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# Lower Extremity Injuries: X-ray Interpretation

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## This session will be recorded

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- ❑ If you would prefer that this recording **not** be shared with your EM colleagues, please email [amcknight@ghem.ca](mailto:amcknight@ghem.ca) within 24 hours of the session.
- ❑ We will share the presentation slides and other materials (journal articles, etc.) by email; you will have access to all materials regardless of whether the recording is shared.



## Please also note:

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- ❑ The information in this presentation and the video recording is up to date as of the date it was recorded (June 4, 2020).
- ❑ It has not been updated to include any subsequent advances in practice, and the information presented in this video does not replace hospital, health centre, or governmental guidelines.



# Learning Objectives

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- X-ray interpretation of adult hip, femur, knee, leg, ankle, and foot
- Verbal description of injury
- Importance of mechanism and clinical exam to predict injury pattern
- Clinical diagnosis
- Management in the Emergency Department



# Outline

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- Principles
- How to describe a fracture
- Cases and review of common xrays



# Principles of Orthopaedics

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## Emergency assessment

- Mechanism of injury
- Neurovascular compromise
- Joint above, joint below



# Principles of Orthopaedics

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## Emergency management

- Immediate interventions
  - Reduction, immobilization
- Stability of injury
  - Referral from ER or outpatient follow-up?
- Potential complications of injury
  - Admission or discharge from ER



# Principles of Radiology

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- Ensure the films are adequate and identified
- Look for a second injury
- Predict injuries based on mechanism
- Fracture description





# Principles of Orthopaedics and Radiology

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# Fracture Description Terminology

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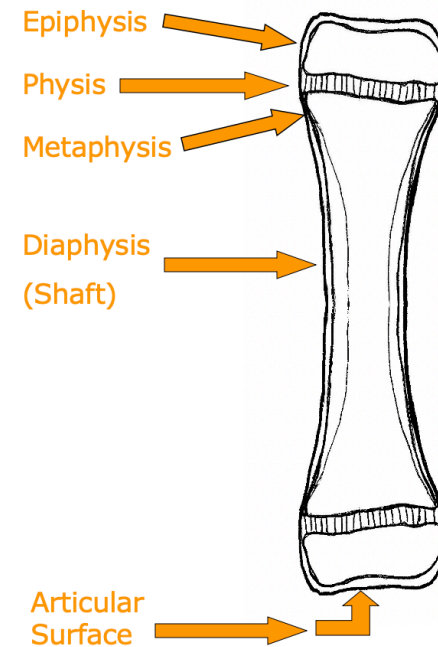
- Open or closed
- Location
- Intra- or extra-articular
- Fracture orientation
- Displacement
- Impaction/shortening
- Dislocation/subluxation
- Angulation
- Rotation



# Location, bone basics

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- Which bone?
- Thirds (long bones)
  - Proximal, middle, distal third
- Anatomic orientation
  - E.g. proximal, distal, medial, lateral, anterior, posterior
- Anatomic landmarks
  - E.g. head, neck, body / shaft, base, condyle



# Intra-Articular Fracture

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(a)



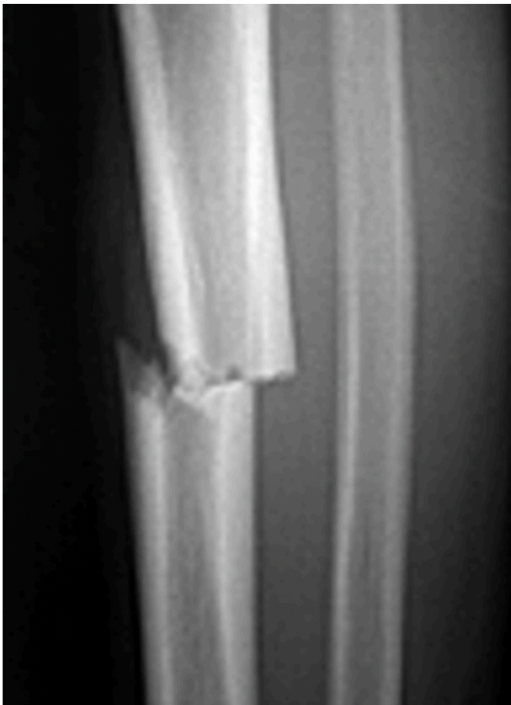
(b)



# Fracture Orientation

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Transverse



Spiral or oblique



# Fracture Orientation

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Comminuted



Segmental



# Displacement

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- ❑ Extent to which fracture fragments are not *axially* aligned
- ❑ Describe displacement of ***distal*** fragment ***relative to proximal***



# Impaction

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- ❑ One bone fragment driven into the other
- ❑ Shortening causes weakness as soft tissues no longer out to length





# Dislocation

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- ❑ Represents significant ligamentous injury
- ❑ Less common in children and elderly
- ❑ Described as ***distal*** fragment ***relative to*** ***proximal*** fragment



# Angulation

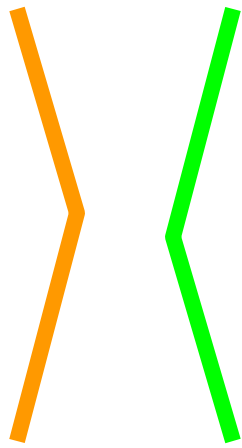
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- ❑ Extent to which fracture fragments are not anatomically aligned
- ❑ Described as ***the direction the apex is pointing relative to anatomical long axis of the bone***



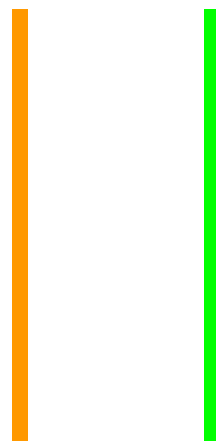
# Angulation

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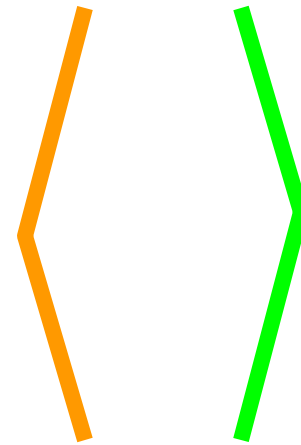


## **VALGUS**

- Apex medial



- Parallel
- No angulation



## **VARUS**

- Apex lateral



# Rotation

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- ❑ Extent to which fracture fragments are rotated relative to each other
- ❑ Described as direction the ***distal*** fragment is rotated **relative to the proximal** portion of the bone
- ❑ Often appreciated clinically rather than on x-ray



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# **PART I: PELVIS, HIP, AND FEMUR**



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# Hip and Pelvis

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# Hip and pelvis

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# Case 1

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Radiopaedia.org



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# Posterior Hip Dislocation

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- Mechanism: usually MVC, requires large forces
- Clinically: adducted, shortened, internally rotated
- Pearls: look for associated fractures, e.g. acetabulum; evaluate thoroughly for other major injuries
- Management?
  - Urgent reduction in ED
  - Risk of avascular necrosis of femoral head



## Case 2

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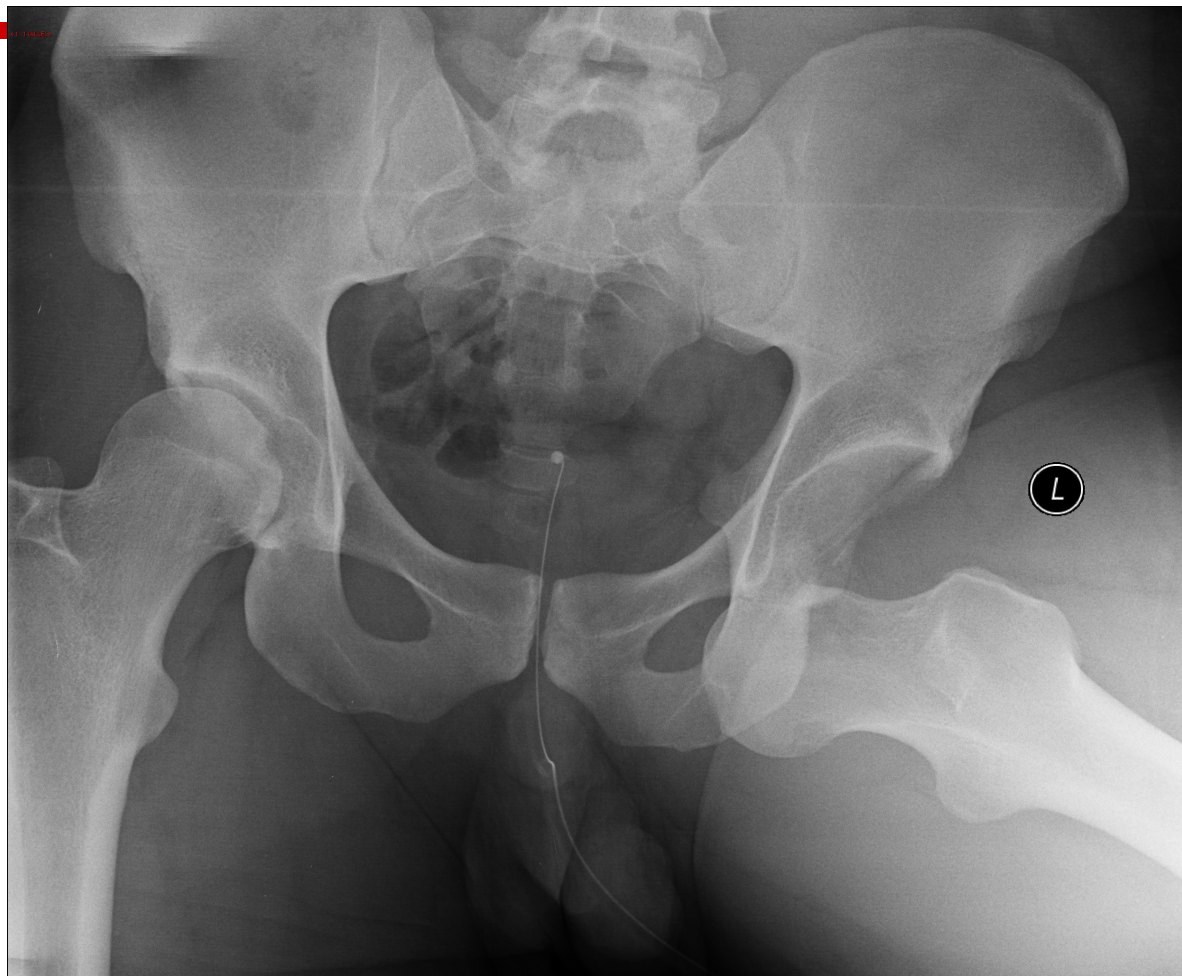


## Case 3

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# Case 4



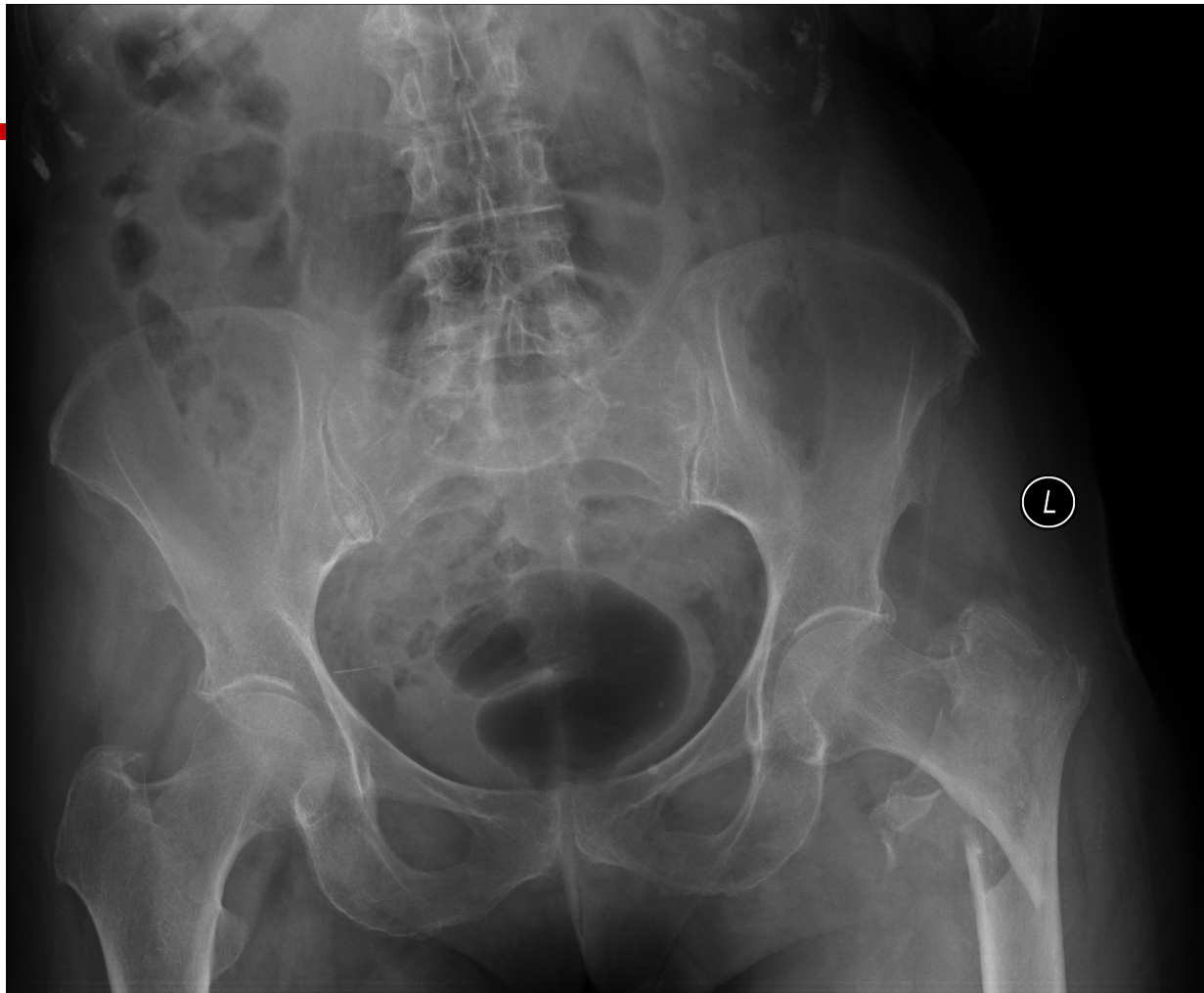
# Case 5

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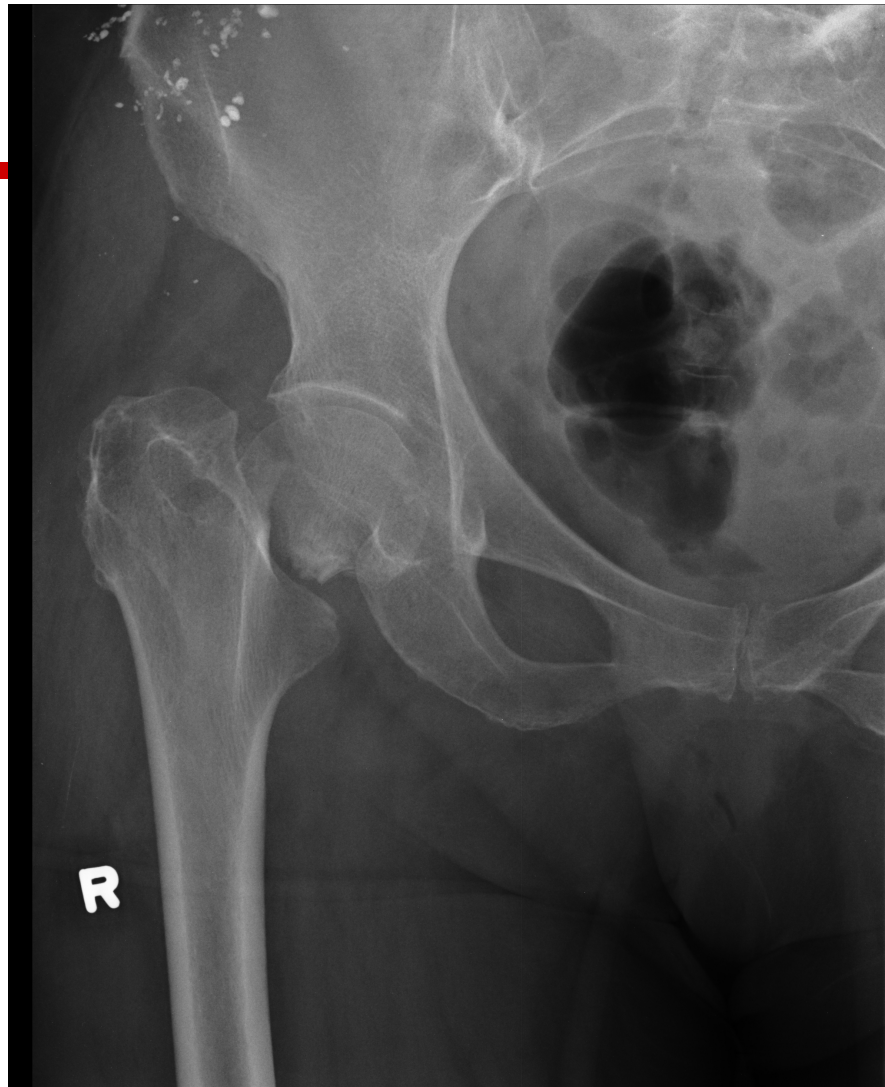
## Case 6

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# Case 7

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## Case 8

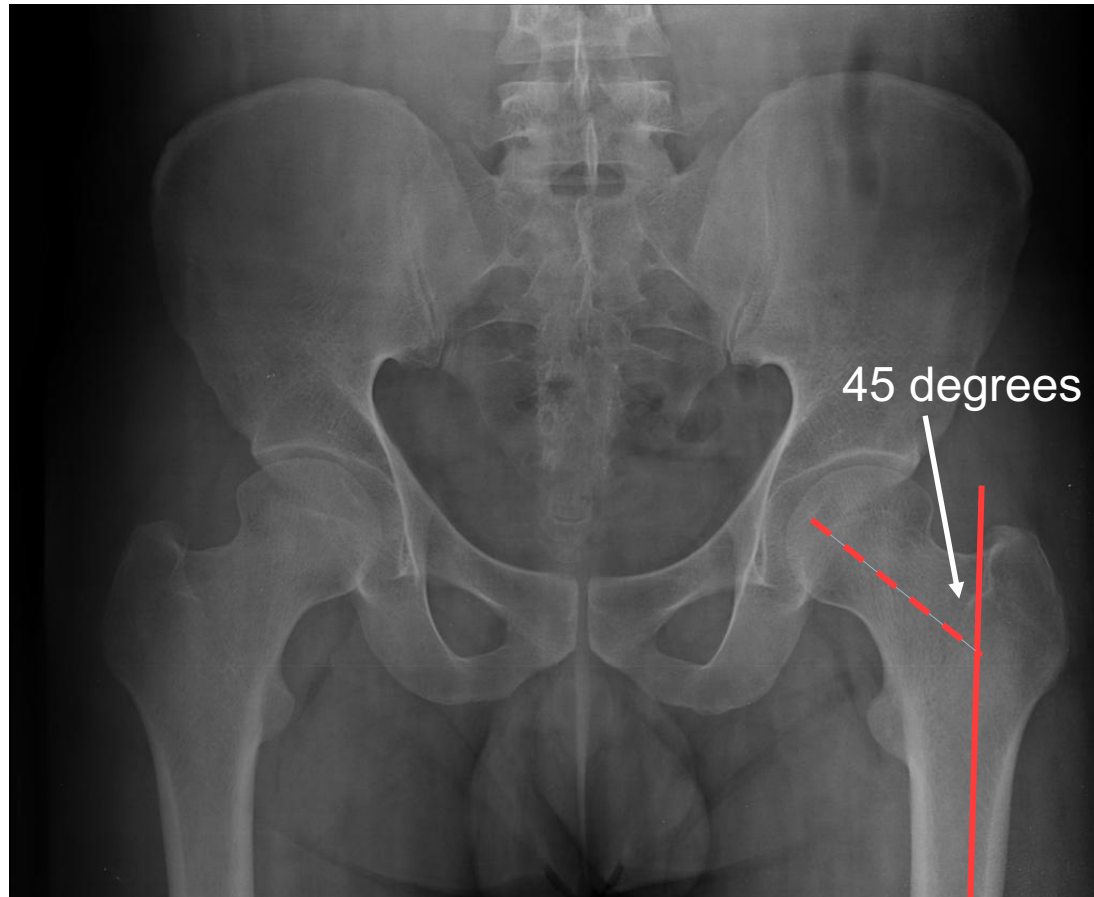
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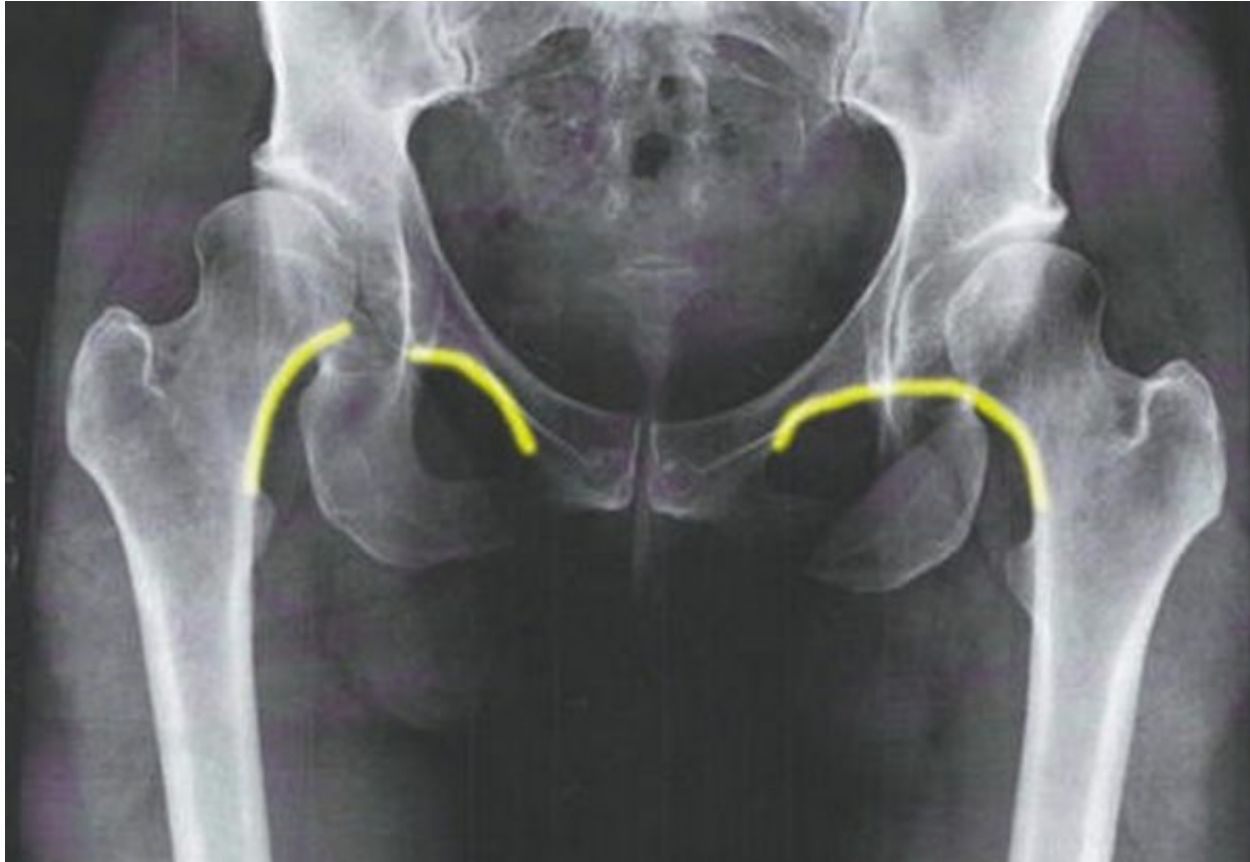
# Detecting occult hip fractures

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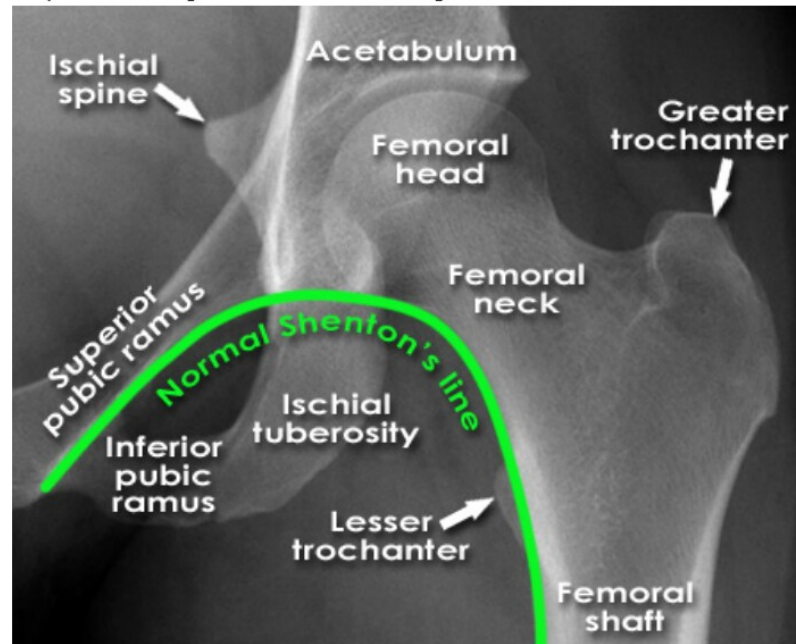


# Detecting occult hip fractures

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# Shenton's line



## Hip X-ray anatomy - Normal AP

- ◆ Shenton's line is formed by the medial edge of the femoral neck and the inferior edge of the superior pubic ramus
- ◆ Loss of contour of Shenton's line is a sign of a fractured neck of femur
- ◆ **IMPORTANT NOTE:** Fractures of the femoral neck do not always cause loss of Shenton's line



# Hip fractures

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- ❑ Mechanism: elderly patient after falling down accident
- ❑ Clinically: *might* be shortened and externally rotated
- ❑ Pearls: risk of avascular necrosis of femoral head
- ❑ In Canada, these are all operative cases
- ❑ What if the X-ray looks normal?
  - Assess for pelvic fractures
  - Further imaging (X-ray 5% miss rate)



# Quiz Question 1

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- What is the most likely clinical scenario to produce a hip dislocation?
  - Assaulted with blunt weapon
  - Tripped and fell
  - Osteoporosis and minimal trauma
  - Motor Vehicle Collision



## Quiz Question 2

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- What is the management plan for a patient with hip pain and normal X-rays?
  - “Walk test”
  - Admit for bedrest
  - Pelvic X-ray, consider CT hip
  - Discharge home with crutches



# Femur



# Case 9

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# Case 10

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# Femoral shaft fracture

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- Very unstable
- Call orthopaedics
- Open reduction and internal fixation



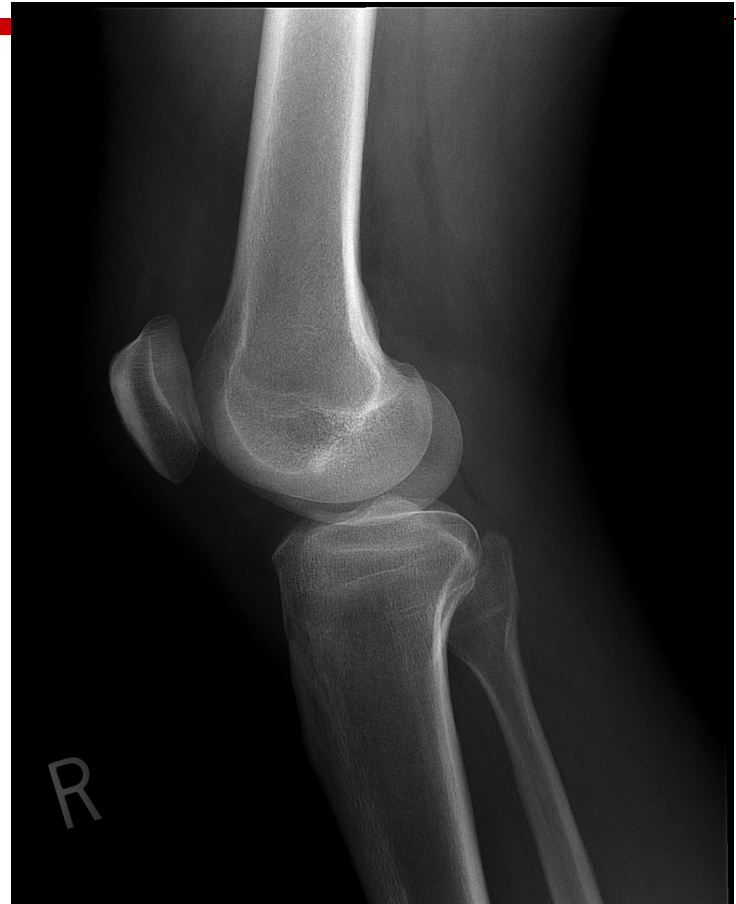
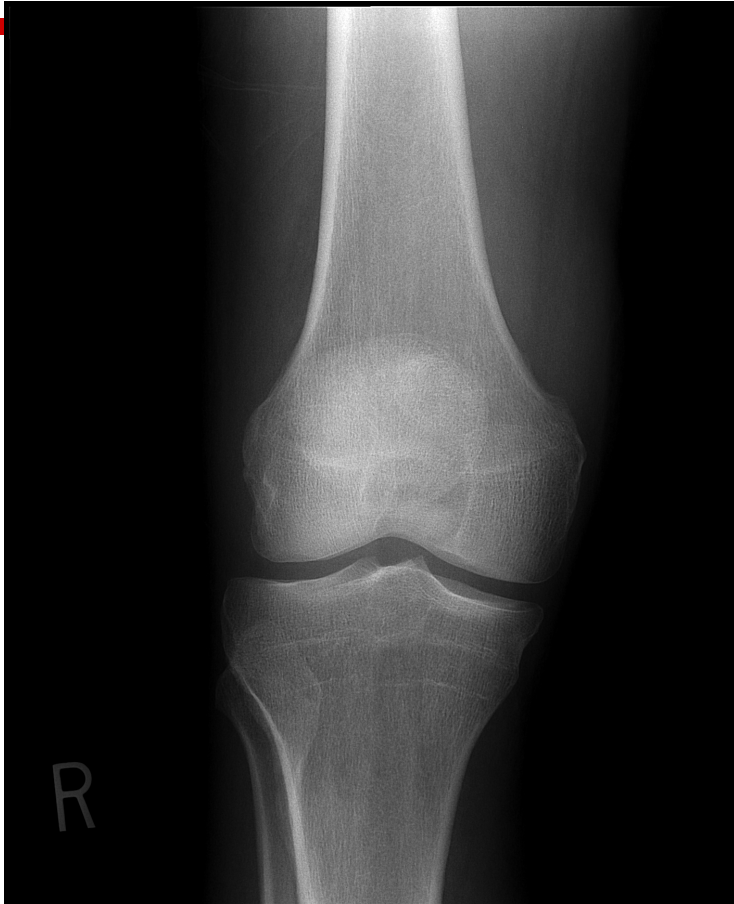
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## **PART II: KNEE AND TIB FIB**



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# Knee



# Soft Tissue Injuries of the Knee

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## Mechanism

- Valgus strain: MCL
- Sudden deceleration: ACL
- Twisting: meniscal

## Timing of swelling

- Immediate: hemarthrosis (ACL, fracture, meniscus)
- Delayed: inflammation (meniscus)

## Physical exam findings: SEADS mnemonic



# Soft Tissue Injuries of the Knee

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- ❑ Active Straight Leg raise
  - Ask supine patient to raise their leg off the stretcher
  - If unable consider:
    - ❑ Patellar tendon rupture
    - ❑ Quadriceps tendon rupture
  - Frequently missed – not seen on XR
  - Acute surgical repair



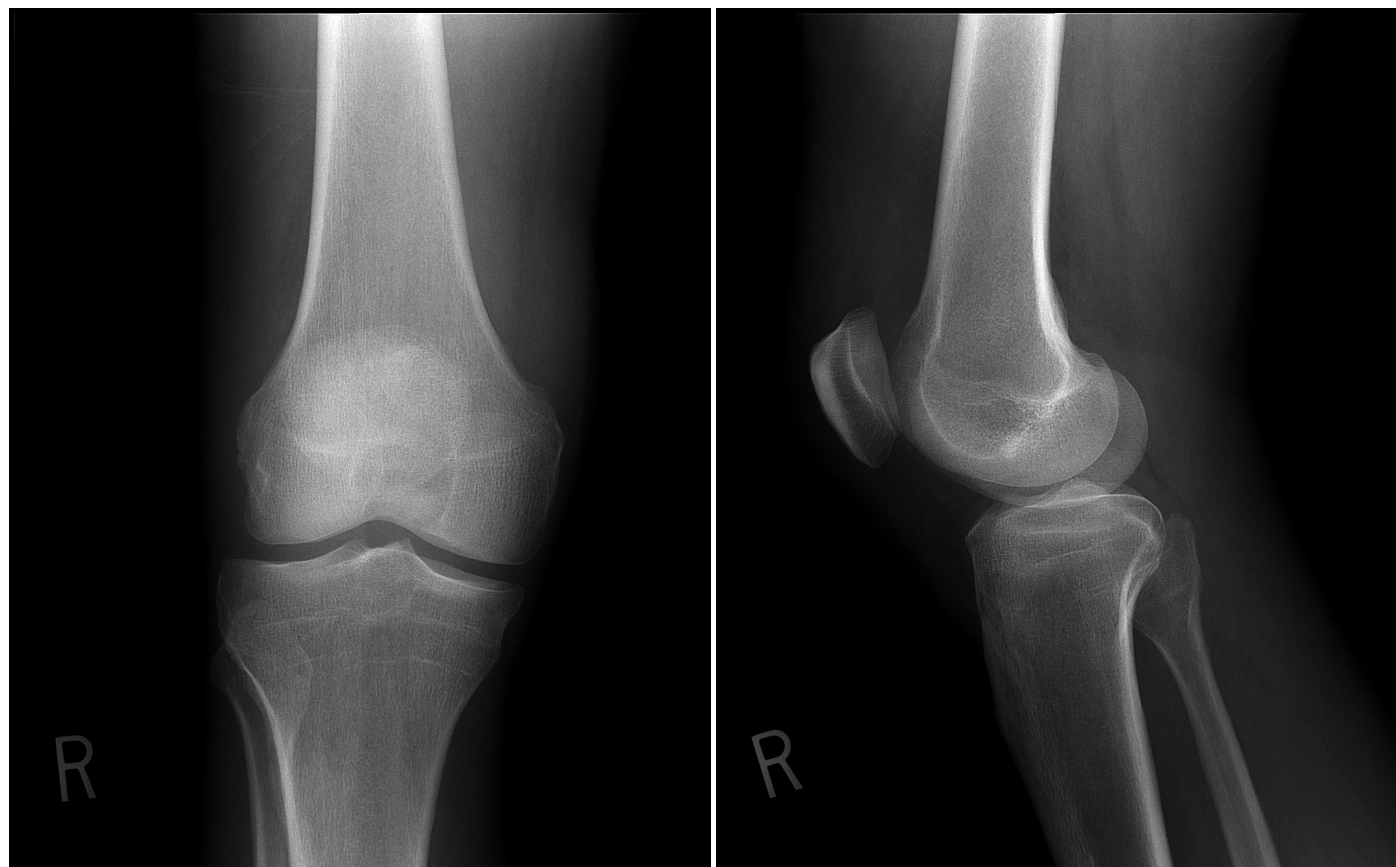
# Case 1

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# Case 1

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# Knee dislocation

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- Serious injury – can be limb threatening
- Mechanism: significant force
- May have spontaneously reduced (XR may be normal)
- Clinical clues are important: mechanism, multiple ligament instability
- High risk for vascular injury
- Require urgent reduction, immobilization
- Call Ortho



## Case 2

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## Case 2

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# Tibial Plateau Fracture

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- ❑ Mechanism: valgus stress, car vs pedestrian, might be low speed
- ❑ Clinical: unable to weight bear, swollen knee, tender joint line
- ❑ X-ray: might be subtle or even normal
- ❑ Management: refer to Orthopedics



## Case 3

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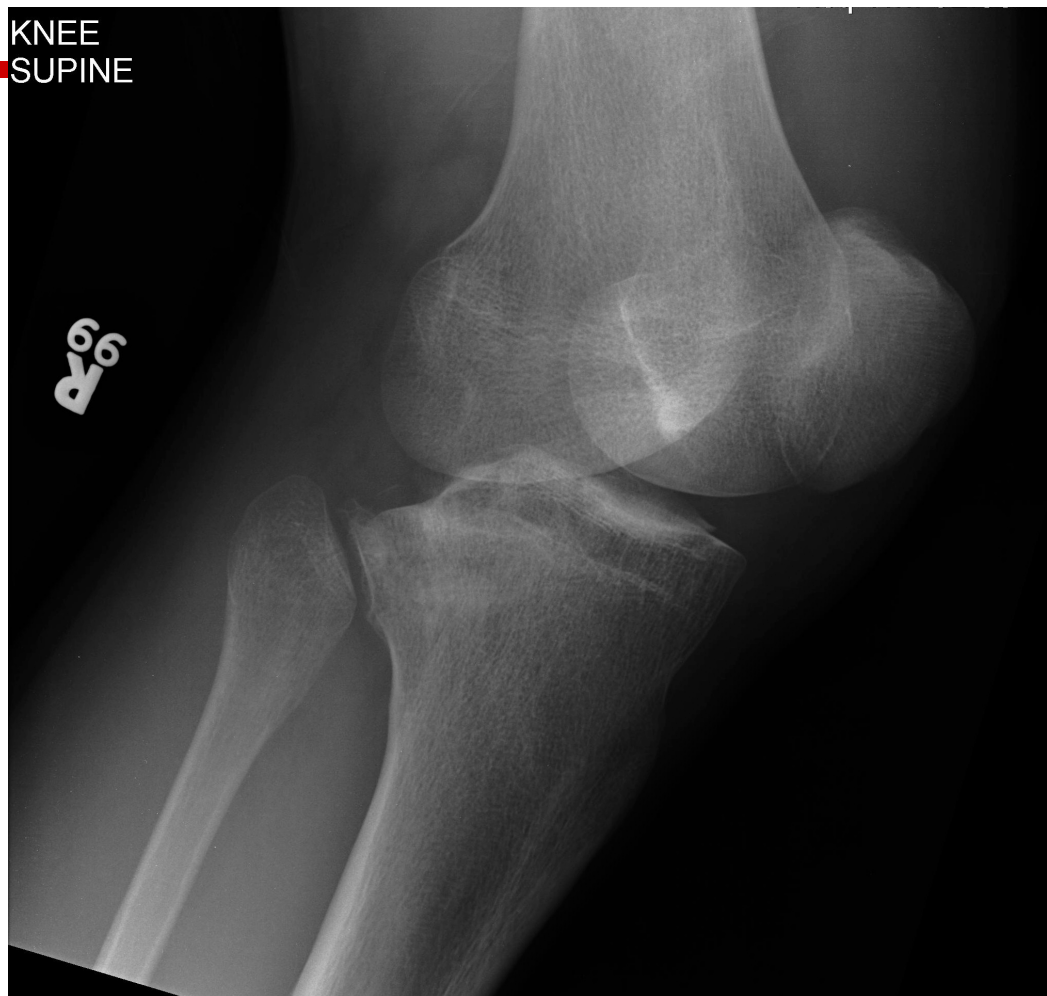
# Case 4

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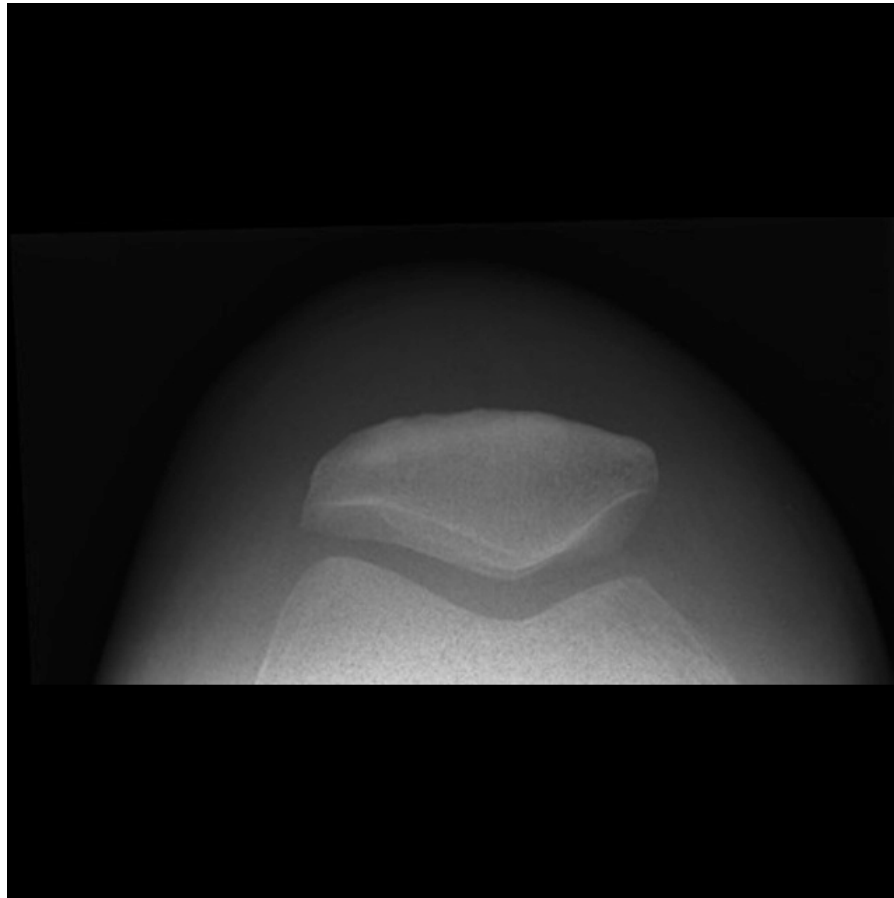
# Case 5

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# Patella

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## Case 6

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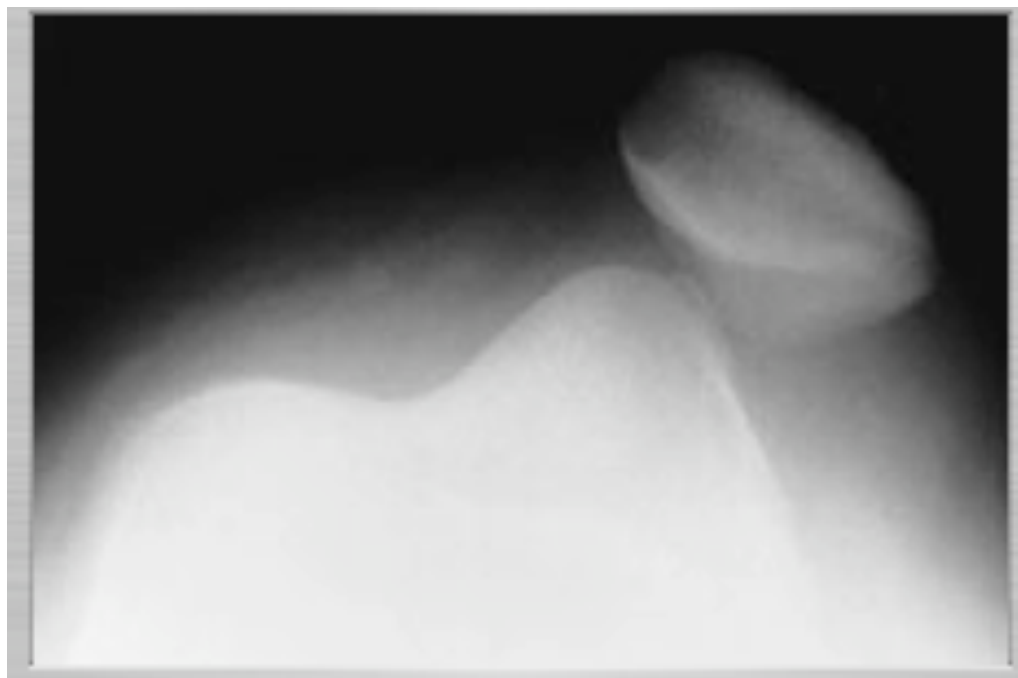
# Case 7

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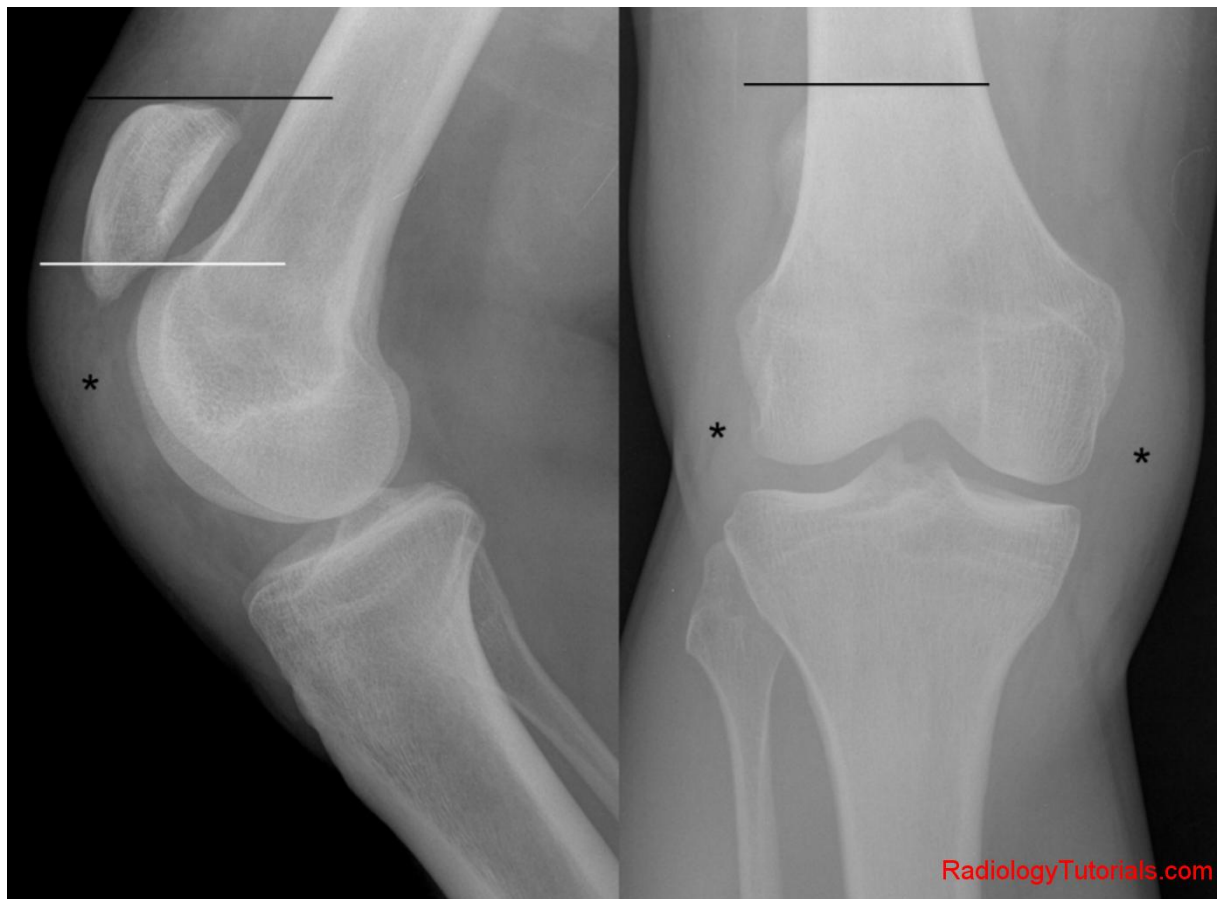
# Case 8

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# Case 9

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# Knee injuries – Bottom Line

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- ❑ A normal X-ray does not exclude serious injury!
  - Knee dislocation
  - Tibial plateau fracture
  - Extensor mechanism rupture
  
- ❑ Mechanism of injury and clinical exam are vital to guide decision-making



## Quiz Question 3

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- A 42F was in a head-on collision and sustained sternum and rib fractures. Her right knee is swollen and painful, and she reports it popped out and back in prior to arrival in hospital. Her knee XR is normal and right lower extremity is neurovascularly intact. What is your next step?
  - Prescribe analgesia with ice and elevation
  - Wrap in compression bandage and WBAT
  - Arrange further imaging
  - Long leg cast and admission



## Quiz Question 4

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- ❑ 35M playing football, misses the ball, now complains of severe knee pain. His XR is normal. Do you:
  - Discharge home with crutches
  - Perform an active straight leg raise
  - Prescribe analgesia and ice/elevation
  - “Walk test” and refer to orthopedics if fails



# Leg

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# Case 10

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# Case 11

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# Tibial shaft fractures

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- ❑ Mechanism: high-velocity e.g. MVC
- ❑ Clinical: often quite obvious deformity
- ❑ Pearls:
  - High risk of open fracture or secondarily open fracture
  - High risk of compartment syndrome
- ❑ Management: reduction, splint, and referral



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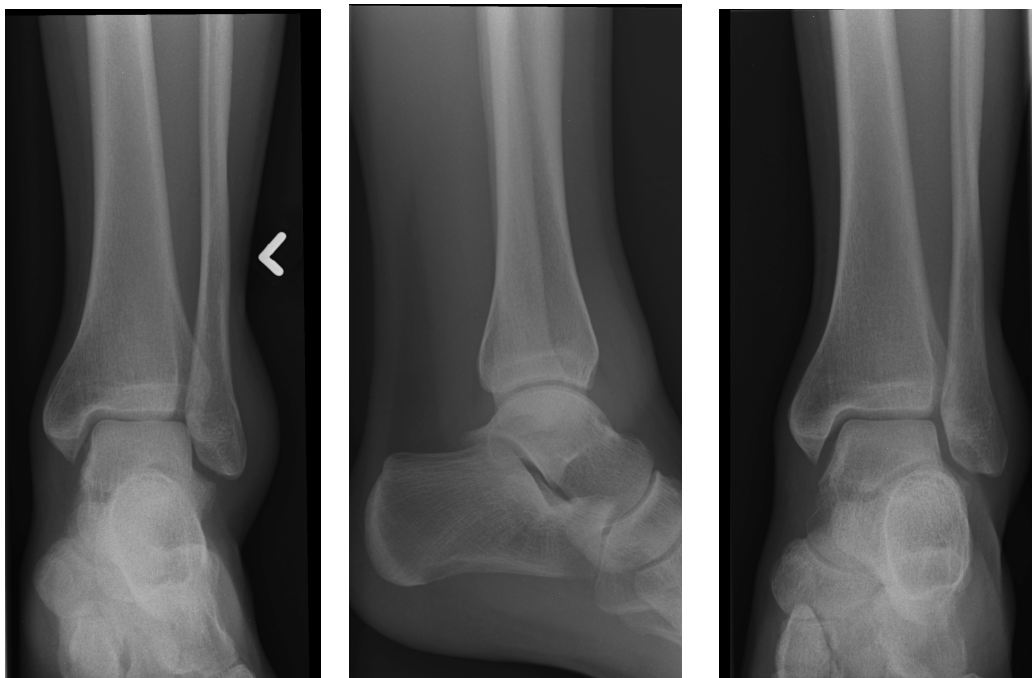
# **PART III: ANKLE AND FOOT**



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# Ankle

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# Ankle Injuries

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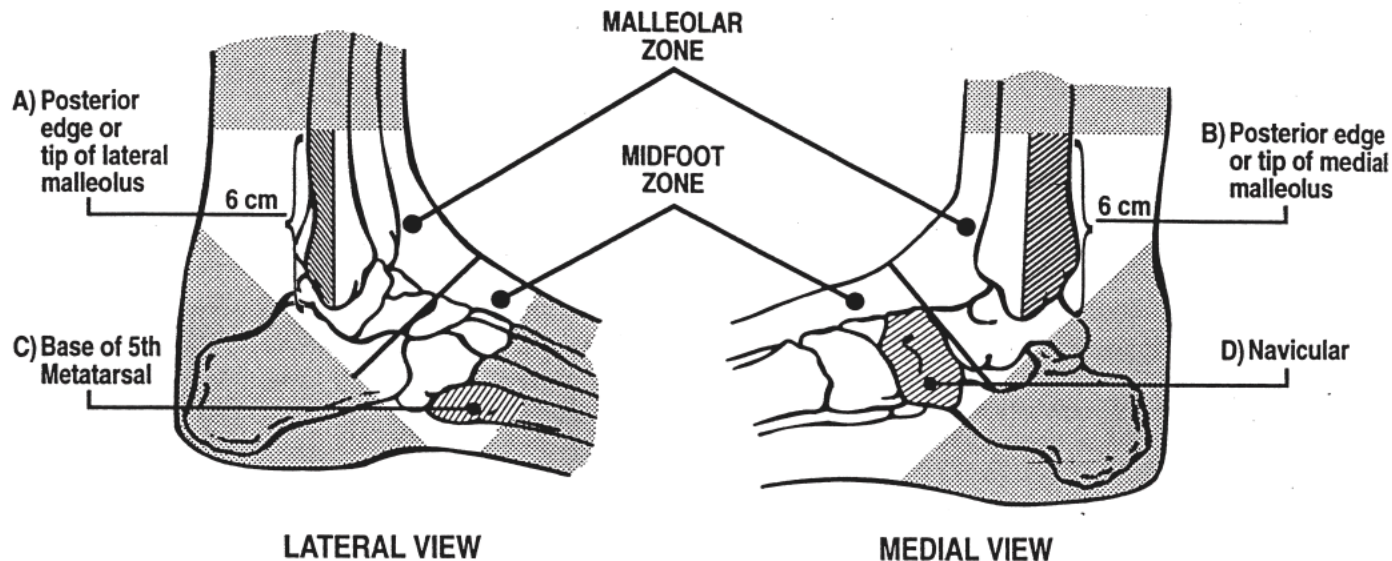
- Mechanism: inversion? eversion? other?
- Clinical: medial/lateral/anterior tenderness? Bony tenderness? Fibula? Foot?
- Ottawa Ankle Rules
- Stable or unstable? Reduction if necessary, even if going to OR



# Ottawa Ankle Rules

## OTTAWA ANKLE RULES

*For Ankle Injury Radiography*



*Stiell IG, McKnight RD, Greenberg GH, et al. Implementation of the Ottawa Ankle Rules. JAMA 1994; 271:827-832.*



# Ottawa Ankle Rules

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- Ankle X-ray recommended for traumatic ankle pain and any of:
  - Bony tenderness at posterior distal 6cm or tip of lateral malleolus
  - Bony tenderness at posterior distal 6cm or tip of medial malleolus
  - Inability to weight-bear both immediately after injury and in ED





# Ottawa Ankle Rules

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- Foot XR recommended for traumatic foot pain and any of:
  - Bony tenderness at base of 5<sup>th</sup> metatarsal
  - Bony tenderness over navicular
  - Inability to weight-bear both immediately after injury and in ED

*\*\*\*Use clinical judgement if patient is intoxicated or uncooperative, has distracting injuries, has significant swelling or diminished leg sensation, or is under 18 years old*



# Case 1

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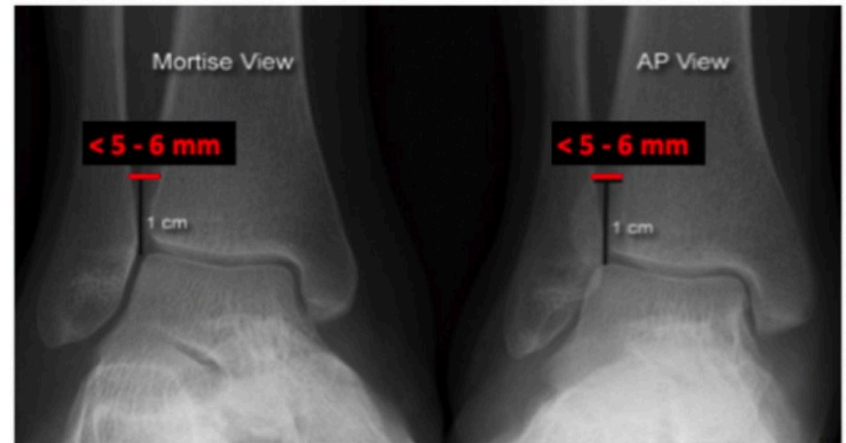
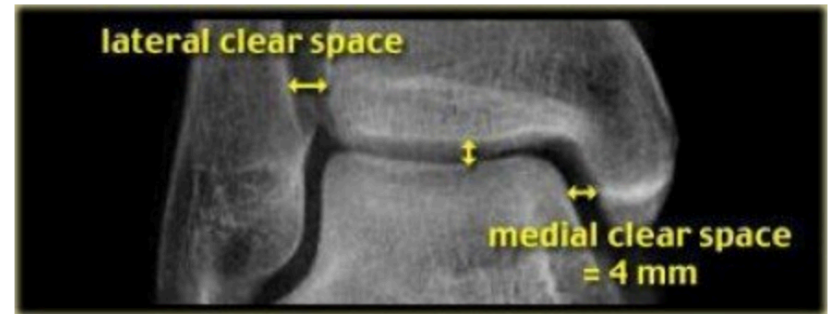
## Case 2

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# Evaluating ankle joint stability on XR

- ❑ Talar shift: anatomic mortise, medial clear space <4mm
- ❑ Talar tilt: parallel lines of tibial plafond and talar dome
- ❑ Tib-fib clear space: <5-6mm on AP or mortise view



# Case 3



## Case 4

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# Case 4

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# Case 5

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# Case 5

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# Maisonneuve and Dupuytren's fractures

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- ❑ Medial malleolus injury + Weber C spiral fractures of proximal (Maisonneuve) or mid (Dupuytren) fibula
- ❑ Always examine whole length of the fibula
- ❑ Consider tib-fib X-rays



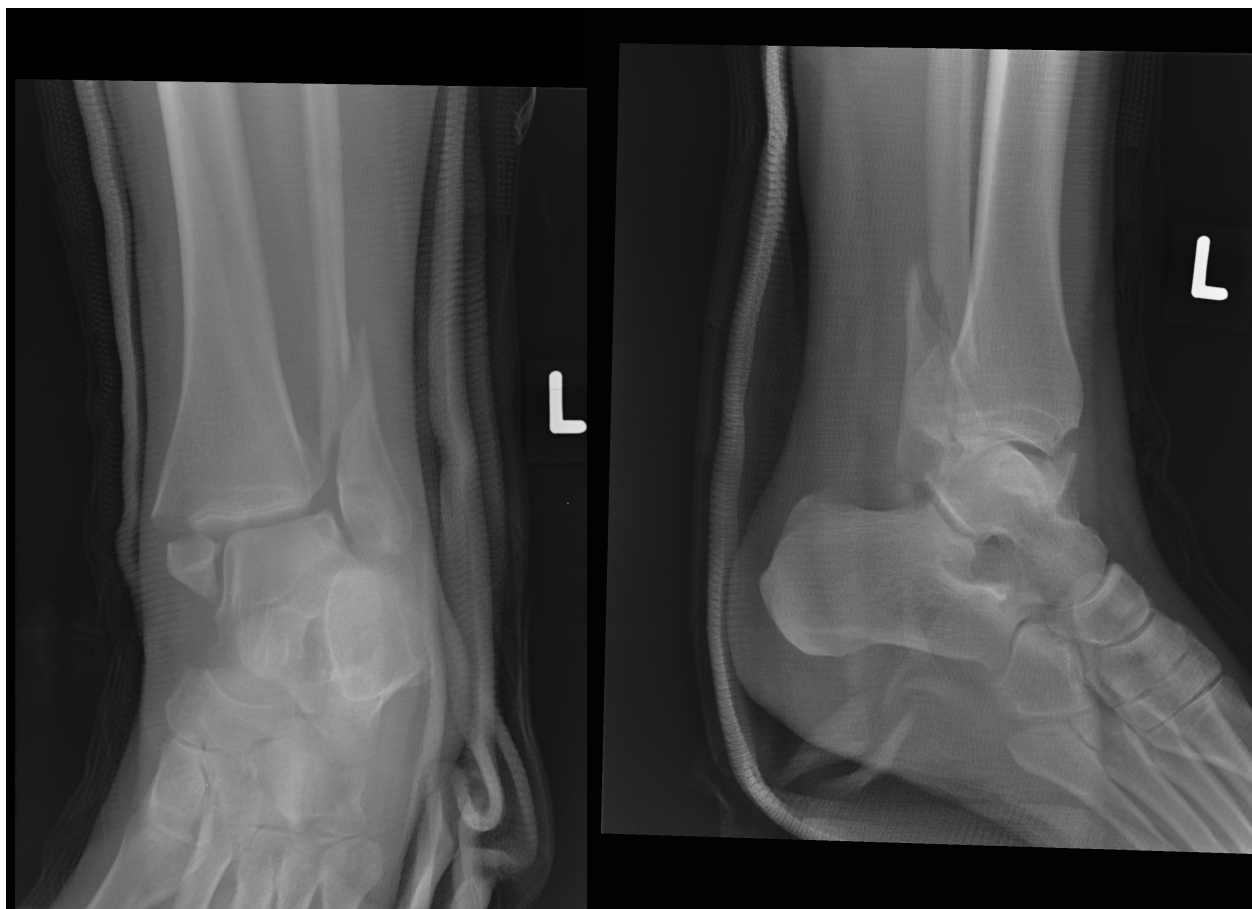
# Case 6

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# Case 7

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## Quiz Question 5

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- Which one(s) of these cases require X-ray? What X-ray should be ordered?
  - 45F inversion, tender base of 5<sup>th</sup> metatarsal, unable to ambulate
  - 18M eversion, tender medial malleolus and proximal fibula, unable to ambulate
  - 23M inversion, tender distal bony aspect lateral malleolus, able to ambulate with pain
  - 70F inversion, unable to ambulate, tender everywhere



# Ankle injuries – Take Home Messages

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- ❑ Don't limit physical exam based on Ottawa ankle rules
- ❑ Always look at the ankle mortise for congruency all the way around
- ❑ Beware of the isolated medial malleolar injury – examine and image full length of tib fib



## Case 8

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# Achilles Rupture

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- ❑ Mechanism: running, heard or felt a snap
- ❑ Clinical: Thompson's test
- ❑ X-ray: likely normal
- ❑ Management:
  - Posterior slab in plantar flexion (equinus)
  - Usually operative





# Calcaneus series

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# Case 9

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# Calcaneus fracture

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- ❑ Mechanism: fall from height
- ❑ Clinical: heel tenderness, unable to weight-bear
- ❑ Pearl: high risk of associated injuries: contralateral calcaneus, knee, hip, T/L-spine
- ❑ Boehler's angle: normal is 30-40 deg
  - Less than 20 deg is highly suspicious for calcaneal fracture
  - Normal angle does not exclude fracture
- ❑ XR may under-estimate extent of injury

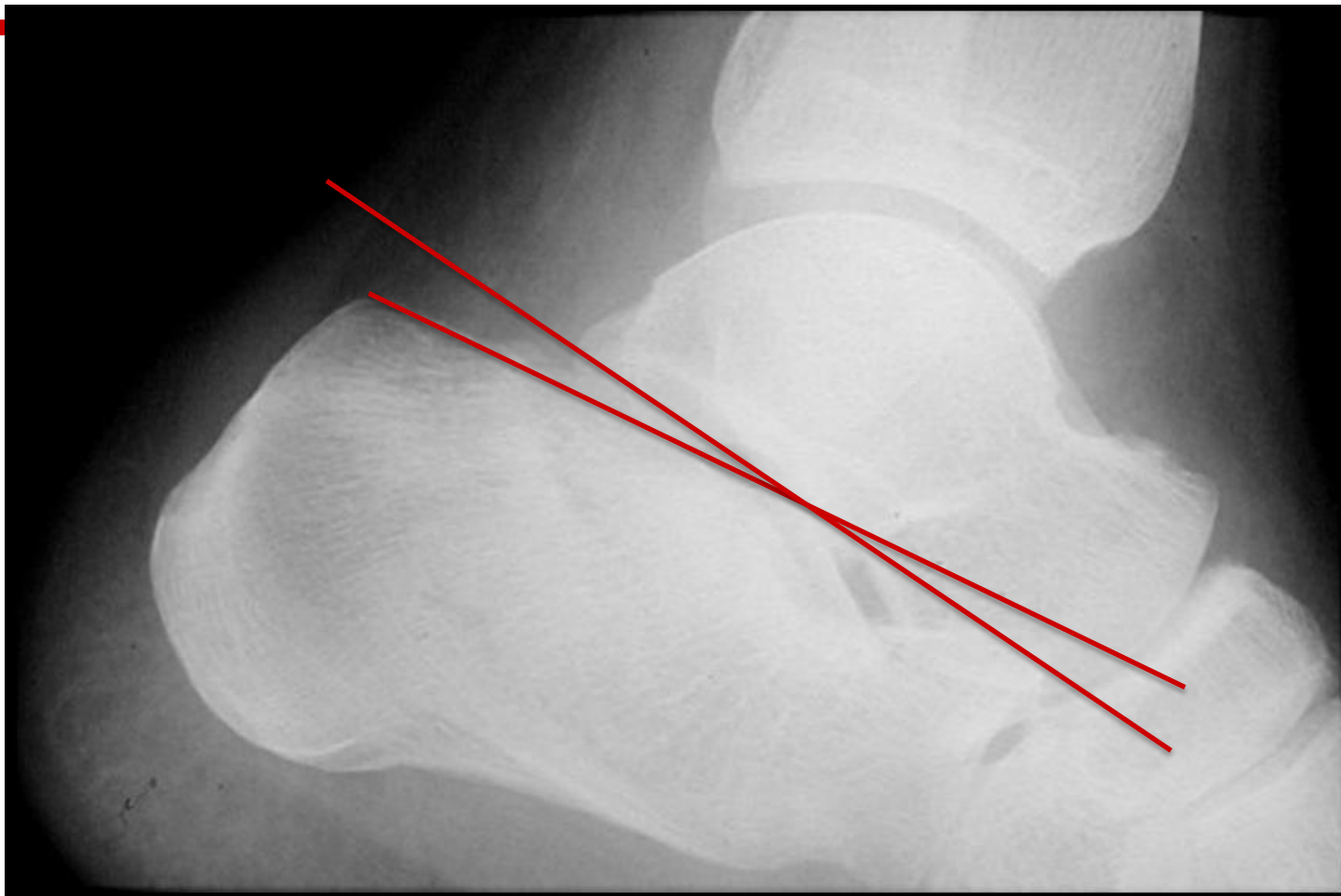


# Boehler's angle

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# Case 9



# Case 10

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# Foot



AP



Oblique



Lateral

# Case 11

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# Case 12

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# Case 13

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# Case 14

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# Lisfranc (tarso-metatarsal) fracture-dislocation

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- Mechanism: MVC, or foot in hole and twisted
- Clinical: significant midfoot pain, with tenderness, swelling and bruising on planter aspect of foot, unable to WB
- Management:
  - Undisplaced/suspected: posterior slab, non-WB, close follow up
  - Displaced/dislocated: reduction, ortho consult
  - Risk of compartment syndrome



# Lisfranc XR – widening and fractures

*MT = metatarsal*

- Widening:
  - >2mm between 1<sup>st</sup>/2<sup>nd</sup> or 2<sup>nd</sup>/3<sup>rd</sup> MTs is abnormal
- Suspect if nearby fractures or avulsions (ex. fleck sign)



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# Lisfranc XR - misalignment

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AP views:

- ❑ lateral 1<sup>st</sup> MT should align with lateral edge of medial cuneiform
- ❑ medial 2<sup>nd</sup> MT should align with medial edge of intermediate cuneiform

Lateral:

- ❑ Long axis of talus intersects with long axis of 5<sup>th</sup> MT

*MT = metatarsal*



# Lisfranc XR: misalignment

*MT = metatarsal*

Oblique:

- ❑ 3<sup>rd</sup> MT should align with medial and lateral edges of lateral cuneiform
- ❑ medial 4<sup>th</sup> MT should align with medial cuboid
- ❑ lateral 5<sup>th</sup> MT should not be more than 3mm beyond cuboid



# Case 15

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# Case 16

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# Case 17

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# Case 18

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## Quiz Question 6

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- A patient falls from 3m and sustains a calcaneal fracture. What other injuries should you assess for?
  - Lumbar spine fractures
  - Tibial plateau fracture
  - Contralateral ankle fracture
  - C-spine fracture



# Summary

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- Mechanism is as important as X-ray
- Joint above, joint below
- Neurovascular compromise
- Soft tissue injury: ligaments, skin
- Open fracture is an emergency!
- Don't miss the second fracture! (or third, or fourth...)



# Summary

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- ❑ Hip: X-ray is not perfect
- ❑ Knee: straight leg raise for ligament injury
- ❑ Tibia-fibula: caution for open fracture or compartment syndrome
- ❑ Ankle: Ottawa Ankle Rules
- ❑ Calcaneus: Boehler's angle
- ❑ Foot: midfoot pain – check for Lisfranc injury



# General References

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## □ Chapters in Textbooks:

- Tintinalli 8<sup>th</sup> ed, Ch. 273-277
- Tintinalli 9<sup>th</sup> ed, Ch 273 – 277
- Section IV (Skeletal Radiology: The Lower Extremity) in Emergency Radiology - Case Studies (Schwartz)
- CASTED manual by Dr. Arun Sayal



# Credits

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- Dr. N. Meshkat for access to radiology library
- Dr. A. Sayal for use of his CASTED course material

