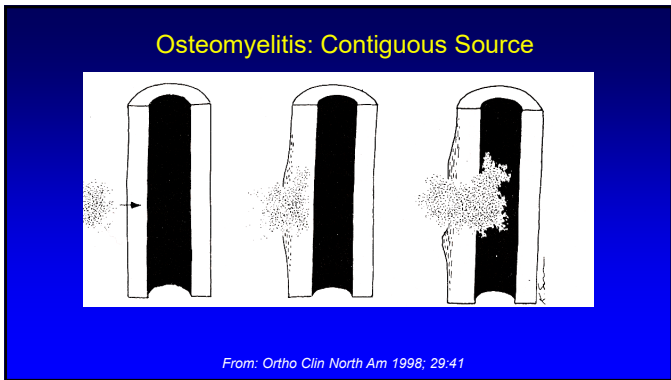
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- ### Outline:
-
- Mechanisms
 - **Soft tissue infection**
 - Septic arthritis
 - Osteomyelitis
 - Neuropathic joint
 - Discitis

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Cellulitis

- Acute inflammation:
 - Dermis, subdermis
 - Erythema, warmth, edema
- Cause: disruption of skin
 - *Staph. Aureus*
 - *Strep. pyogenes*
- Susceptible:
 - Vascular disease
 - Indwelling objects



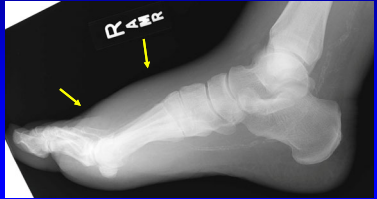
From: RadioGraphics 2007; 27:1723

From: Skeletal Radiol 2010 in print

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Cellulitis

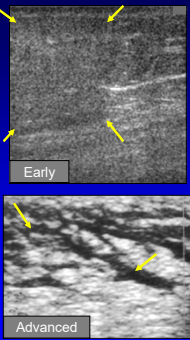
- Radiography and CT:
 - Soft tissue swelling
 - Increased density



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Cellulitis: ultrasound

- Early (<3 days):
 - Thick subcutaneous tissues, increase echogenicity
- Advanced:
 - Distorted, anechoic channels
- Severe, advanced:
 - Fluctuating purulent fluid
 - Guided aspiration: efficacy similar to surgery
- Late: abscess formation

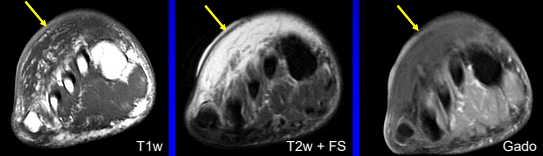


J Ultrasound Med 2000; 19:743

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Cellulitis

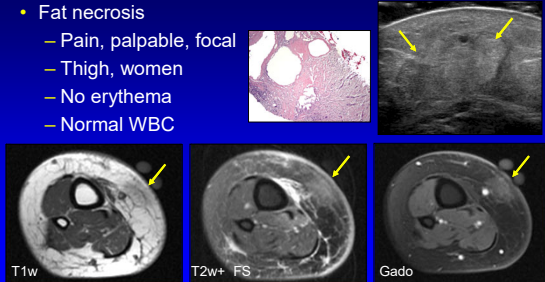
- MRI:
 - Abnormal fluid signal
 - Isolated: subcutaneous tissues



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Differential Diagnosis

- Fat necrosis
 - Pain, palpable, focal
 - Thigh, women
 - No erythema
 - Normal WBC

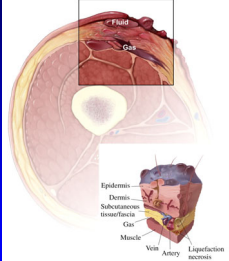


J Ultrasound Med 2008; 27:1751

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Necrotizing Fasciitis

- Infection:
 - Into deep fascia: progressive
 - Necrosis: subcutaneous
- Gas-forming:
 - Anaerobes, aerobic gram negative
- Life threatening emergency
 - 70 – 80% mortality if delayed diagnosis

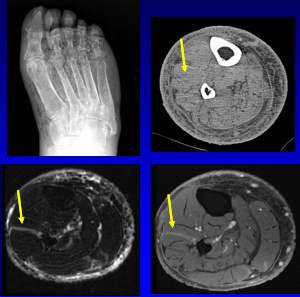


From: RadioGraphics 2007; 27:1723

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Necrotizing Fasciitis

- Deep fascia
 - Thick, enhancing
 - Non-specific
- Gas:
 - Radiography, CT
 - MRI: signal void
 - US: echogenic, dirty shadow
- Muscle abscesses

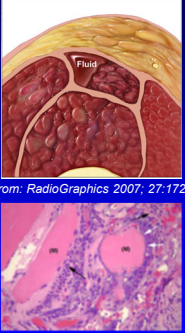


RadioGraphics 2004; 24:1472

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Abscess

- *Staph. aureus*: 77%
- Direct spread or hematogenous
- Usually one muscle:
 - Quads > gluteal > iliopsoas
- Pyomyositis: bacterial
 - Common: HIV



From: RadioGraphics 2007; 27:1723
From: Skeletal Radiol 2010 in print

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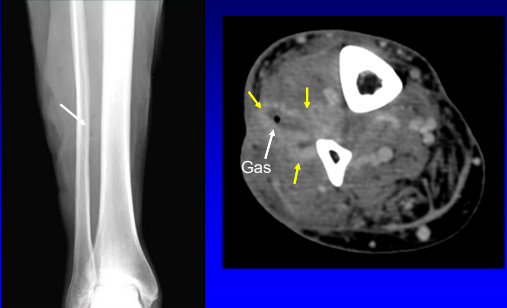
Abscess

- CT:
 - Fluid collection + ring enhancement
- Ultrasound:
 - Fluid: hypoechoic to hyperechoic
 - May appear solid
- MRI:
 - Fluid signal + ring enhancement
 - T1w: high signal rim*

Radiology 1995; 197:279

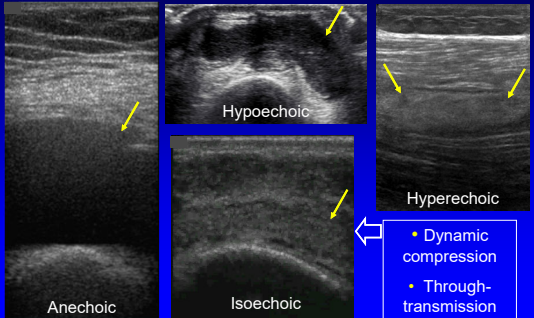
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Abscess: Radiography and CT



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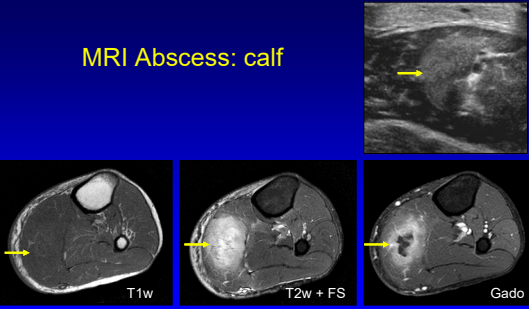
Abscess: ultrasound



- Dynamic compression
- Through-transmission

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MRI Abscess: calf



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Differential Diagnosis

- Diabetic muscle infarction
- Imaging:
 - Not homogeneous fluid signal
 - Relatively normal muscle architecture
- History:
 - Diabetes
 - Long standing)
 - Normal WBC
- Thigh > calf

AJR 2000; 174:165

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Differential Diagnosis

- Retained foreign body
 - Surgical material
 - Gossypiboma
 - Looks like heterogeneous fluid
 - Low signal gas on MRI

AJR 2000; 174:165

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Infective Tenosynovitis

- Uncommon
- Puncture, bite: hand, foot
- Hand: anatomy
 - Flexor tendon sheaths:
 - Thumb connects to little finger
 - Extensors: separate sheaths
- Imaging:
 - Fluid distention: complex
 - Synovitis

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Tenosynovitis

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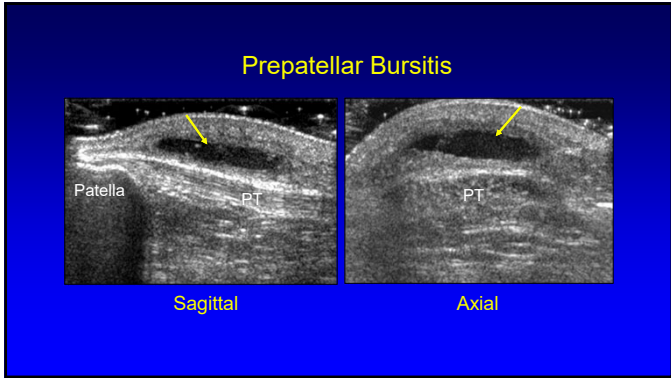
Infective Tenosynovitis: wrist

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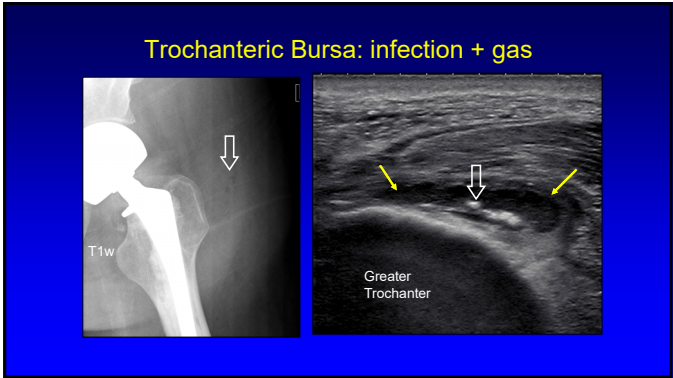
Septic Bursitis

- Direct inoculation
- Olecranon & prepatellar
- Spread from joint
- Radiography:
 - Swelling, possible gas
- Ultrasound / MRI:
 - Fluid collection in expected location of a bursa
 - Possible gas

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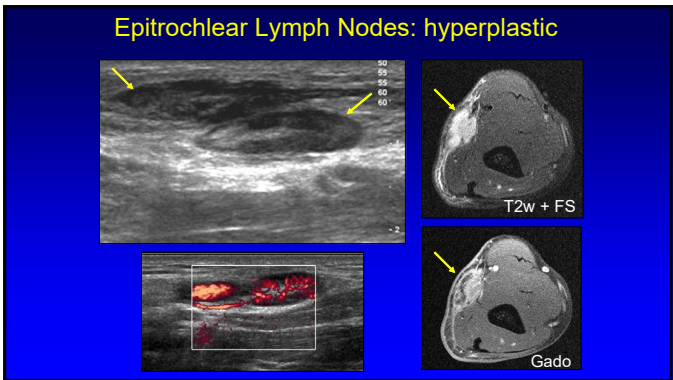


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Cat scratch disease = infection

- Animal scratch: usually a cat
 - *Bartonella henselae*
- Child or adolescent:
 - Most common
- Elbow:
 - Lymphadenopathy
 - Epitrochlear lymph node (medial)

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Outline:

- Mechanisms
- Soft tissue infection
- **Septic arthritis**
- Osteomyelitis
 - Neuropathic joint
 - Discitis

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Septic Arthritis

- Hematogenous:
 - *S. aureus* > *Streptococcus*
- Usually large joint
- Also, joints with acronyms
 - ACJ, SCJ, SIJ
 - Small vessels, slow flow
 - Increased risk of infection
- Irreversible joint damage:
 - 48 hours

©MMG 2005

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Septic Arthritis

- Radiography / CT:
 - Periarticular osteopenia
 - Joint space widening
 - Acute lax joint, chronic infection
 - Uniform joint space narrowing
 - Indistinct subchondral bone plate
 - Erosions
 - Bone destruction

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Septic Arthritis

- Ultrasound:
 - Joint effusion:
 - Variable echogenicity
 - Anechoic to echogenic
 - Hyperemia:
 - Lack of flow does not exclude infection*
 - Synovial thickening
 - Guided aspiration

RadioGraphics 1999; 19:1585
*AJR 1998; 206:731

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Septic Arthritis

- MRI:
 - Synovial enhancement (98%)
 - Perisynovial edema (84%)
 - Adjacent marrow edema (84%)
 - Joint effusion:
 - 91% of large joints
 - 54% of small joints
 - Synovial thickening (22%): atypical infection

AJR 2004; 182:119

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Joint Recesses:

- Shoulder: biceps, posterior
- Elbow: posterior
- Wrist: dorsal
- Hip: anterior femoral neck
- Knee: superior, medial, lateral to patella
- Ankle: anterior
- MCP, MTP: dorsal recesses

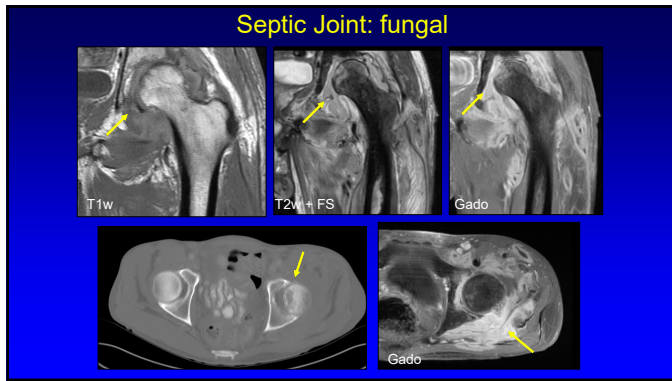
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Septic Joint: sternoclavicular

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Septic Joint: fungal

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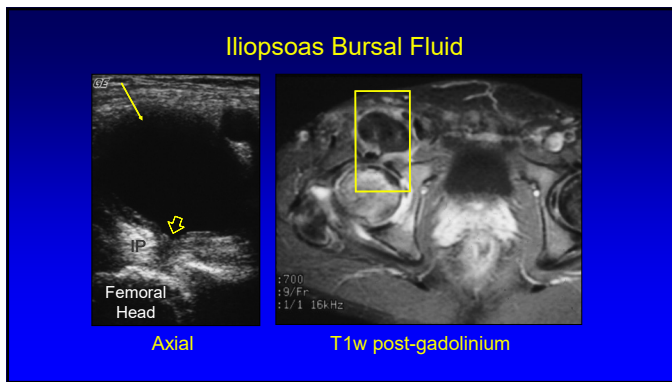


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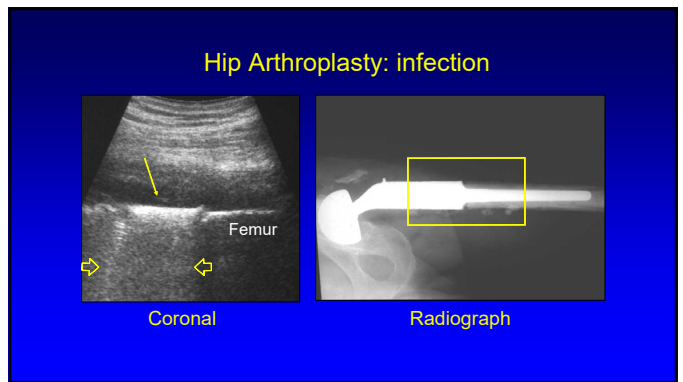
Septic Arthritis: diagnosis

- Joint aspiration:
 - Fluoroscopic or ultrasound-guided
- Prior to fluoroscopic aspiration:
 - Must have cross-sectional imaging
 - Exclude overlying bursa or abscess
 - Avoid contamination of a sterile joint by passing needle through overlying bursa
 - Screen for post-operative fluid collections

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Outline:

- Mechanisms
- Soft tissue infection
- Septic arthritis
- **Osteomyelitis**
 - Neuropathic joint
 - Discitis

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Osteomyelitis

- Staphylococcus aureus
 - HIV: atypical Mycobacteria
- Blood cultures:
 - Only positive in 50% (hematogenous)
- Radiographs:
 - Abnormal after 14 – 21 days
- Serology:
 - ESR elevated
 - WBC: often elevated
 - Fever: variable

Osteomyelitis:
Contiguous
Source

From: RadioGraphics 2007; 27:1723

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Osteomyelitis: mechanism

- Hematogenous:
 - Infection begins in medullary space of bone
 - Spreads out from bone
 - Children, intravenous drug abusers, septic
- Contiguous source:
 - Soft tissue abnormality (ulcer) extends to bone
- Direct implantation
 - Surgery (2%), cat bite, puncture wound

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Osteomyelitis: acute versus chronic

- Acute:
 - Bone destruction
 - Periostitis: in children (loose periosteum)
- Chronic:
 - Extensive periostitis, sclerosis
 - Brodie's abscess
 - Sequestrum, cloaca, involucrum

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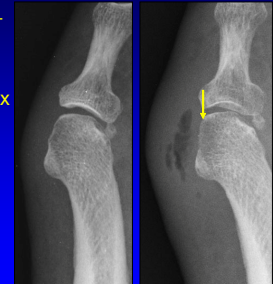
Osteomyelitis: adult versus child

- Adult:
 - Often direct spread: ulcer
 - Periostitis: only when subacute / chronic
 - Child:
 - Hematogenous
 - Metaphyseal equivalent (100%)*
 - Single bone (63%), contiguous bones (37%)*
 - Subperiosteal abscess: early finding**
 - Periostitis: early sign (acute)
 - Adjacent soft tissue abscess (55%)*
- *AJR 2007; 189:867
**Pediatr Radiol 1996; 26:291

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Acute Osteomyelitis: Radiography

- If ulcer:
 - Look at adjacent bone
 - Early: discontinuous cortex
 - Later: bone destruction
 - Periostitis: not a feature
- If no ulcer:
 - Look for permeative appearance of bone
- Up to 3 weeks to identify



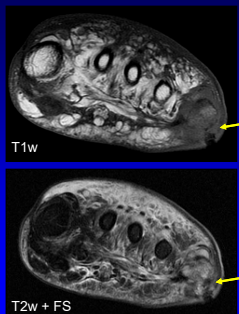
Follow-up

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Acute Osteomyelitis: MRI: criteria

- If ulcer:
 1. Extends from ulcer to bone
 2. Cortex disrupted
 3. T1w: low signal
 4. T2w: high signal
 5. Contrast: + enhancement

*More criteria, higher likelihood of osteomyelitis



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Osteomyelitis: MRI

- Inversion recovery and T2w fat saturation:*
 - Highest sensitivity for osteomyelitis (not specific)
 - Highest negative predictive value
- T1-weighted images:**
 - Adds specificity
 - If high T2w and normal T1w: reactive edema
- Intravenous gadolinium:
 - If normal T2w: contrast not needed***
 - Delineates soft tissues: abscess

*Radiology 1998; 207:625
**AJR 2005; 185:386
***AJR 2009; 192:1232

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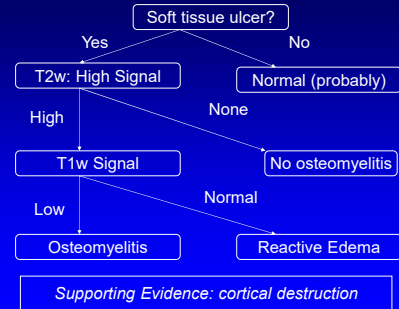
Osteomyelitis: MRI

- MRI with fat-suppression and contrast:
 - 88% sensitivity, 93% specificity*
- MRI unenhanced:
 - 98% sensitivity, 75% specificity**
- Decreased T1w marrow signal concordant with abnormal signal on T2w and post-intravenous contrast images
 - 100% osteomyelitis***

*Radiology 1993; 189:251
 **Radiology 1991; 180:533
 ***AJR 2005; 185:386

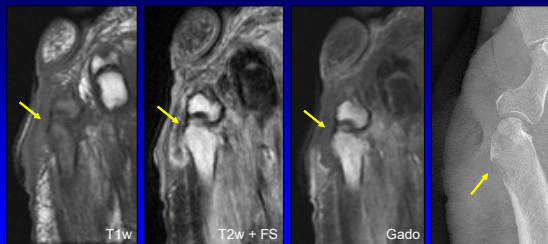
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Osteomyelitis: adult diabetic



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Osteomyelitis: 5th metatarsal



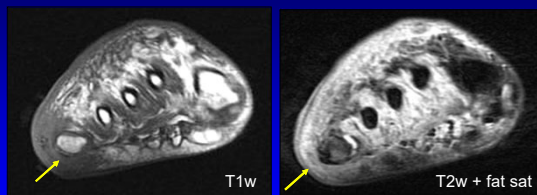
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Osteomyelitis: 1st distal phalanx



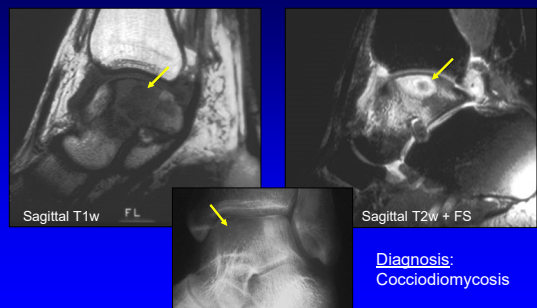
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Reactive Edema



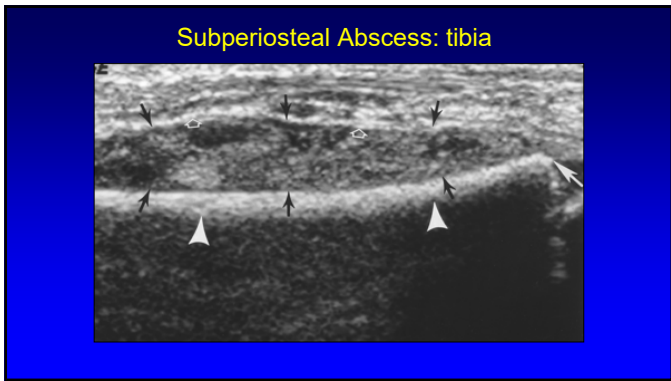
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Osteomyelitis: hematogenous

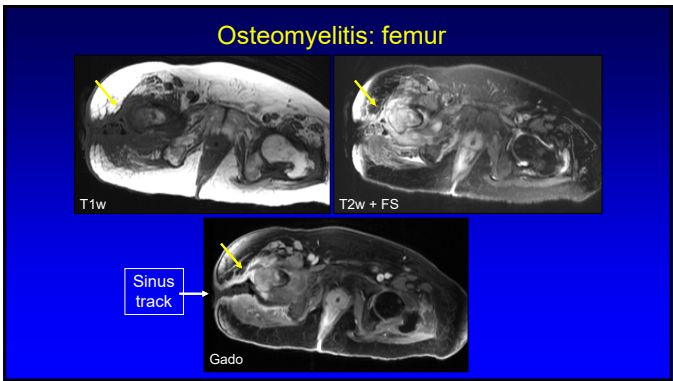


Diagnosis:
Coccidiomycosis

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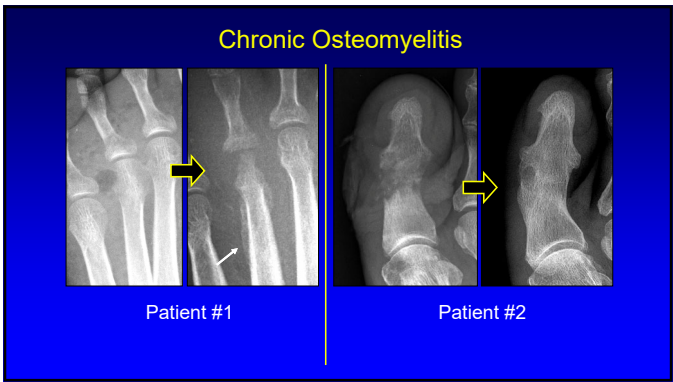
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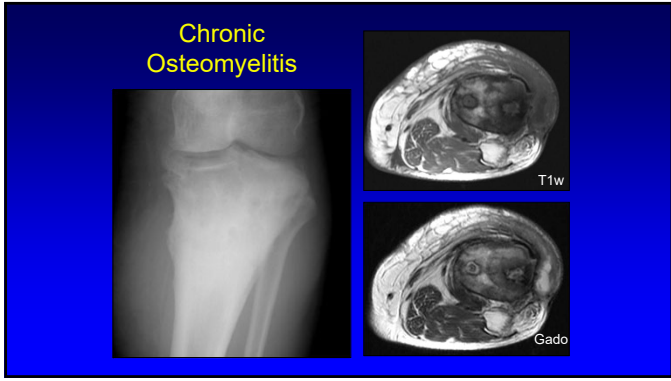
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- ### Osteomyelitis: chronic
- Radiography:
 - Remodeled, sclerotic, lucent
 - Exuberant periostitis
 - CT:
 - Sequestrum:
 - Scan without and with contrast
 - MRI:
 - Less fluid signal
 - Brodie's abscess
- *Radiology 1998; 207:625
 **AJR 2005; 185:386
 ***Radiology 1997; 203:849

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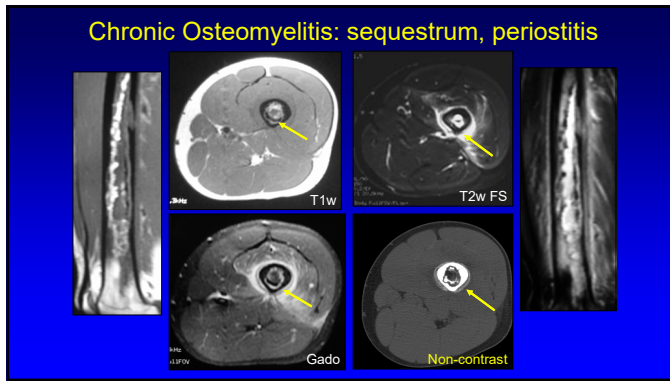
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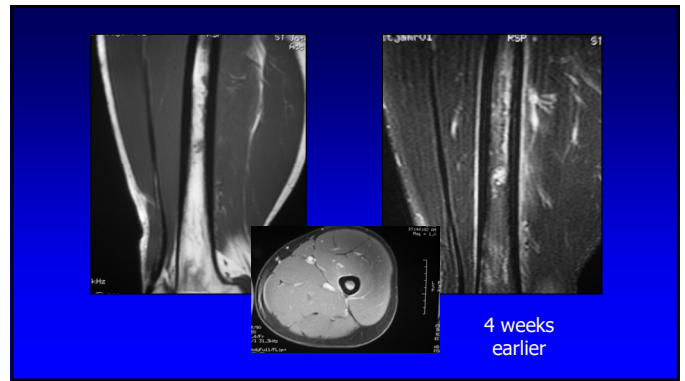
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- ### Osteomyelitis: chronic
- Terminology:
 - Brodie abscess: chronic abscess of bone with surrounding fibrosis/sclerosis
 - Sequestrum: dead bone separated from normal bone
 - Cloaca: passage into bone leading to cavity and sequestrum
 - Involucrum: envelope of new bone surrounding sequestrum

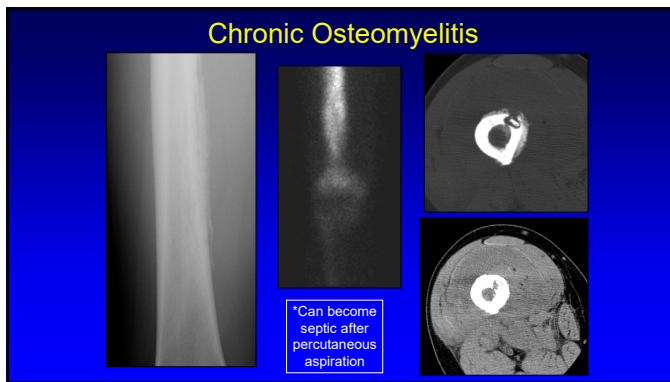
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Neuropathic Foot

- Loss of proprioception and deep sensation
- Relaxation, hypotonia
- Recurrent injury
- Malalignment
- Joint destruction and disorganization
- Location: determined by disease
 - Diabetes: lower extremity, esp. midfoot
 - Syring: upper extremity, spine

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Neuropathic Foot

- Bone marrow edema:
 - High T2w
 - T1w: variable, often normal
- No adjacent ulcer
- Multiple joints: esp. midfoot
 - Osteomyelitis: 5th MT > 1st MT > calcaneus
- Subluxation

Radiology 2002; 224:649

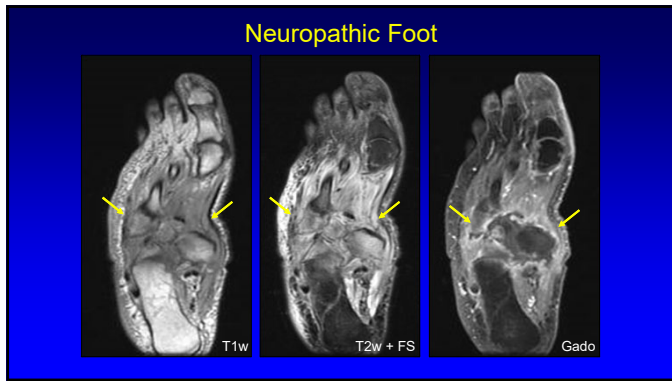
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Neuropathic Foot vs Osteomyelitis

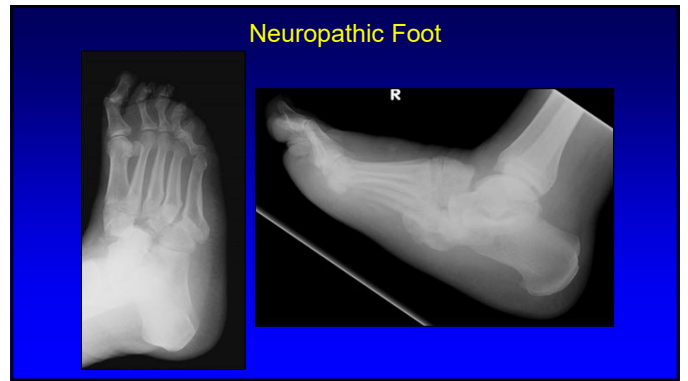
- Absence of ulceration:
 - Osteomyelitis unlikely: no need for MRI*
- Other findings: exclude infection:
 - Location: midfoot
 - Thin rim enhancement of effusion
 - Subchondral cysts, intra-articular bodies
- Findings: superimposed infection**
 - Sinus track, abnormal soft tissues, fluid collection
 - Diffuse abn marrow: low T1, high T2, +enhancement

*J Am Coll Radiol 2008; 5:881
**Radiology 2006; 238:622

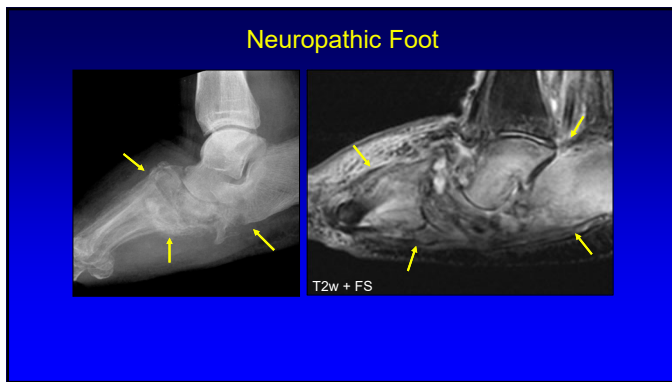
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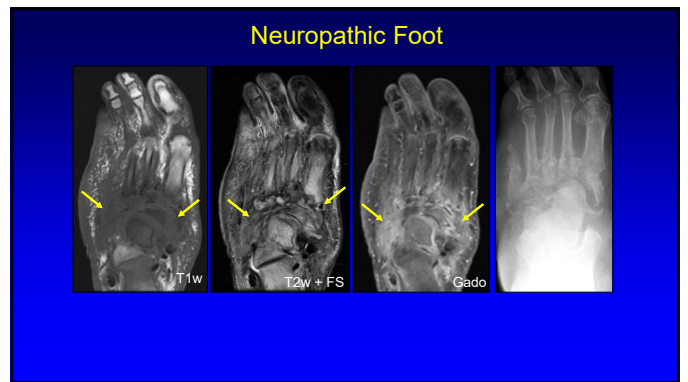
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Discitis

- Adult:
 - Begins subchondral bone: anterolateral
 - Spreads into disc and next vertebra

- Child: may begin in disc (usually < 7 years old)
 - Annulus fibrosus: vascular / lymphatic supply up to 20 years

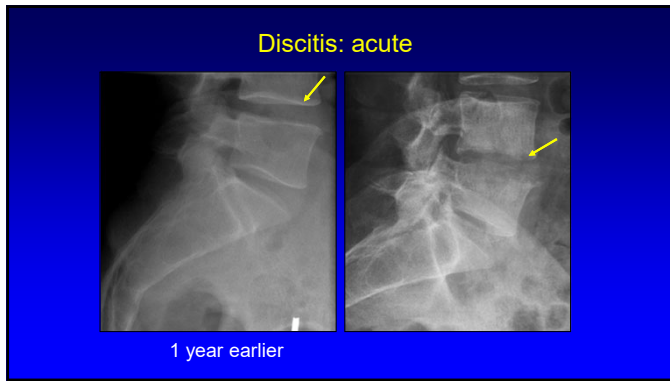
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Discitis: acute

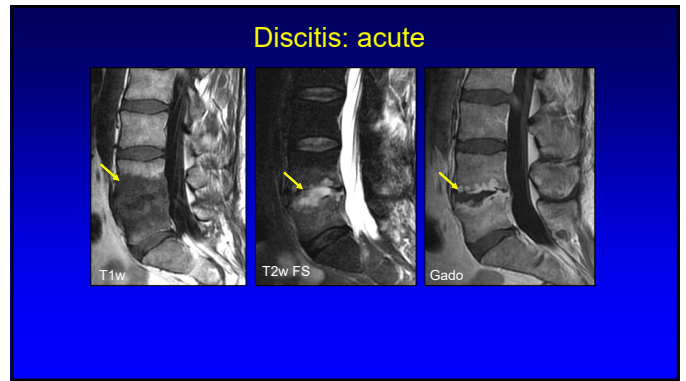
- Radiography:
 - Ill-defined endplate
 - Possible disc space narrowing
 - Focal lucency: anterior subchondral bone
- MRI:
 - Endplates: fluid signal
 - Disc: fluid signal
 - May not be uniform
 - Paraspinal abscesses: TB

Sem Musculoskel Radiol 2004; 8:215

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Differential Diagnosis

- Degenerative changes:
 - Modic 1: fluid signal →
 - Modic 2: fat signal
 - Modic 3: low signal
- Signal of disc: helpful
 - If low: degeneration
 - If high: suspect infection

T2w + FS

Note low signal of disc

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Discitis: chronic

- Radiographs / CT:
 - Ill-defined endplates
 - Sclerotic
- MRI:
 - Improvement in fluid signal

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Take Home Points:

- Osteomyelitis: adult
 - Look at bone adjacent to ulcer
 - Radiograph: loss of cortical line
 - MRI:
 - High T2, low T1 = osteomyelitis
 - High T2, normal T1 = reactive edema
- Osteomyelitis: child
 - Subperiosteal abscess, periostitis

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Take Home Points:

- Neuropathic joint:
 - No ulcer: osteomyelitis rare
- Septic hip or shoulder:
 - Screen soft tissues with cross-sectional imaging before fluoroscopic aspiration

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Thank you!

Syllabus on line and other educational material:
www.jacobsonmskus.com

Twitter handle: @jjacobsn