

# Imaging of Musculoskeletal Infection

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## Disclosures

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

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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:

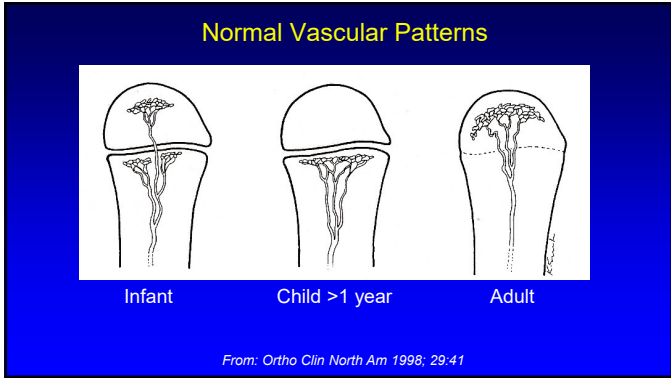
- Hematogenous
  - Children, intravenous drug abusers
- Contiguous source
  - Diabetic ulcer
- Direct implantation
  - Penetrating injury
  - Surgery

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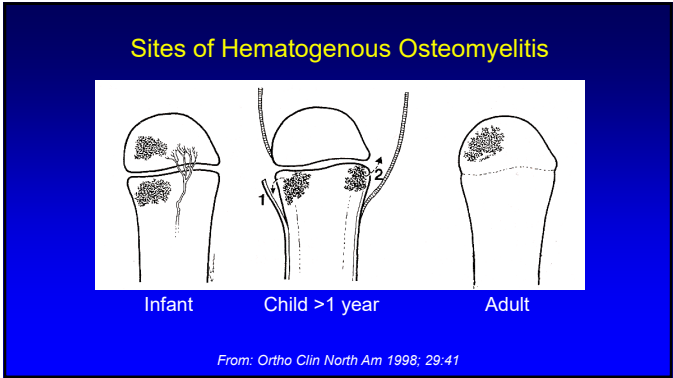
## Infection: hematogenous

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

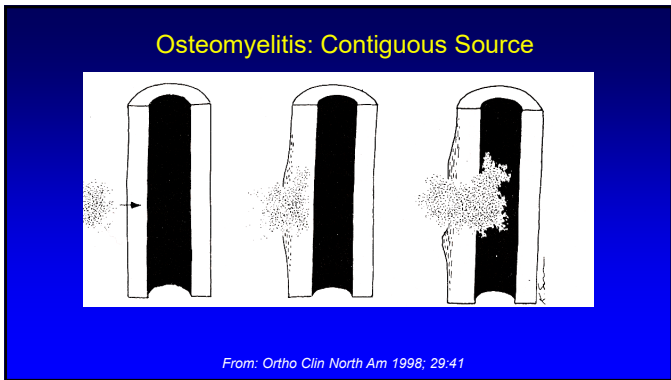
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- ### Outline:
- 
- Mechanisms
  - **Soft tissue infection**
  - Septic arthritis
  - Osteomyelitis
    - Neuropathic joint
    - Discitis

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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



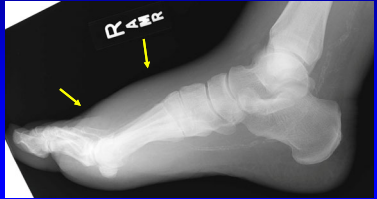
From: RadioGraphics 2007; 27:1723

From: Skeletal Radiol 2010 in print

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### Cellulitis

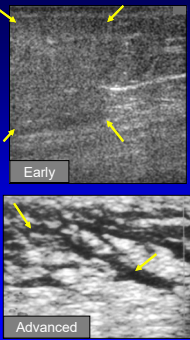
- Radiography and CT:
  - Soft tissue swelling
  - Increased density



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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

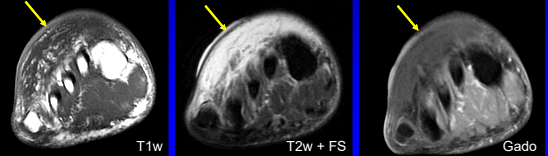


J Ultrasound Med 2000; 19:743

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### Cellulitis

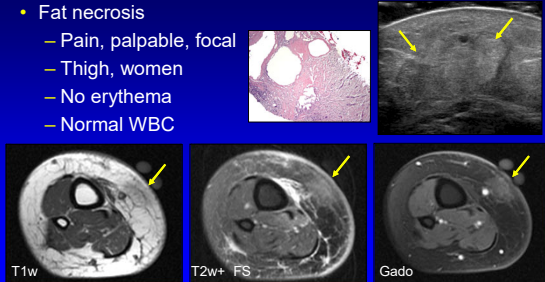
- MRI:
  - Abnormal fluid signal
  - Isolated: subcutaneous tissues



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### Differential Diagnosis

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

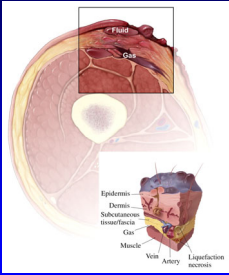


J Ultrasound Med 2008; 27:1751

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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

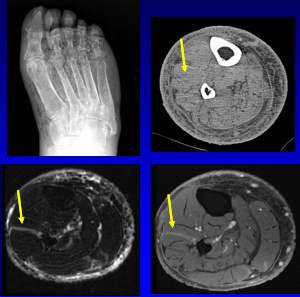


From: RadioGraphics 2007; 27:1723

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### Necrotizing Fasciitis

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

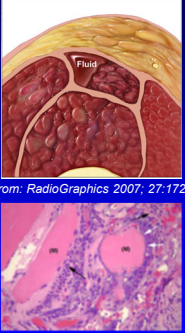


RadioGraphics 2004; 24:1472

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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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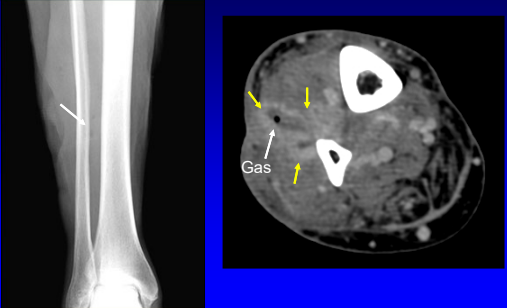
### Abscess

- 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

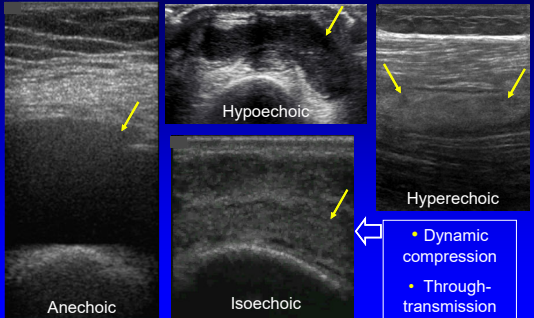
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### Abscess: Radiography and CT



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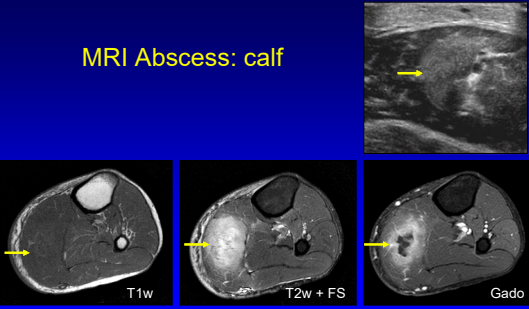
### Abscess: ultrasound



- 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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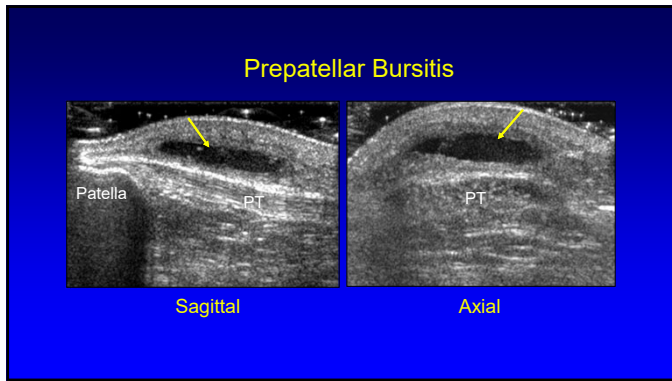
### Infective Tenosynovitis: wrist

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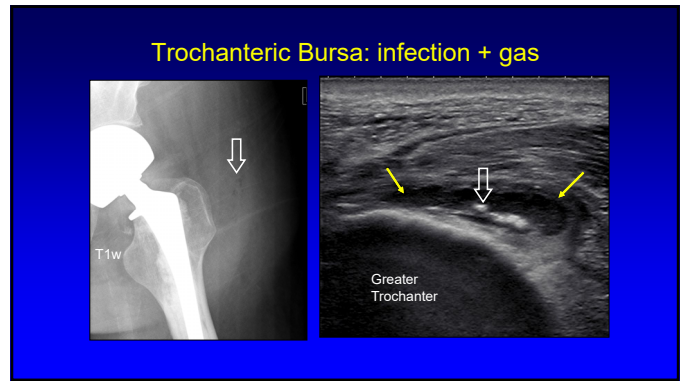
### Septic Bursitis

- 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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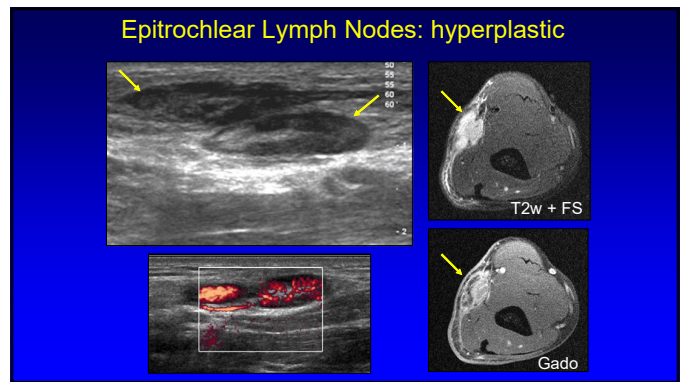


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### Cat scratch disease = infection

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

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### Outline:

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- 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

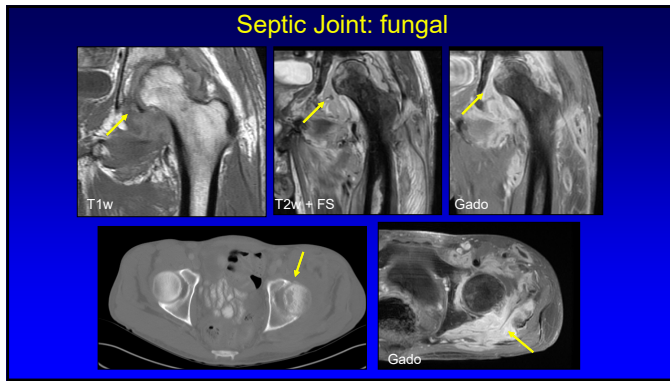
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### Septic Joint: sternoclavicular

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### Septic Joint: fungal

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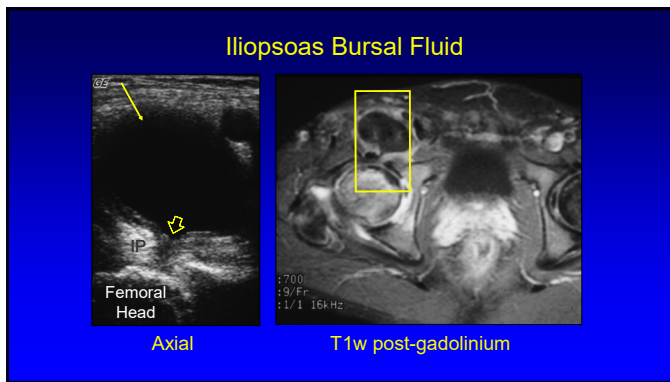


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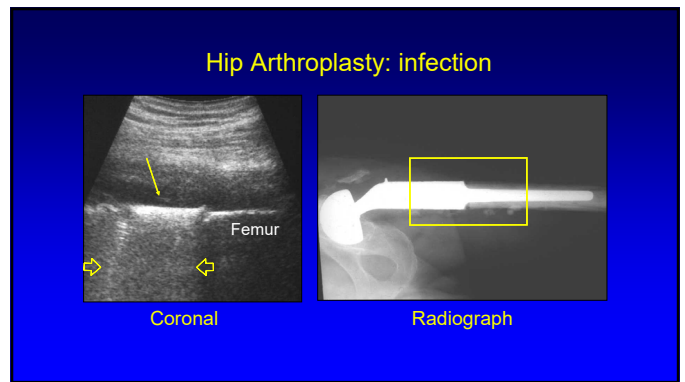
### Septic Arthritis: diagnosis

- 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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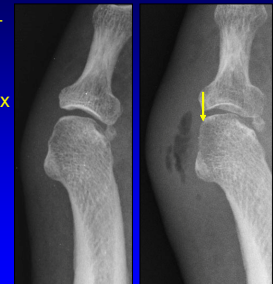
### Osteomyelitis: adult versus child

- 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



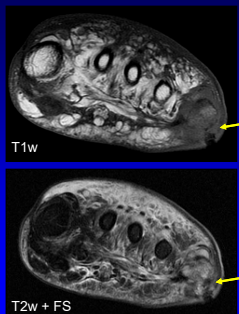
Follow-up

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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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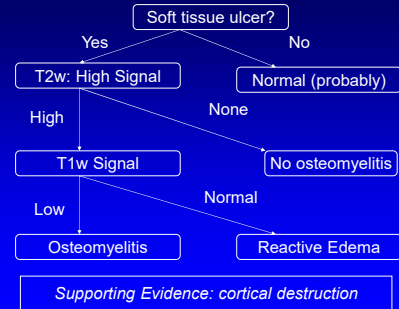
### Osteomyelitis: MRI

- 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

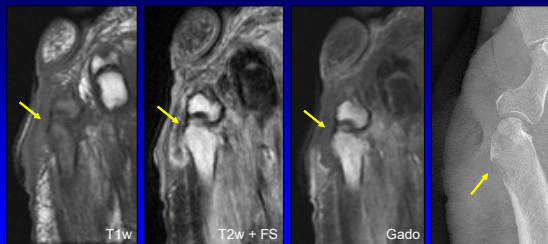
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### Osteomyelitis: adult diabetic



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### Osteomyelitis: 5th metatarsal



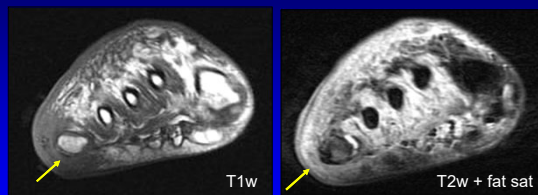
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### Osteomyelitis: 1st distal phalanx



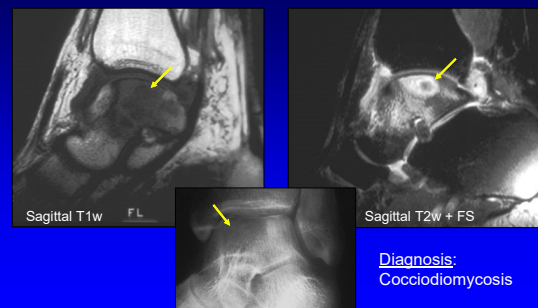
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### Reactive Edema

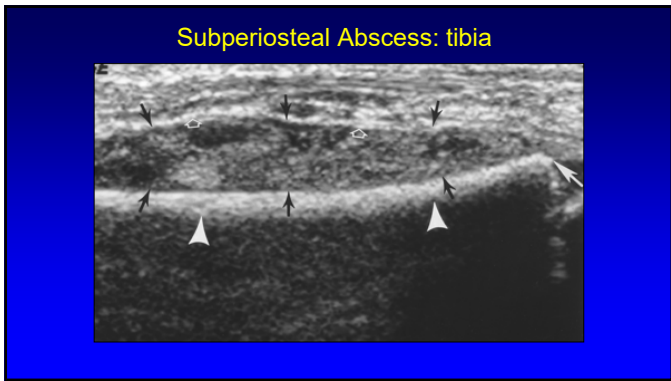


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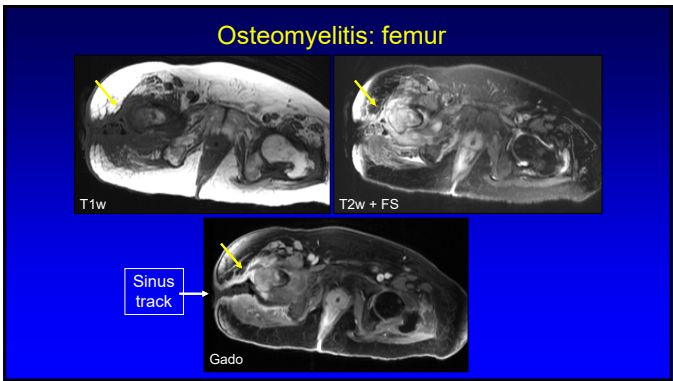
### Osteomyelitis: hematogenous



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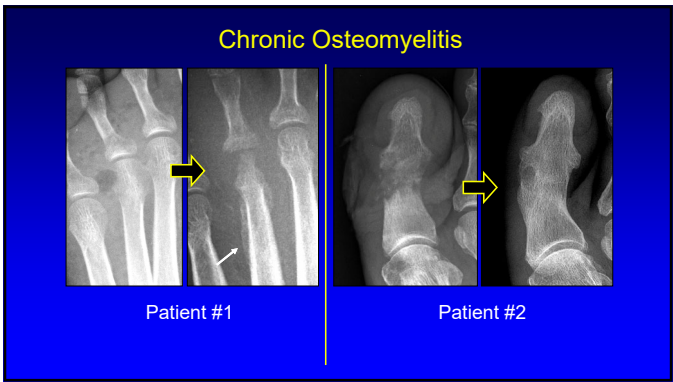
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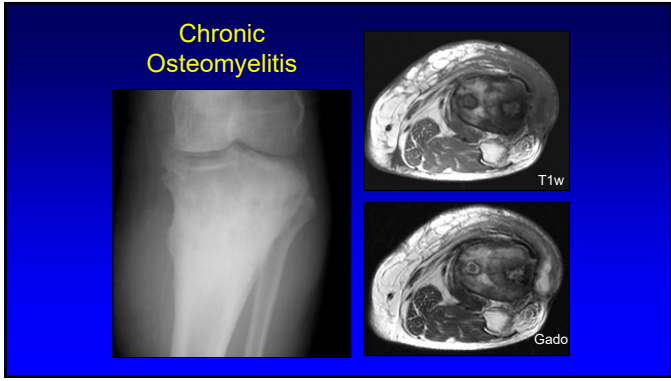
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- ### Osteomyelitis: chronic
- Radiography:
    - Remodeled, sclerotic, lucent
    - Exuberant periostitis
  - CT:
    - Sequestrum:
    - Scan without and with contrast
  - MRI:
    - Less fluid signal
    - Brodie's abscess
- \*Radiology 1998; 207:625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

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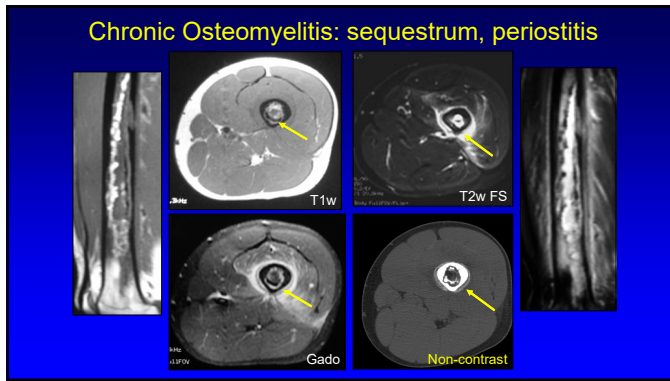
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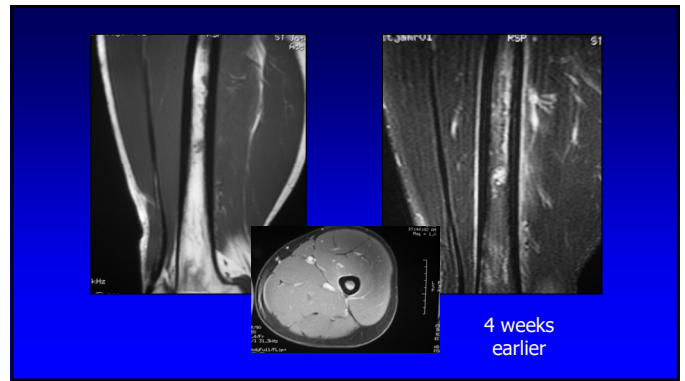
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- ### Osteomyelitis: chronic
- Terminology:
    - Brodie abscess: chronic abscess of bone with surrounding fibrosis/sclerosis
    - Sequestrum: dead bone separated from normal bone
    - Cloaca: passage into bone leading to cavity and sequestrum
 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

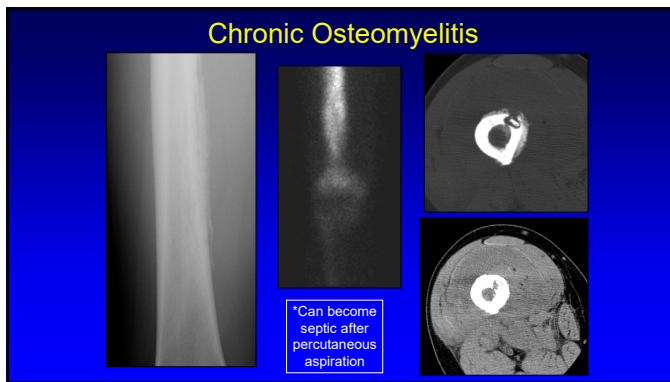
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### Neuropathic Foot

- 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: 5<sup>th</sup> MT > 1<sup>st</sup> MT > calcaneus
- Subluxation

Radiology 2002; 224:649

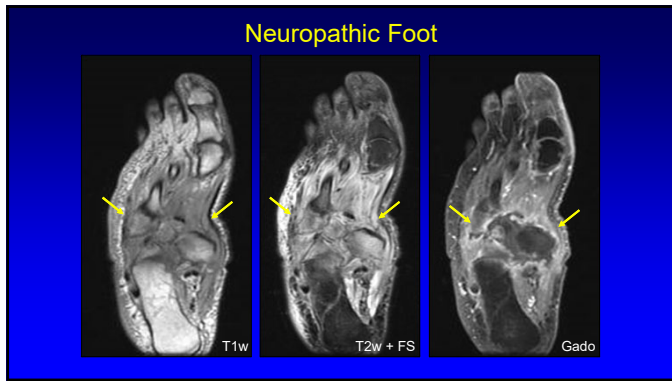
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### Neuropathic Foot vs Osteomyelitis

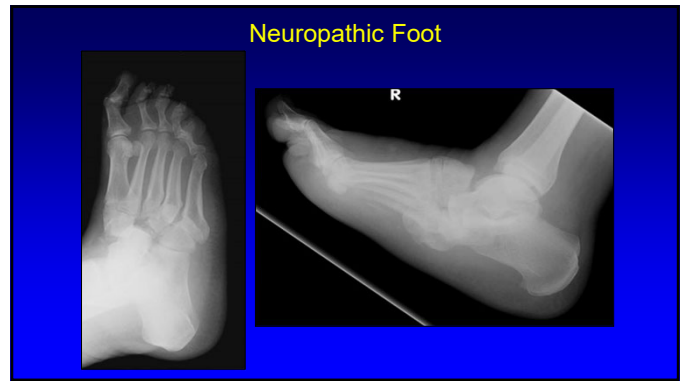
- Absence of ulceration:
  - Osteomyelitis unlikely: no need for MRI\*
- Other findings: exclude infection:
  - Location: midfoot
  - Thin rim enhancement of effusion
  - Subchondral cysts, intra-articular bodies
- Findings: superimposed infection\*\*
  - Sinus track, abnormal soft tissues, fluid collection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

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

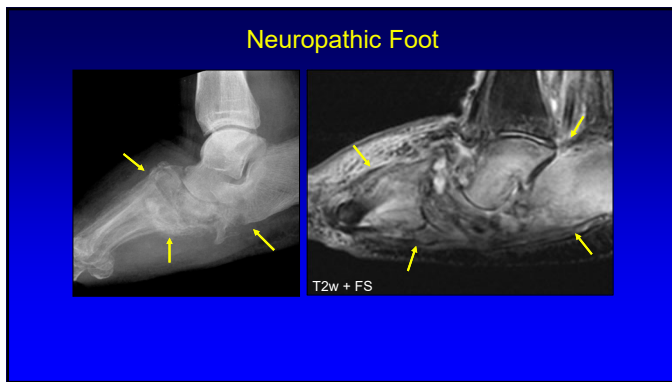
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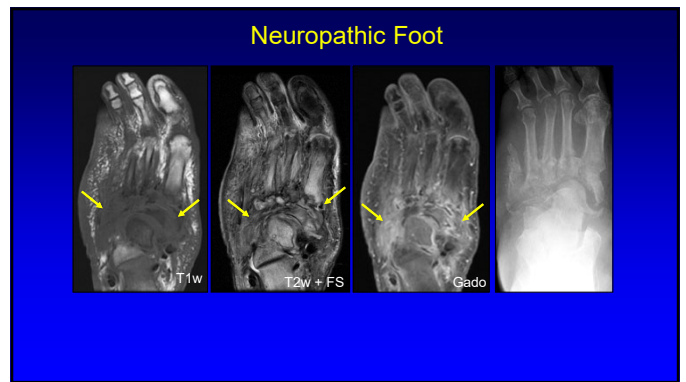
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**Discitis**

- 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

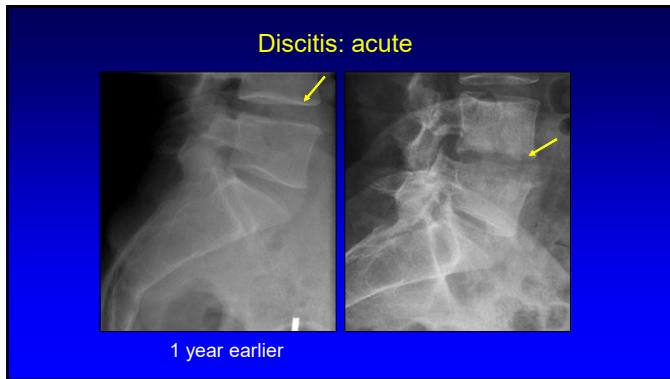
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**Discitis: acute**

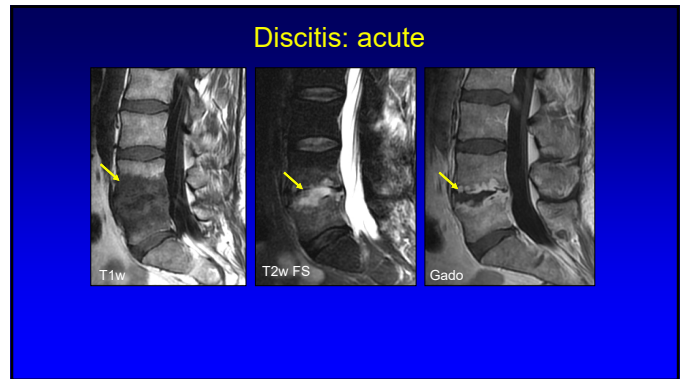
- Radiography:
  - Ill-defined endplate
  - Possible disc space narrowing
  - Focal lucency: anterior subchondral bone
- MRI:
  - Endplates: fluid signal
  - Disc: fluid signal
    - May not be uniform
  - Paraspinal abscesses: TB

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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Syllabus on line and additional educational material:  
[www.jacobsonmskus.com](http://www.jacobsonmskus.com)

Twitter handle: @jjacobsn