

## Radiology of Subtle and Important Fractures

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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

- To recognize subtle fractures
- To identify fractures with hidden implications
- To understand the importance of MRI

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### Imaging Approach:

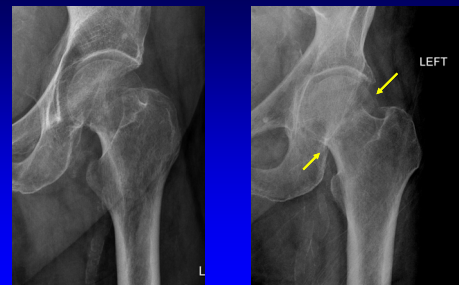
- Look for common fractures in characteristic locations
- Specifically look at sites of subtle and important fractures
- Use MRI if negative radiograph and continued symptoms

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### Femoral Neck Fracture

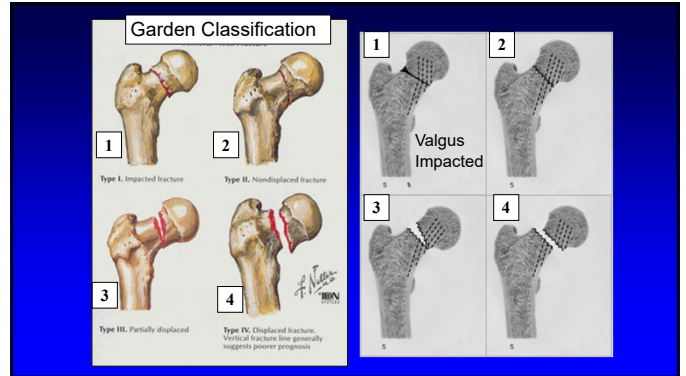


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### Femoral Neck Fracture:

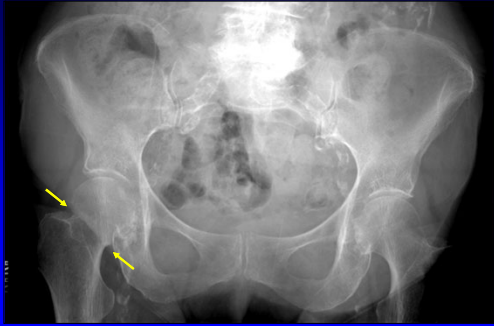
- Internal rotation radiograph essential
- Goal: diagnose non-displaced femoral neck fracture
- Garden Classification: 1 – 4
  - 1 & 2: non-displaced → percutaneous pins
  - 3 & 4: displaced → arthroplasty (risk of AVN)
- With osteopenia, MRI necessary
  - CT not effective

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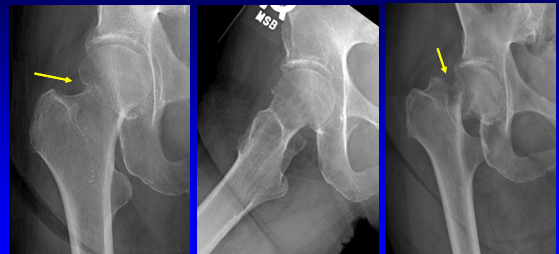
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### Femoral Neck Fracture: Garden 1



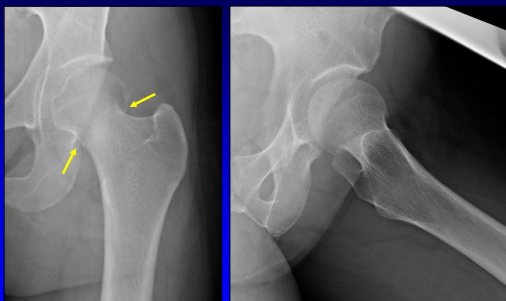
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### Femoral Neck Fracture: now displaced

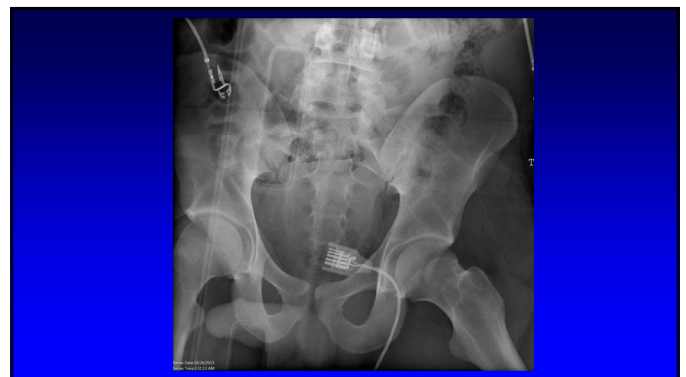


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### Femoral Neck Fracture: Garden 1

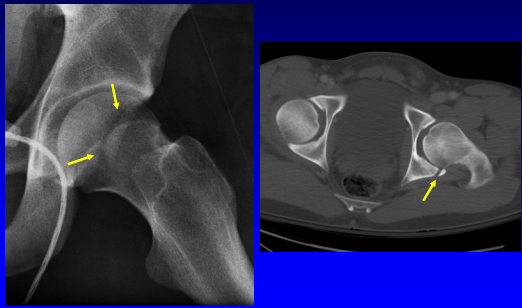


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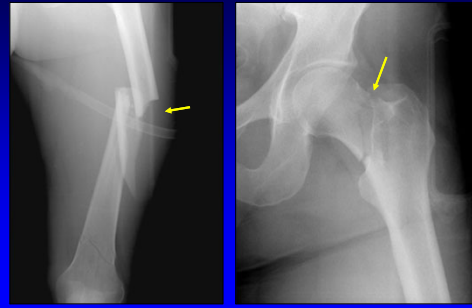
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Acetabulum: posterior wall fracture



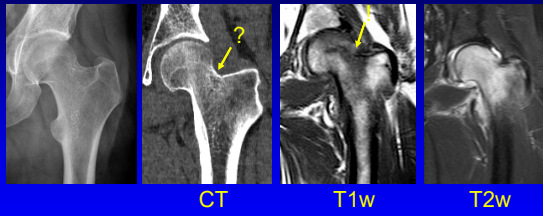
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Femoral Shaft and Neck Fractures



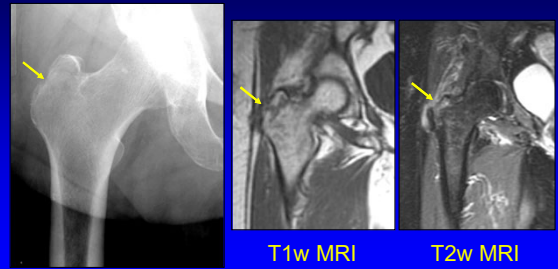
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Intertrochanteric Fracture



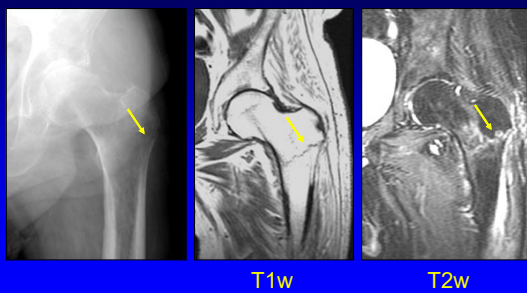
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Greater Trochanter Fracture



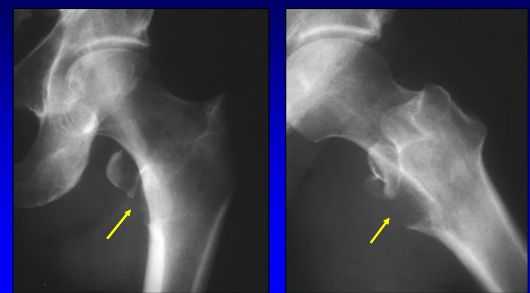
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Subtrochanteric Fracture

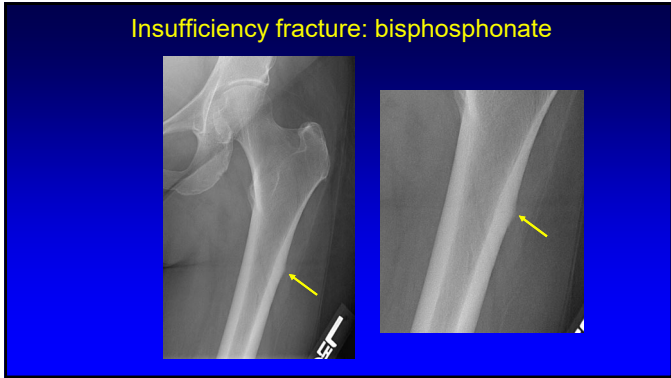


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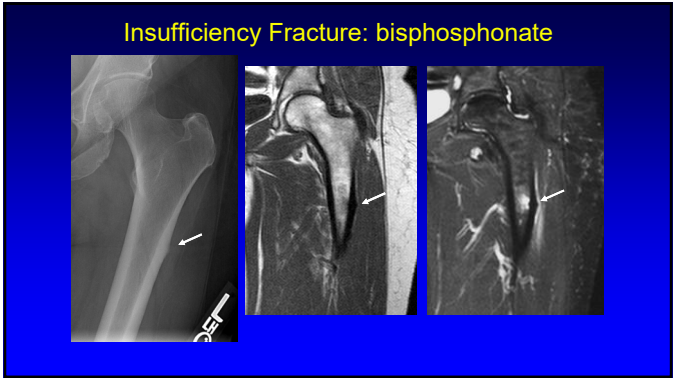
Metastatic Lung Cancer: avulsion



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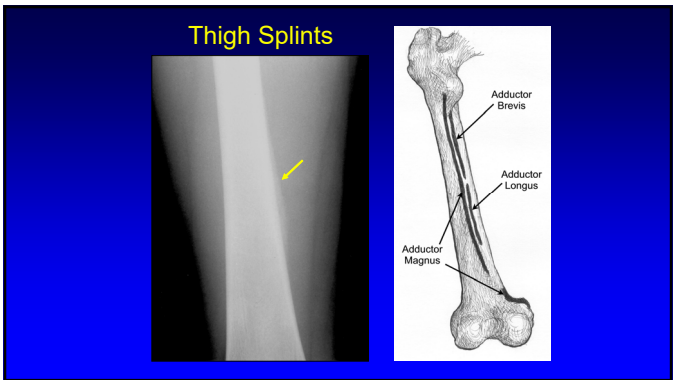
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**Bisphosphonate**

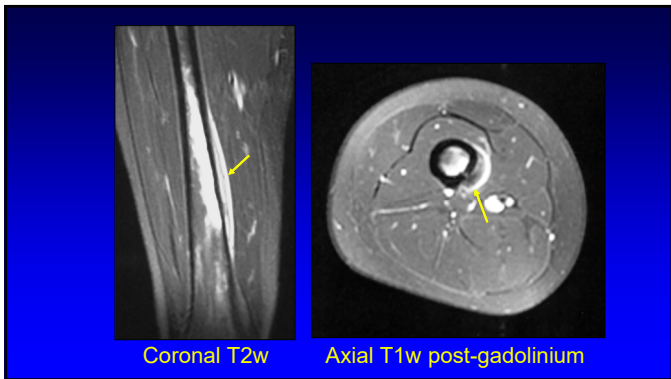
- To treat osteoporosis: *i.e. Fosamax*
  - Inhibits osteoclasts, may slow bone turnover
- Increased risk of fracture:
  - Average treatment at fracture: 6 years
  - Femur: subtrochanteric, diaphyseal, lateral cortex
- Early sign: periosteal reaction
  - 2% are asymptomatic at early stage

AJR 2011; 197:954

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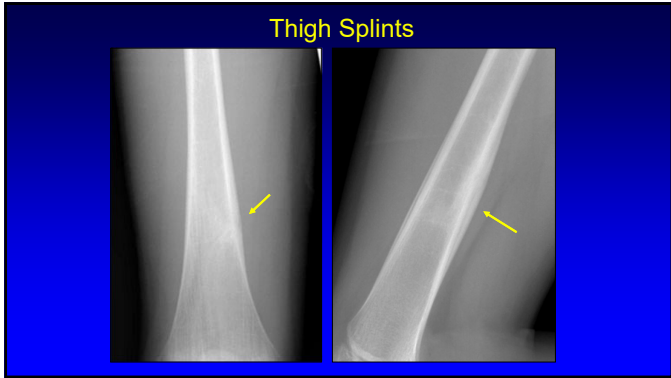
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**Thigh splints**

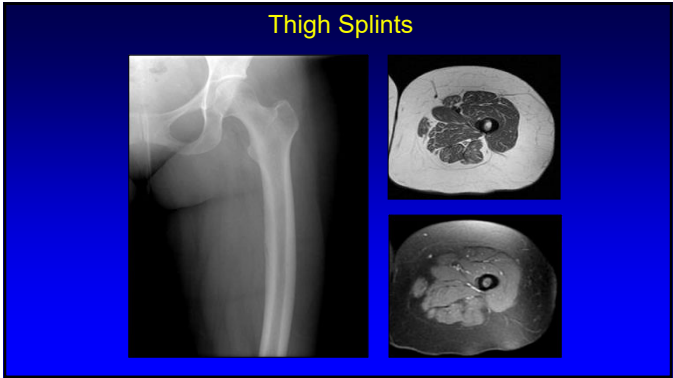
- Adductor insertion avulsion syndrome
- MRI:
  - Edema, enhancement, periostitis
  - May simulate tumor
- Key: location, history
- Fracture line: very helpful

AJR 2001; 177:673

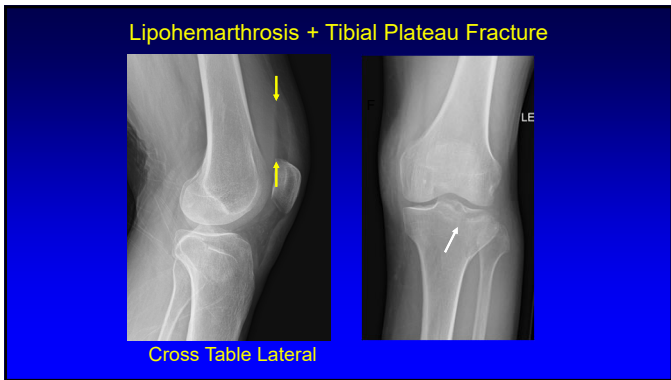
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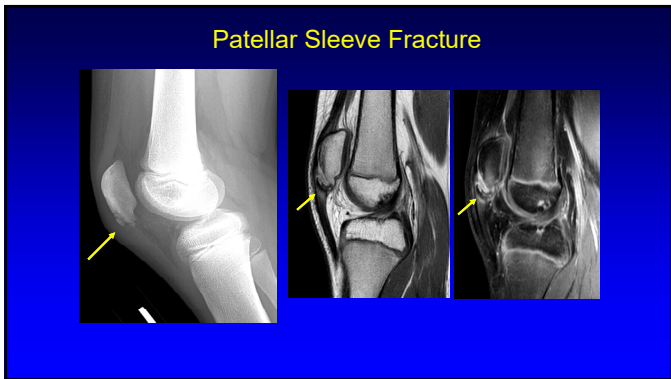


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### Lipohemarthrosis

- Intraarticular fat with hemorrhagic effusion
- Indicates occult intra-articular fracture
  - Lateral tibial plateau
- With trauma: lateral knee is supine
  - Cross-table lateral
  - Look for distinct fat-fluid level

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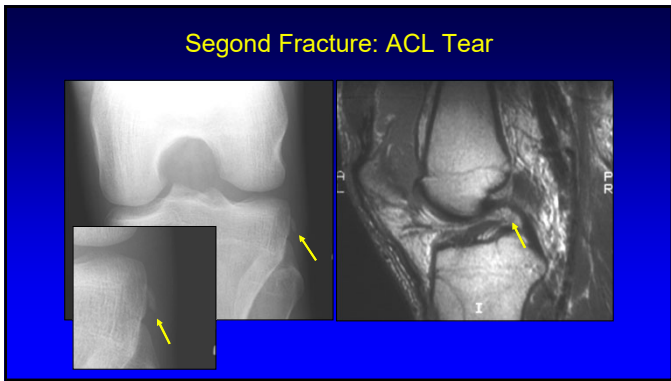
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### Patellar Sleeve Fracture

- Hyperextension injury: children
- Inferior patella: small bone fragments
- Cartilage avulsion: under-estimated
- Patella alta may be present
- MRI displays full extent of injury

Bates DG et al. Radiology 1994; 193:825

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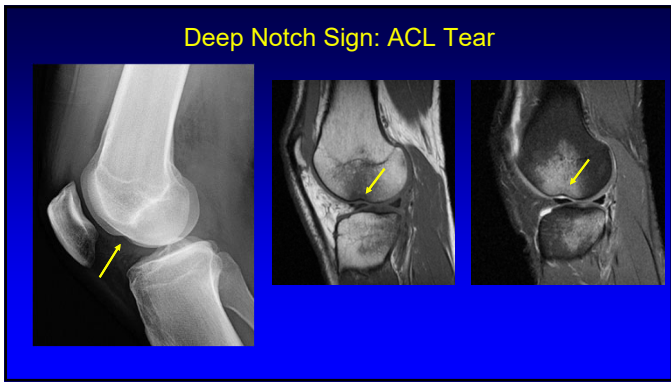
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### Second Fracture

- Varus injury
- Avulsion of tibia
  - Lateral capsular ligament
  - Posterior aspect of ITB
- Anterior cruciate ligament tear in 75 – 100%

Flores DV et al. Skeletal Radiol 2016; 45:1635

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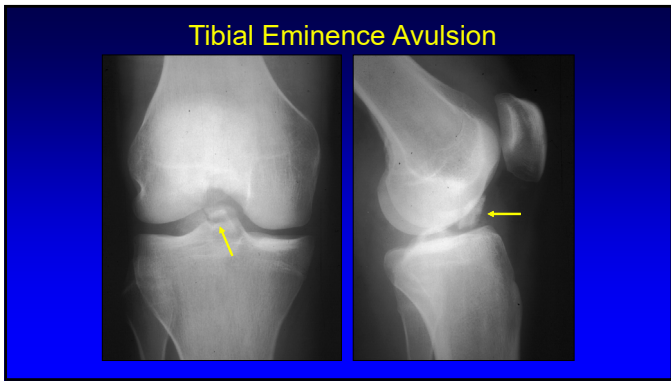


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### Deep Notch Sign

- Impaction fracture of lateral femoral condyle: valgus injury
- Abnormal if > 1.5 - 2 mm deep
- Associated with ACL tear

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### Tibial Eminence Avulsion

- Hyperextension injury
- Children
- Associated with functional ACL tear

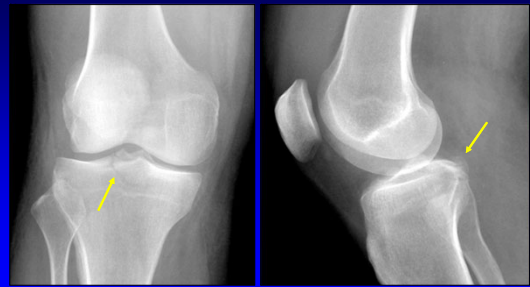
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### ACL Associated Fractures

- Segond fracture: varus rotation
- Deep notch sign: valgus rotation
- Tibial eminence avulsion: hyperextension

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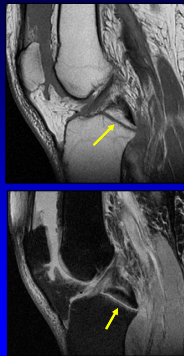
### PCL Avulsion



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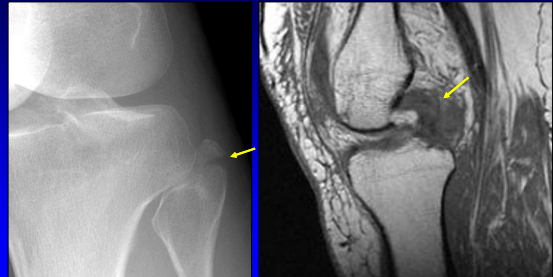
### Posterior Cruciate Avulsion

- May be associated with tibial fragment
- Difficult to identify if not true lateral
- Associated with:
  - Anterior cruciate ligament tear
  - Posterolateral corner injury



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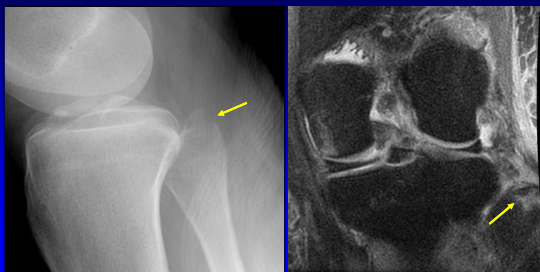
### Arcuate Sign: posterolateral corner injury



Sagittal T1w

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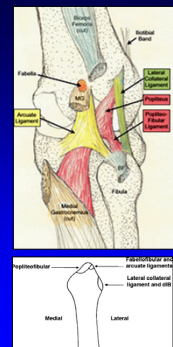
### Arcuate Sign



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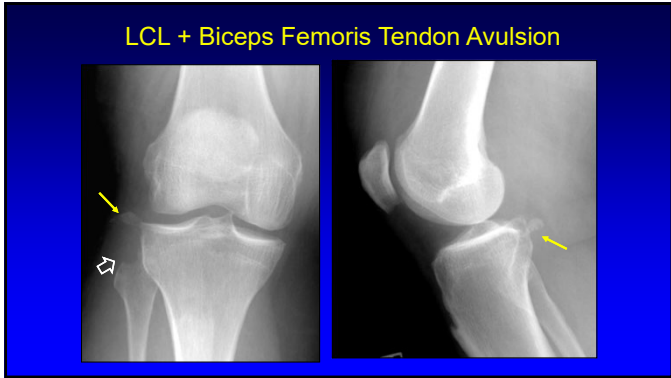
### Arcuate Sign

- Popliteofibular and arcuate ligament avulsion
- Insertion: styloid process of fibula
- Indicates posterolateral corner injury
- Uncommon without LCL tear
- Associated PCL tear

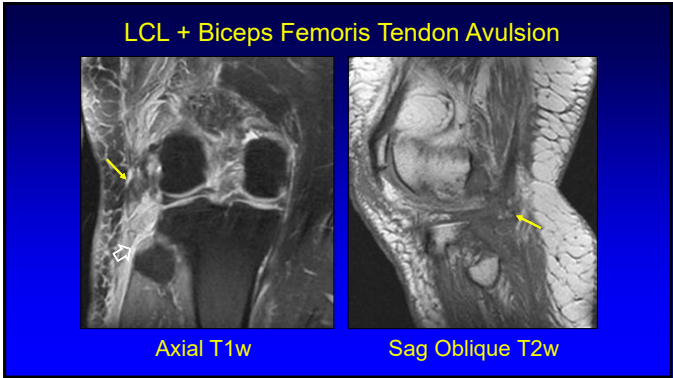


Huang et al. AJR 2003; 180:381

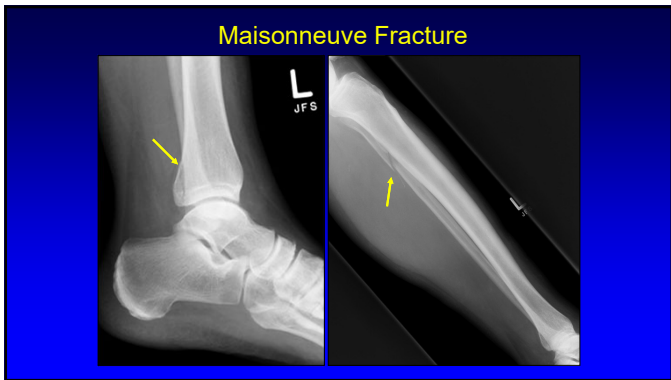
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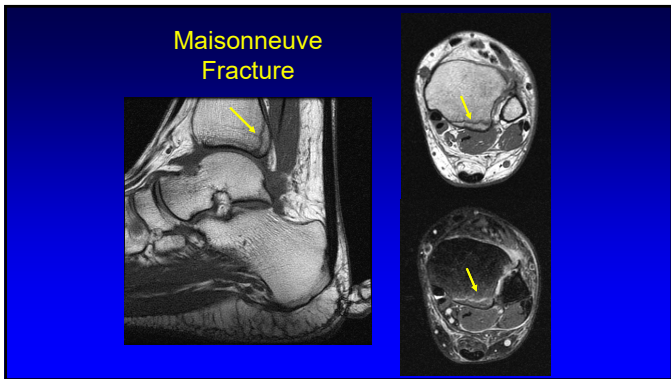


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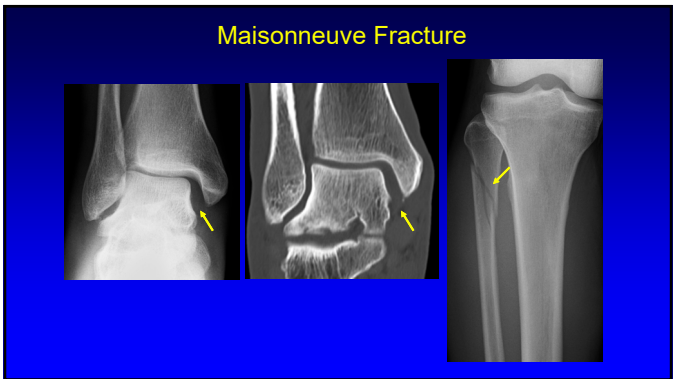
Maisonneuve Fracture:

- High fibula fracture
  - Ankle injury
  - Interosseous membrane injury
- Fibula fracture may not be obvious
- Isolated posterior or medial malleolus fracture: look for fibular fracture

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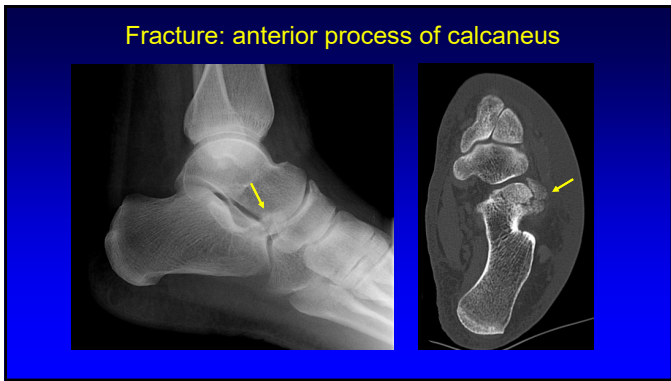


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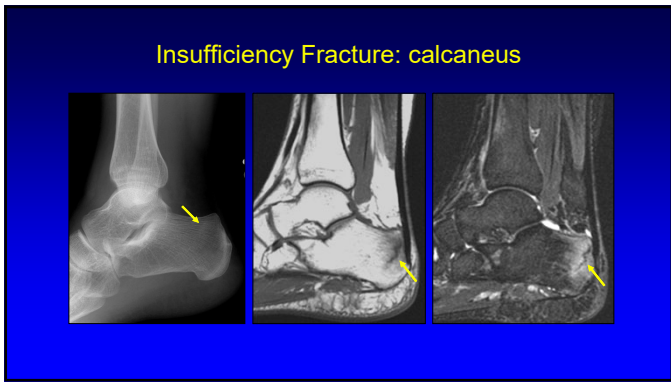


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Anterior Process Fracture

- Insertion of bifurcate ligament
- Often difficult to identify at radiography

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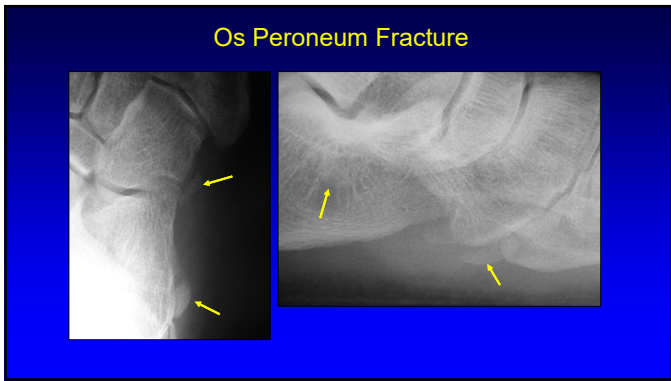


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Insufficiency Fracture

- Trabecular bone: ill-defined linear sclerosis
- Normal stress on abnormal bone: osteopenia
- MRI diagnostic: fracture line

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Os Peroneum Fracture:

- Interval fragmentation or fracture
- Contraction + compression on cuboid
- Separation: > 6 mm (unlike bipartite)
- Associated: peroneus longus tear

Kalume-Brigido et al. 2007; Radiology 2005; 237:235.

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### Os Peroneum Fracture

*From: Kalume-Brigido et al. 2007; Radiology 2005: 237:235*

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### Avulsion Fracture: extensor digitorum brevis

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### Extensor Digitorum Brevis Tendon

- Lateral surface of calcaneus
- Extensor digitorum brevis origin
- Fracture displaces away from calcaneus
- Only seen on AP view

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### Sesamoid Fracture

Contralateral Side

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### Hallux Sesamoid

- 1<sup>st</sup> metatarsophalangeal joint
- Medial sesamoid: bipartite or tripartite
  - Lateral: uncommonly bipartite
- Well-defined sclerotic margins
- Fracture:
  - Interval fragmentation
  - Separated fragments
  - Non-sclerotic margins


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### 5<sup>th</sup> Metatarsal Avulsion Fracture

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### Fifth Metatarsal Fracture

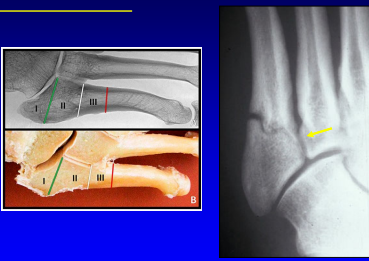
- Peroneus brevis tendon and retinaculum avulsion at 5<sup>th</sup> metatarsal
- May present after ankle trauma
- All ankle radiographs must include proximal 5<sup>th</sup> metatarsal!



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### Fifth Metatarsal Fractures

- Avulsion (I): Extends to cuboid
- Jones (II): Extends to 4<sup>th</sup> MT
- Diaphyseal (III): Distal to 4<sup>th</sup> MT articulation

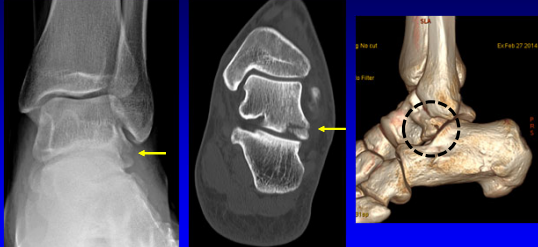


Jones Fracture

Buskova K et al. JBJS Reviews 2021; 9:1

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### Snowboarder's Fracture



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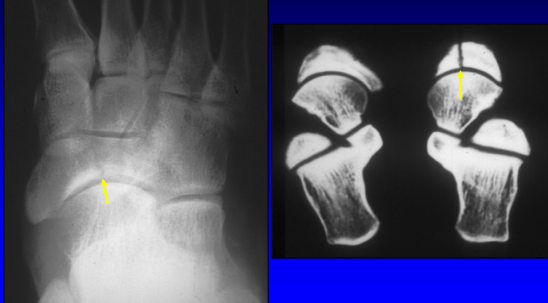
### Snowboarder's Fracture

- Lateral process of talus
- 2% of all snowboarding injuries
- Snowboarders: 17x more likely to get this fracture than general population
- Often only seen on anteroposterior ankle radiograph

Melenevsky Y et al. Radiographics 2015; 35:765

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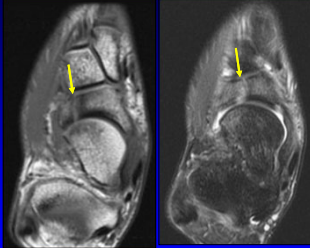
### Fatigue Fracture: Navicular



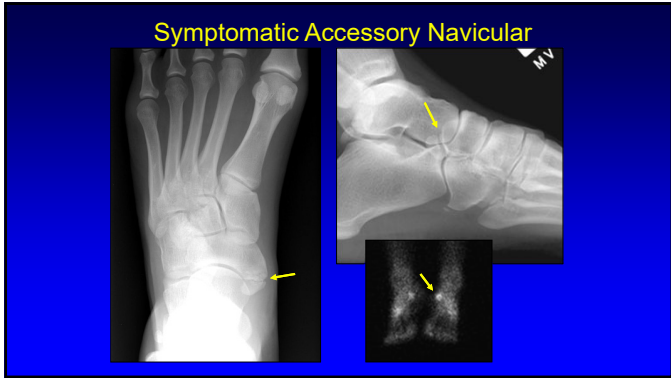
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### Navicular Stress Fracture

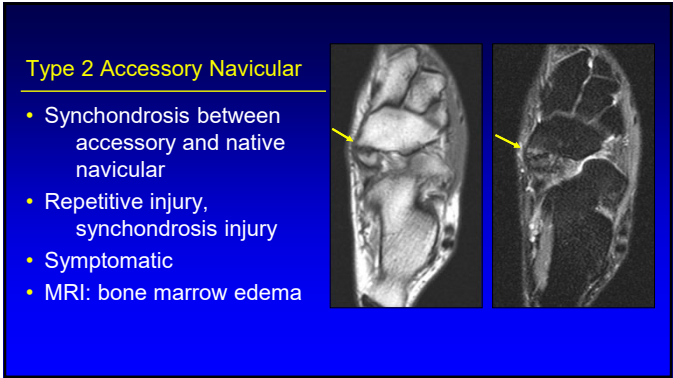
- Abnormal stress on normal bone
- Very characteristic configuration:
  - Linear
  - Sagittal plane
- Only seen on anteroposterior radiograph



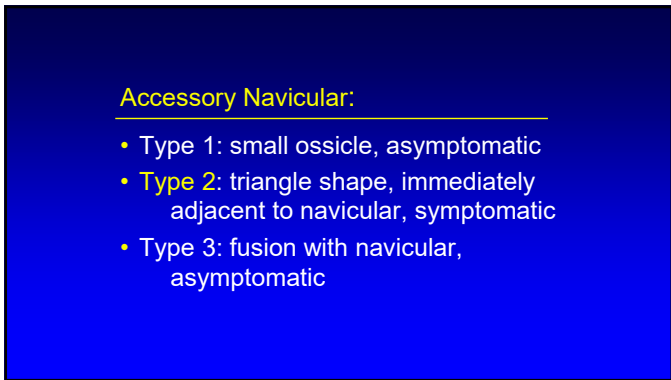
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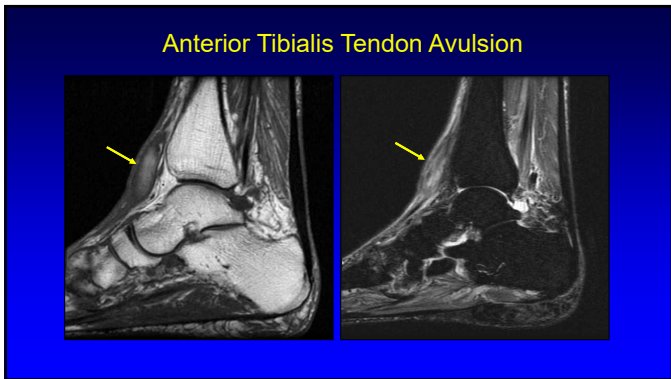
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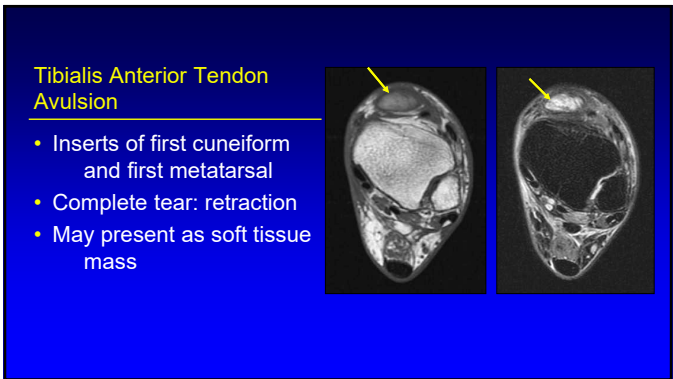
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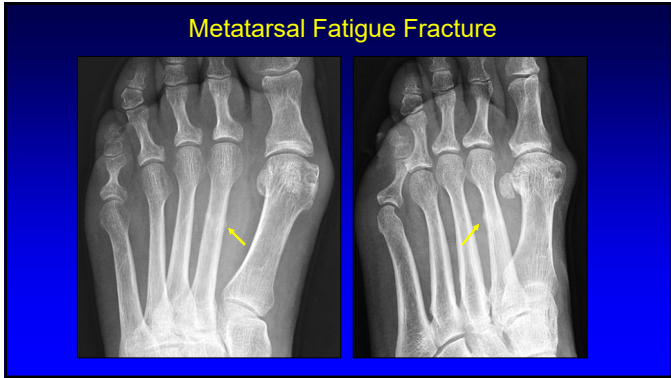
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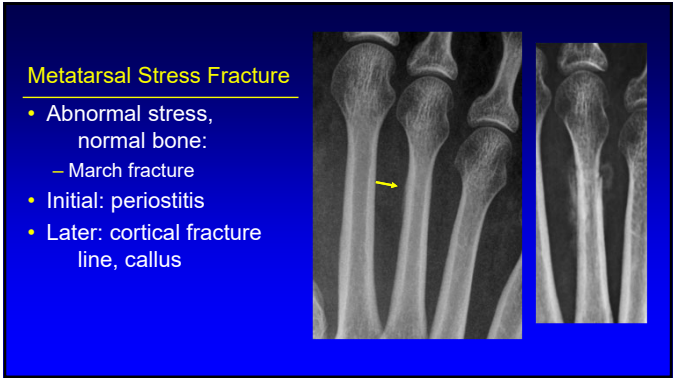
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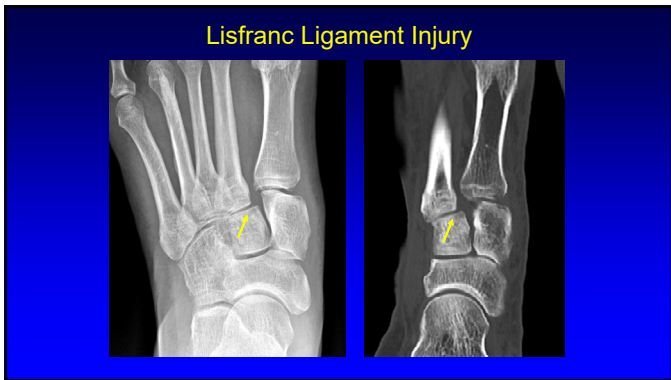
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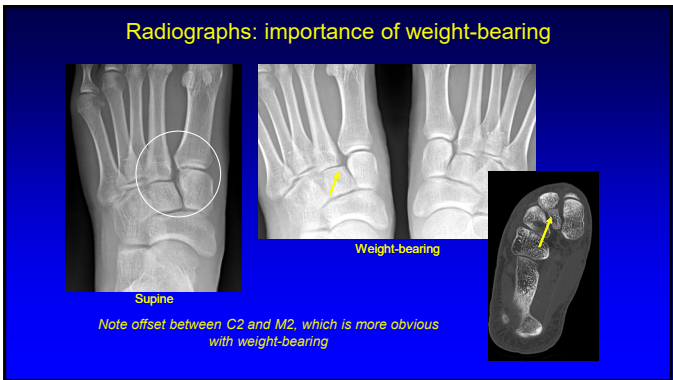
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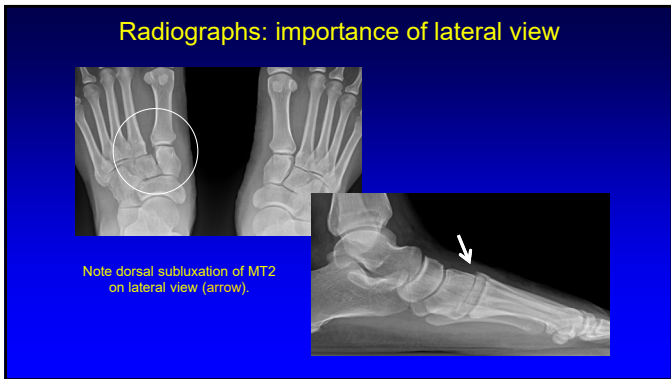
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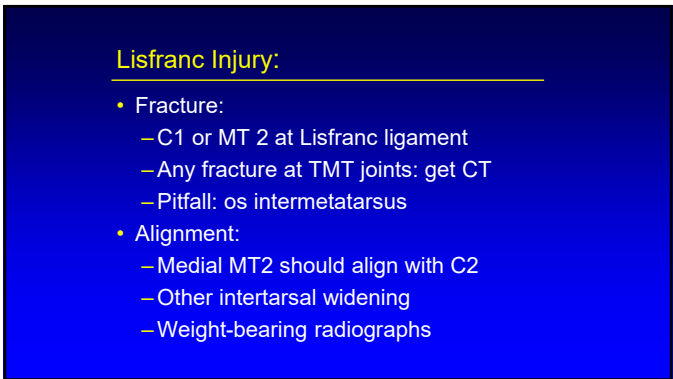
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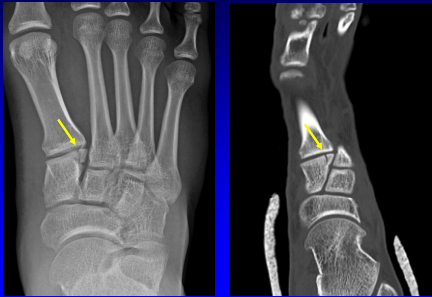


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### Lisfranc Injury: fracture



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### Pitfall: Os Intermetarsus



- Unlike Lisfranc avulsion:
- Location: distal to Lisfranc ligament between MT1 and 2
  - Well-corticated
  - Shape: oblong or "torpedo"

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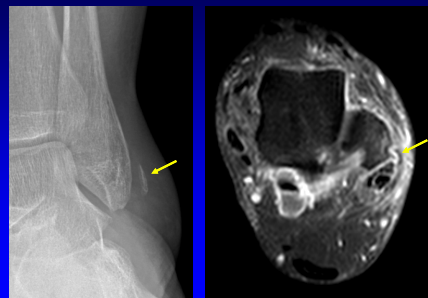
### Radiographs: wide intertarsal space



Note asymmetric widened intertarsal space (arrow) and offset at navicular (arrowhead). There is no offset at the 2<sup>nd</sup> TMT joint.

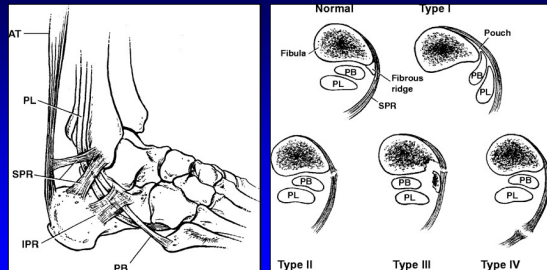
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### Superior Retinaculum Avulsion (+ PB split)



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### Peroneal Retinaculum



Rosenberg et al. AJR 2003; 181:1551

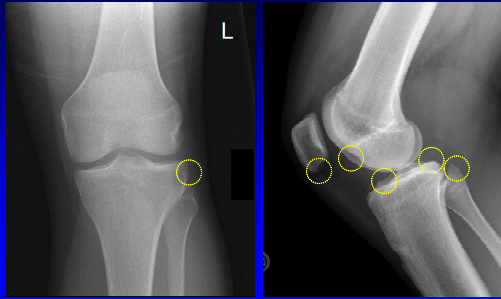
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### Summary

- Know where common fractures occur
- Look for subtle or important fractures
- Know specific avulsion fractures
- Consider MRI

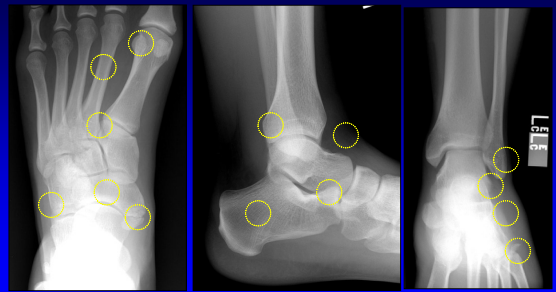
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### Knee Fractures: target approach



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### Ankle / Foot Fractures: target approach



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