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# Injuries of the Lower Extremity: Knee, Ankle and Foot

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# First Steps

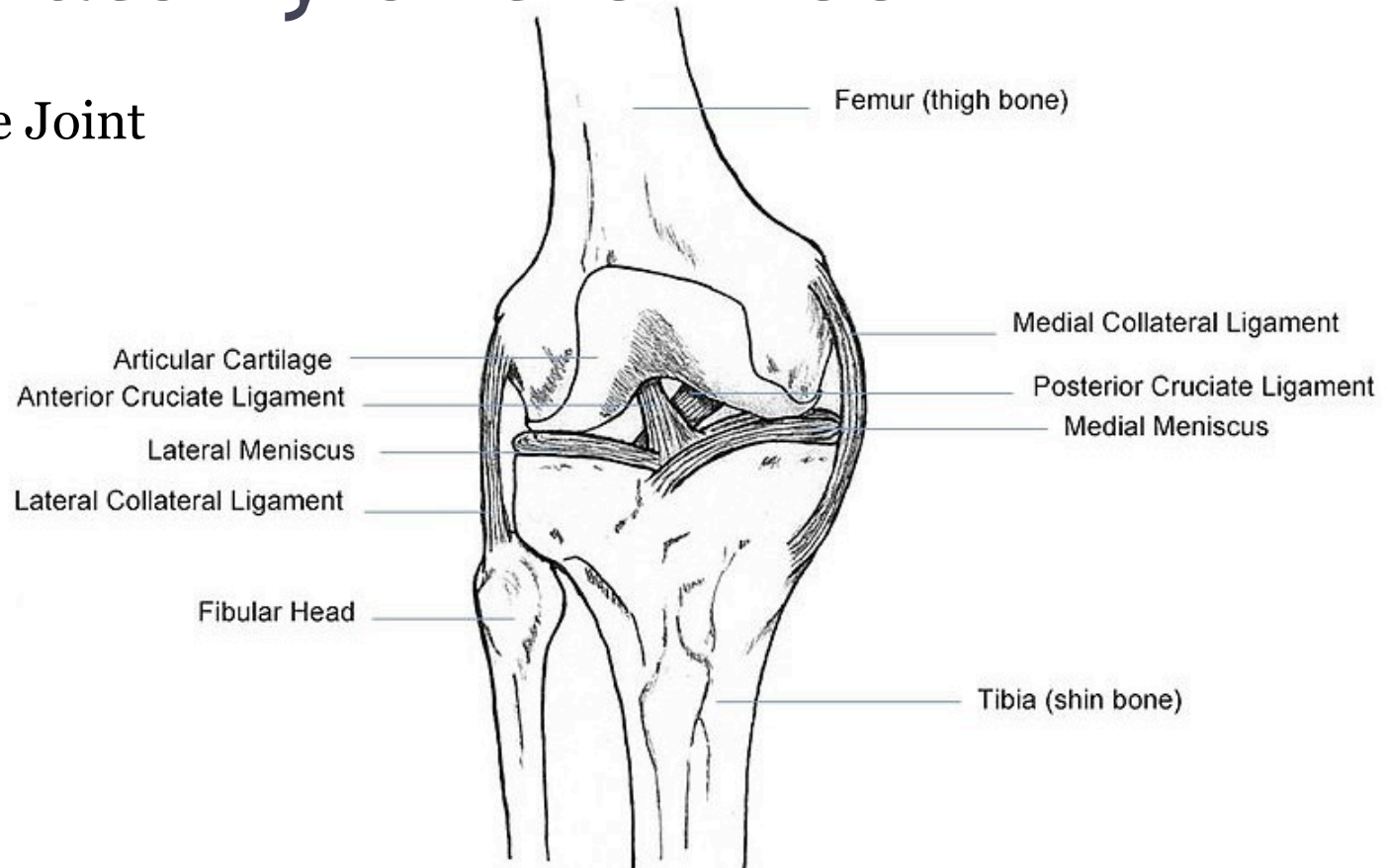
- I need a volunteer or two who is willing to move up to the front of the room and help me a demonstration
- The rest of you come closer and arrange yourselves so you can talk amongst yourselves (No not because my lecture is going to be that boring)

# Objectives

- To provide a review of common lower extremity injuries that present in an Emergency Department setting, focusing on those involving in the knee, ankle and foot
- To describe the epidemiology of these injuries
- To review the appropriate history and physical exam maneuvers in order to quickly evaluate and distinguish the different emergent injuries
- To review the diagnostic examinations available for further evaluation
- To describe the preliminary management of the in the emergent setting

# Basic Anatomy of the Knee

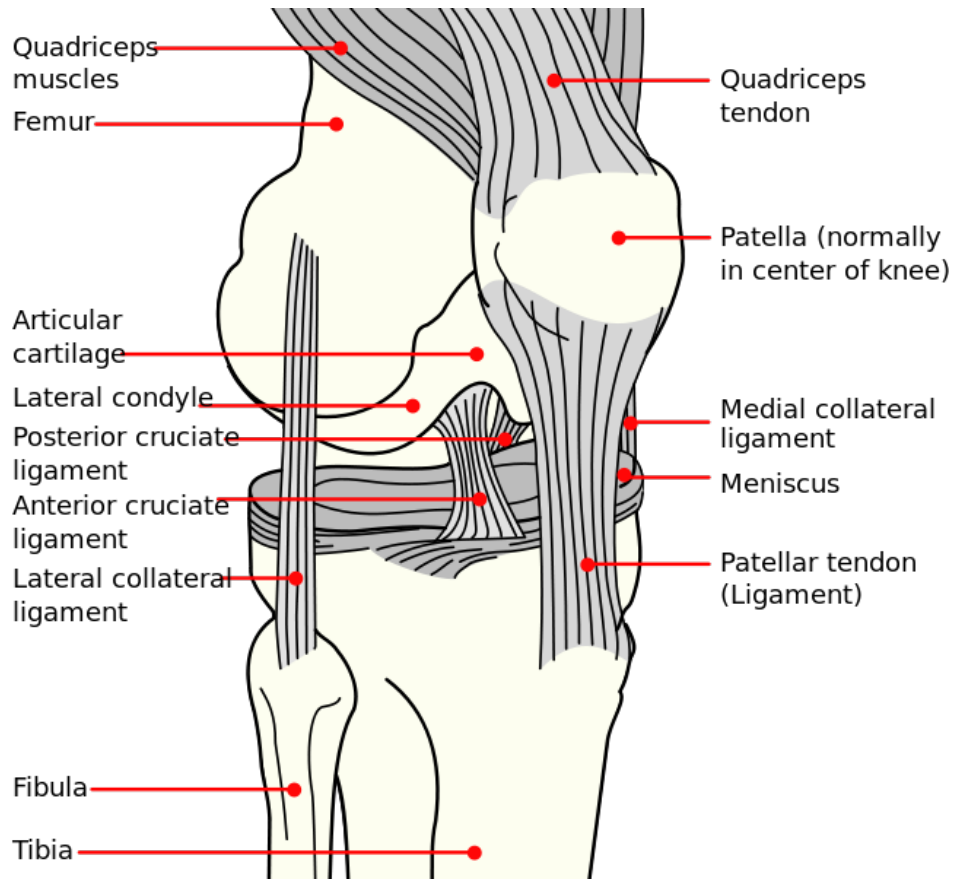
- Large Hinge Joint
- Femur
- Tibia
- Fibula
- Patella



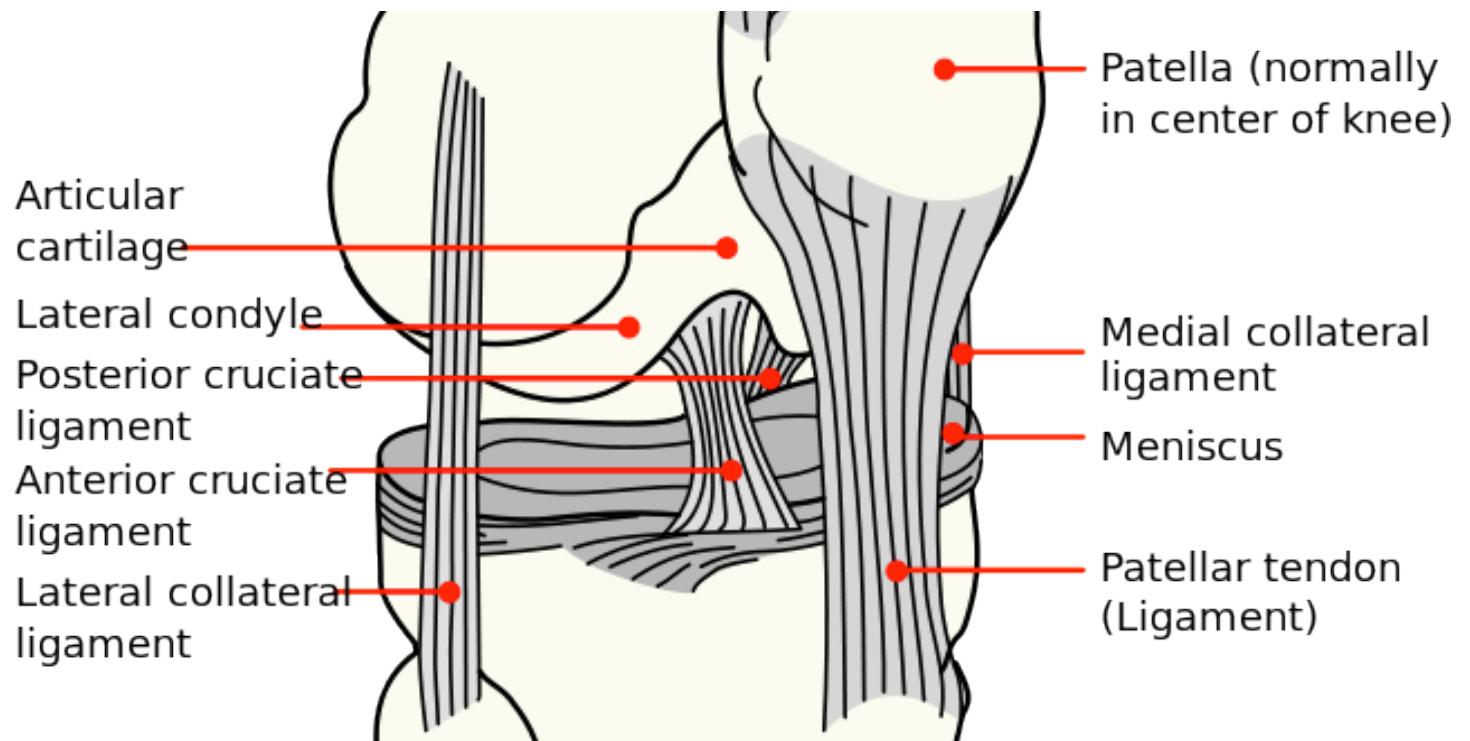
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# More Basic Anatomy



- Ligaments
- Medial Collateral Ligament (MCL)
- Lateral Collateral Ligament (LCL)
- Anterior Cruciate Ligament (ACL)
- Posterior Cruciate Ligament (PCL)



- Articular Cartilage
- Medial Meniscus
- Lateral Meniscus



Mysid, [Wikimedia Commons](#)



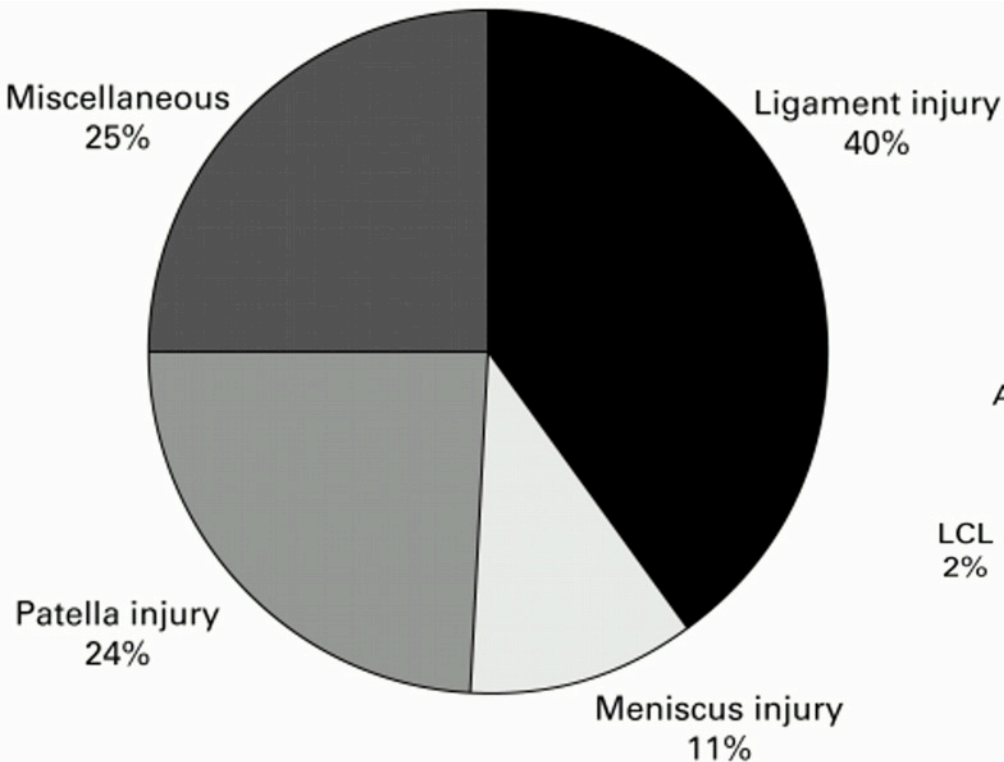
# Types of Knee Injuries

- Injuries to one or more of the ligaments of the knee (ACL, PCL, MCL, and LCL)
- Injuries to the bony structures (Patellar fractures, femur fractures, tibial fractures)
- Injuries to the meniscus and articulating surface

# Key Pieces of History

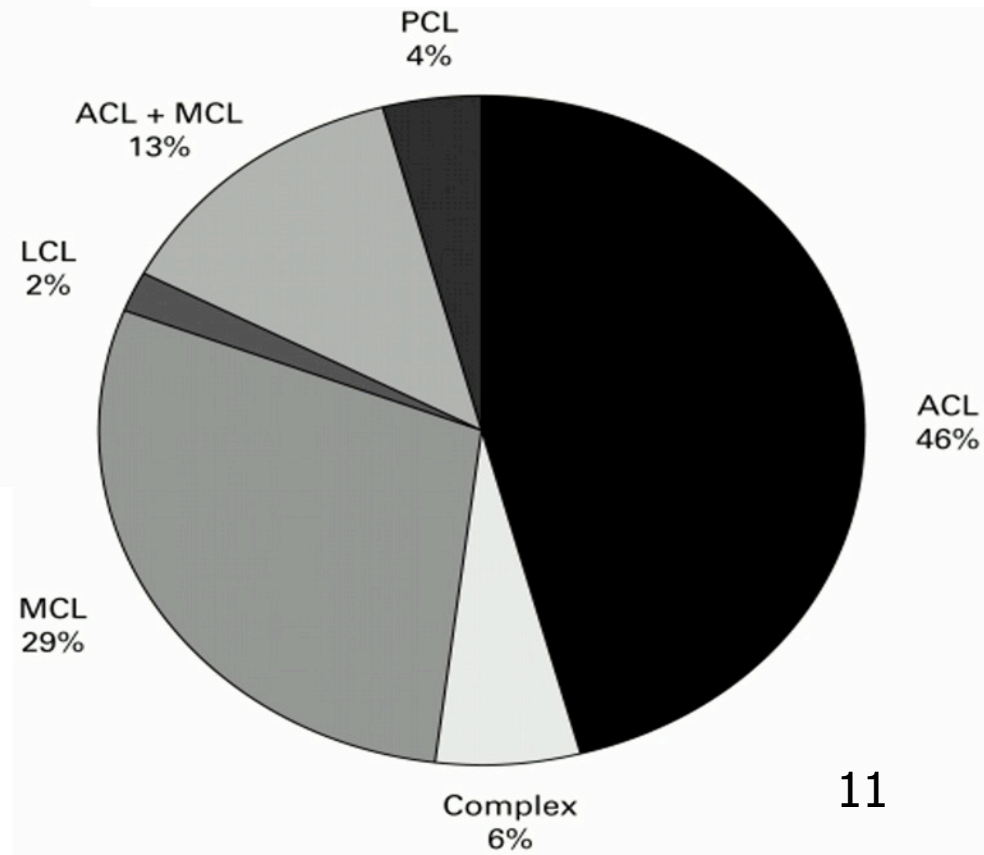
- Fracture
  - High-velocity collision
  - Inability to immediately bear weight
  - "Pop" occurred with injury
- ACL tear
  - Cut or pivot mechanism of injury
  - Knee "gave way"
  - Inability to continue participation
  - "Pop" felt or heard with injury
- PCL tear
  - Blow to proximal tibia
  - Less instability than ACL tear
- Meniscal tear
  - Squat/kneel associated with a twist
  - Clicking
  - Locking
  - Pain with rotational movement
- Overuse syndrome
  - Occupational or recreational repetitive movement

# Epidemiology of Knee Injuries



- All Knee injuries

- Subset of Ligamentous injuries



# Stepwise evaluation of the injured knee

- Palpate the knee and determine the areas of maximal tenderness
- Examine and note the presence and location of any effusion
- Evaluate the Range of Motion at the Knee
- Evaluate the movement and stability of the patella
- Perform specific ligamentous stability testing
- Perform Meniscal examination
- Examine for neurovascular compromise

# Palpation

- Superior Patella Pole (Quadriceps Tendonitis)
- Inferior Patella Pole (Prepatellar Tendonitis)
- Anterior Patella (Prepatellar Bursitis)



# Joint line (Meniscal Injury)

- Lateral Medial



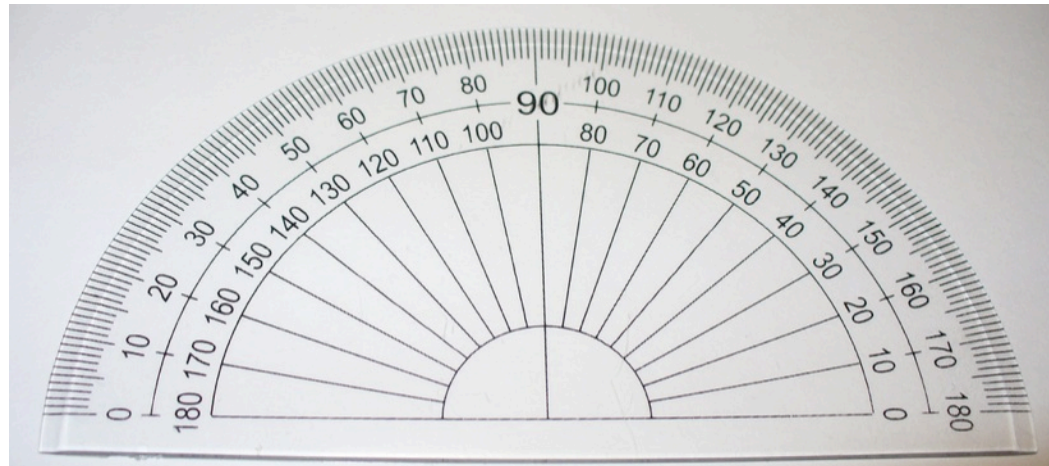
# Palpation in Adolescents

- Tibial Tubersosity (Osgood-Schlatter)
- Femoral or Tibial Epiphysis (Non displaced fracture through the physis)

# DDX of Effusions

- Trauma
  - Ligamentous injury
  - Intra-articular fracture
  - Patellar dislocation
  - Meniscus injury
- Polyarthritis
  - Reiter's syndrome
  - Juvenile rheumatoid arthritis
  - Rheumatoid arthritis
- Infection
  - Gonorrhea
  - Lyme disease
  - Tuberculosis
  - Brucellosis
- Gout
  - Pseudogout (calcium pyrophosphate deposition disease)
  - Osteoarthritis and overuse syndrome
- Tumor
  - Malignant
    - Hematologic
    - Solid tumor
    - Chondroblastoma
    - Eosinophilic granuloma
    - Giant cell tumor
    - Ewing's sarcoma
    - Osteosarcoma
    - Synovial sarcoma
  - Benign
    - Aneurysmal bone cyst
    - Fibrous cortical defect
    - Fibrous dysplasia
    - Osteochondroma
    - Osteoid osteoma
    - Pigmented villonodular synovitis





 tronixstuff, [flickr](#)

## Range of Motion

- The knee should be able to range from hyperextension to 135 degrees of flexion
- Loss of active extension and inability to maintain passive extension are indicative of quadriceps and patellar tendon

# Patellar Testing

- Examine the patella, with ROM testing, feeling for catches and grinding
- Next test the movement of the patella testing for lateral laxity (Patellar Dislocation)



 openmichigan, [YouTube](#)

# ACL testing

- Anterior Drawer sign
  - Performed at 90 degrees flexion
  - Make sure the quadriceps muscles are relaxed
  - Compare the amount of laxity of movement compared to unaffected side
- Lachman's Test
  - Performed at 20 to 30 degrees flexion



# PCL Testing

- Posterior Drawer sign
  - Gold Standard
  - Performed similarly to Anterior drawer sign



 openmichigan, [YouTube](#)



 openmichigan, [YouTube](#)

## Posterior Sag Sign

- Observe the lag at maximum muscle relaxation
- Compare to unaffected leg

# MCL Testing

- Valgus stressing of the MCL at both 0 and 30 degrees
- Testing at 30 degrees removes the stabilization provided by the cruciate ligaments



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# LCL Testing

- LCL testing similar to MCL testing
- Varus stress testing
- Performed at 0 and 30 degrees





# Meniscal Testing



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- McMurray's Test to evaluate for Meniscal injury
- Positive test is “clicking” along joint line along with pain during internal and external rotation

# Ottawa Knee Rules

- OK break into groups and lets take 1 minute and list the criteria
- Hint: There are 5



# Ottawa Knee Rules

- Age 55 years or older
- Tenderness at head of fibula
- Isolated tenderness of patella
- Inability to flex to 90°
- Inability to bear weight both immediately and in ED

# Ottawa Knee Rules: The Numbers

- In one meta-analysis the decision rule had a sensitivity of 1.0 (95% confidence interval 0.96 to 1.0) in identifying clinically important fractures.
- In the same study the potential reduction in use of radiography was estimated to be 49%
- The probability of fracture, if the decision rules were negative, was estimated to be 0% (95% CI 0% to 0.5%)
- Not worth a patient complaint



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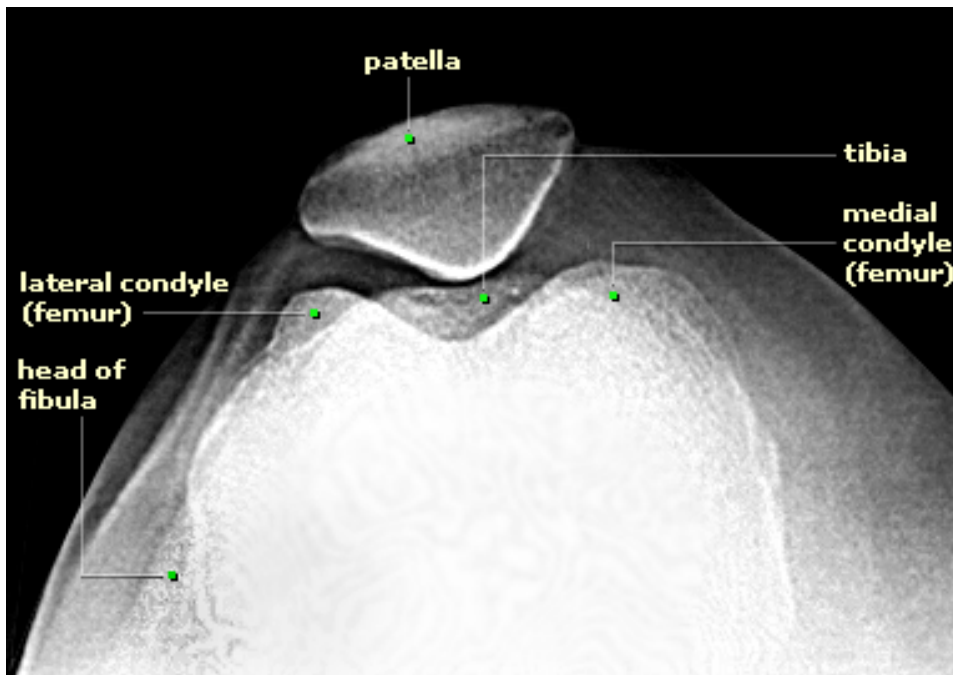
# Imaging Modalities

- Plain X-Rays
- CT
- Ultrasound
- Bone Scan
- MRI



Source Undetermined

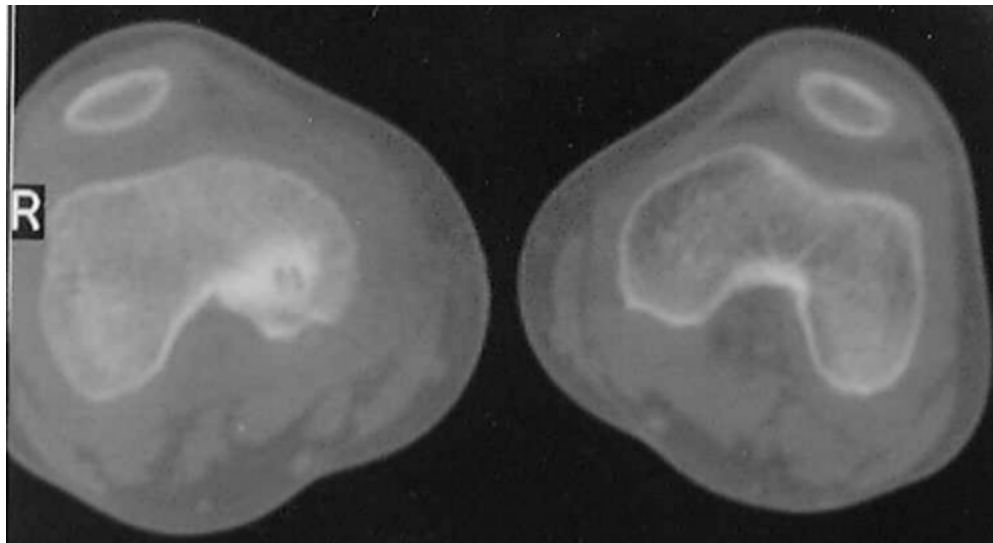
# Plain Films



- Traditional Standard of Care when concern for fracture
- Generally A/P and Lateral performed in ER
- Additional Useful images include a “Sunrise” view

# Computer Tomography

- Useful in detecting tibial plateau fracture
- Usually performed when diagnosis is unclear



# Ultrasound

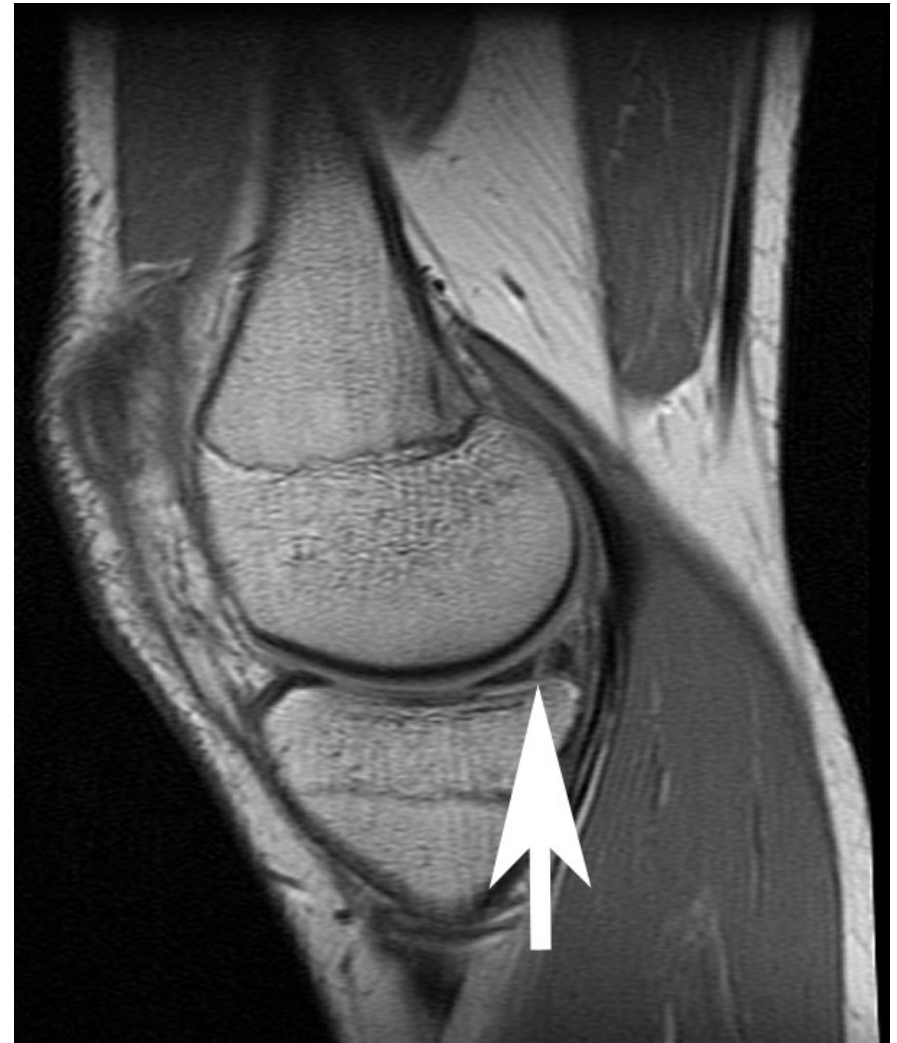


Source Undetermined

- Often used to examine the musculature of a joint while in use
- Provides dynamic imaging for examining muscle tears, tendon ruptures, and other soft tissue injuries.

# Magnetic Resonance Imaging

- Most useful for examination of meniscal injuries
- Can be used for evaluating for ligamentous injury
  - ACL has high sensitivity but poor sensitivity in determining complete versus partial tear
  - Very sensitive in PCL



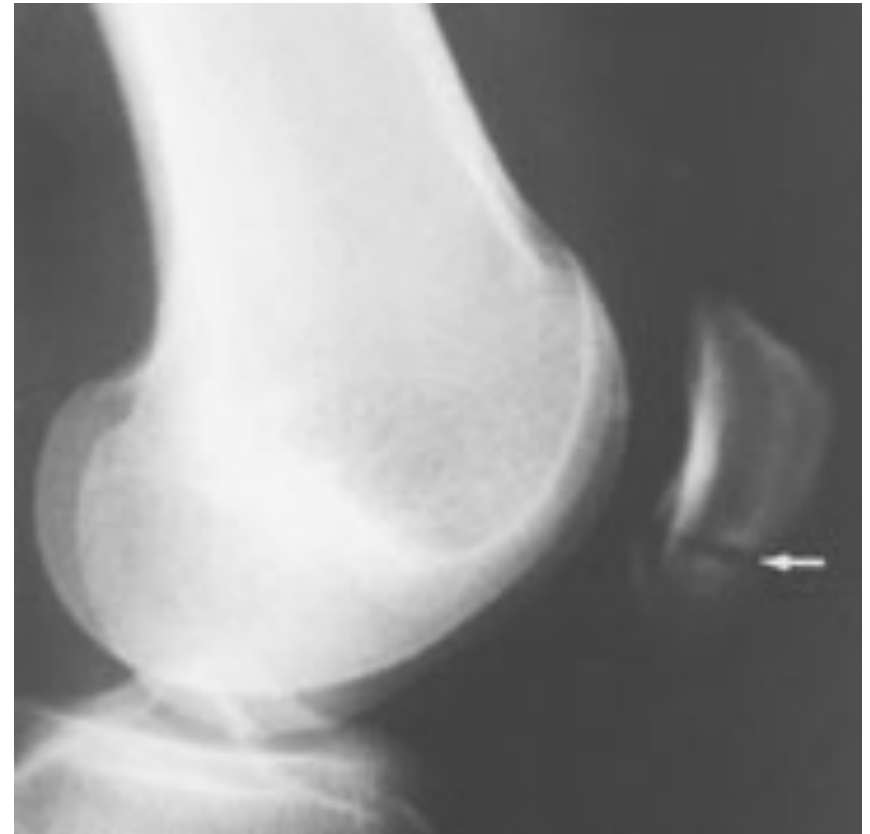
# Initial Management

- Or in the other words, after all of that what should we do?



# Patellar Fractures

- If extension is possible without displacement
  - non operative management
  - Initially treated in knee immobilizer
  - Treated long leg cast 4-6 weeks
  - Operative management consists of ORIF



# Patellar Dislocation



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- Closed reduction may be attempted
  - Gentle extension of the leg with anteriomedial pressure on the lateral aspect of the patella
  - Following reduction patient should be placed in a knee immobilizer for 3-6 weeks
  - 30-50% recurrence rate in properly treated primary dislocations

# Distal Femur Fracture



- Usually secondary to MVC or significant fall
- After examination, the leg should be splinted
- If joint incongruity, Ortho consult and ORIF
- Patients are at risk for fat embolus

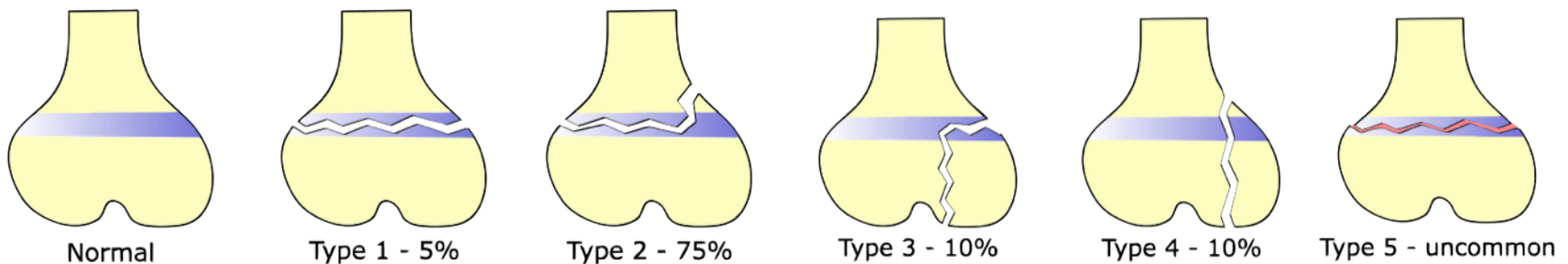
# Tibial Plateau Fracture

- More common in the elderly
- Usually strong varus force as cause
- By definition are intrarticular
- Often with associated ACL or MCL injury (20-25%)
- Patient should be made non-weight bearing and placed in immobilization either with a long leg cast or immobilizer
- Patient may require ORIF in more serious or displaced fractures



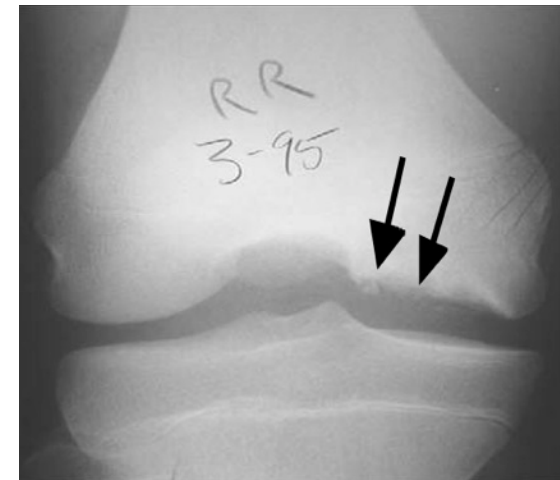
# Epiphyseal Fracture

- Constitute a fracture through an open growth plate
- Anatomic reduction
- Ice, elevation, immobilization with a long leg splint
- Early orthopedic consultation

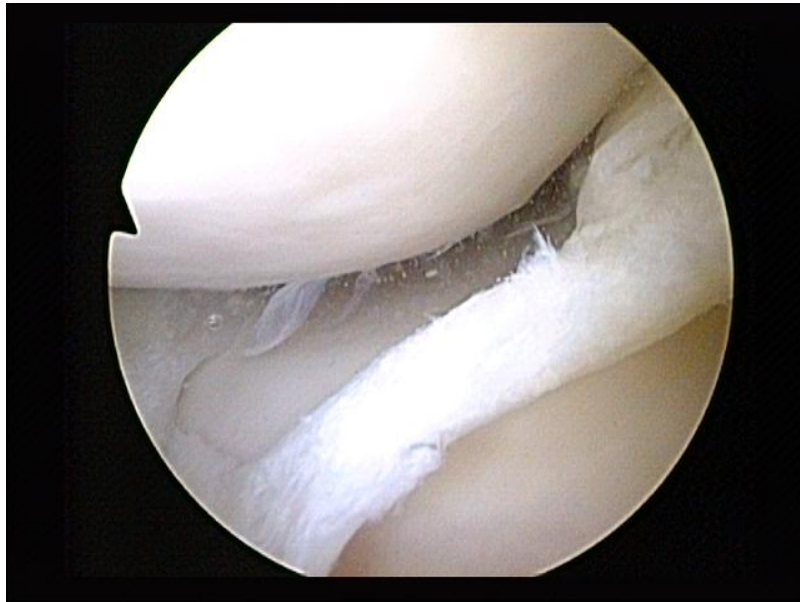


# Osteochondritis Dissecans (OCD)

- Unknown etiology, thought to be related to chronic or acute trauma
- Occurs mostly in adolescent males
- Usually seen on plain films
- In patients with open growth plates, treat with protected weight bearing
- Poor prognosis if closed
- If loose piece, may require OR



# Meniscal Injuries



Arthroscopist,  
[Wikimedia Commons](#)

- Crescent shaped semilunar fibrocartilaginous structures
- Diagnosis via MRI after clinical suspicion
- Unless locking, initial management is NSAIDs, ice, knee immobilization, non weight bearing, and orthopedic referral
- Ultimate management is determined often secondary to associate ligamentous injury

# Ligamentous Injuries

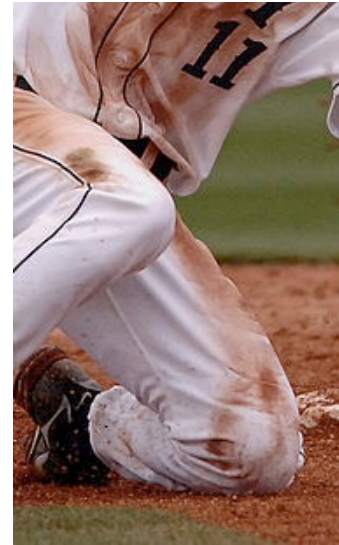
- ACL injuries
- PCL injuries
- MCL injuries
- LCL injuries



# ACL injuries

- 50% of ACL injuries are associated with meniscal injuries
- Often associated with bleeding and thus immediate swelling
- Grade I and II should be managed conservatively with pain meds and range of motion exercises
- Patient should be made non weight bearing
- If possible, patient should not be placed in a knee immobilizer if an isolated injury

# PCL injuries



 PD-GOV

John Collins,  
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- Hyperflexion and Dashboard injuries when isolated injury
- Generally managed non-operatively
- Treated long term with quadriceps strengthening

# MCL injuries

- Often due to a direct blow to the lateral aspect of the knee
- Should be placed in knee immobilizer and allowed to “scar” down
- Long term management is generally non operative in isolated injury

# LCL injury

- Less common than others, due to protection provided by other leg
- Management the same as with MCL
  - Non-operative management
  - Knee immobilization

# Tibial Femoral Knee Dislocation

- Limb Threatening Injury
- Half of all Dislocations reduce spontaneously
- 2/3 From MVCs
- 2 ligament injuries
- Neurovascular injury



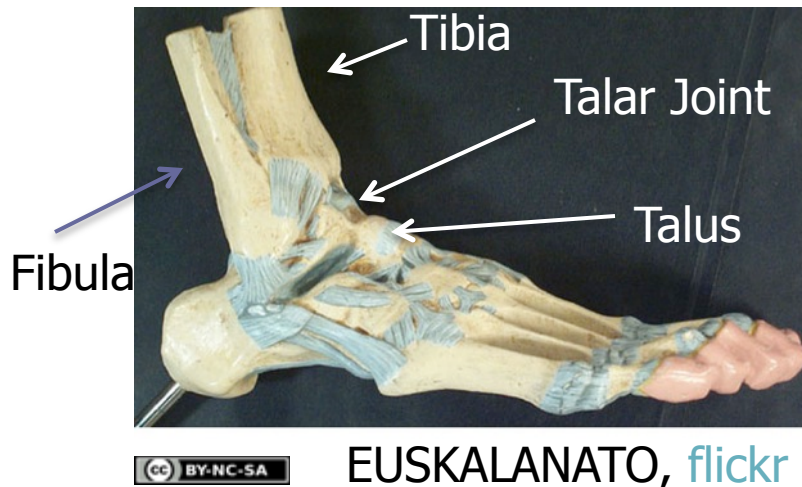
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# Tibial Femoral Knee Dislocation

- Longitudinal Reduction should be attempted immediately after documentation of neurovascular status
- Recheck of neurovascular status post reduction
- Arteriogram should be performed in any patient not immediately going to the OR if there is any concern of vascular injury
- Prompt vascular surgery involvement in a must

# Demonstration and Review

# Ankle Anatomy



- Bony anatomy
  - Calcaneus/talus (dome)
  - Tibia (medial malleolus)
  - Fibula (lateral malleolus)
- Composed of 2 joints:
  - True Ankle joint
  - Subtalar joint
- True ankle joint contains the tibia, fibula, and talus
- Allows for dorsiflexion and plantar flexion



# Ankle Anatomy

## Subtalar Function



eversion

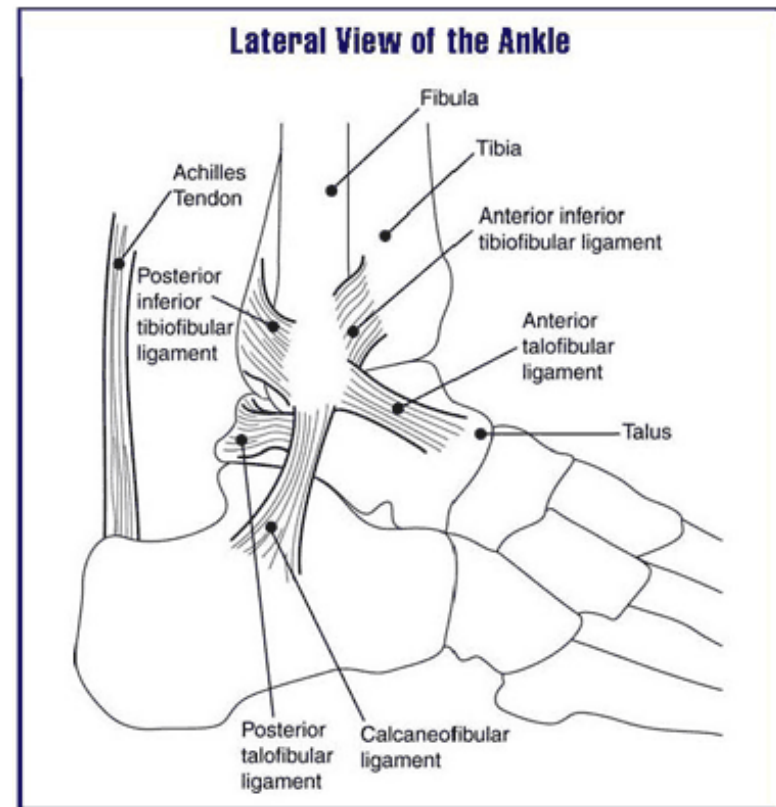


inversion

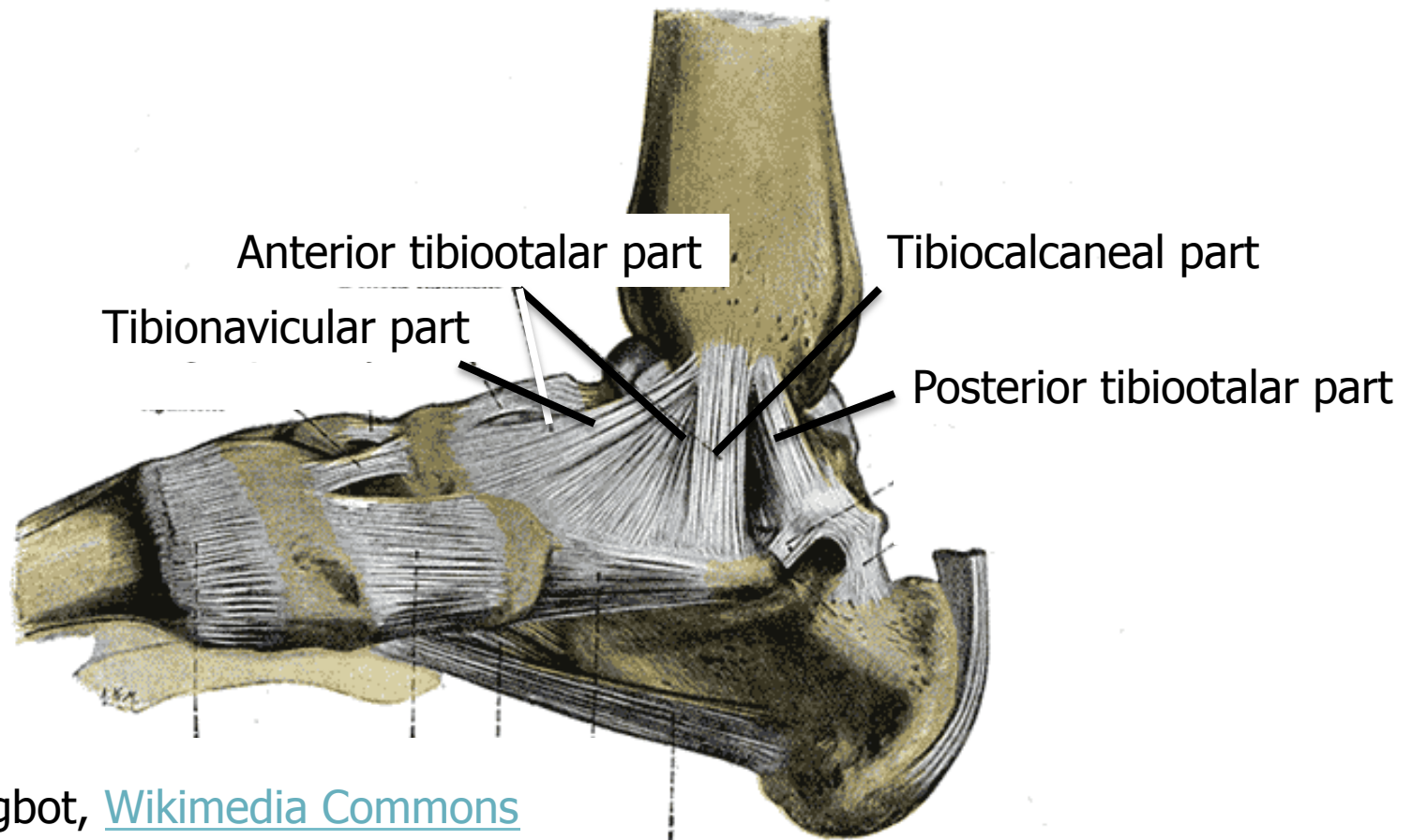
- Subtalar joint consists of the talus and the calcaneus
- Allows for inversion and eversion

# Ankle Lateral Ligaments

- Anterior talofibular
- Posterior talofibular
- Calcaneofibular
- Anterior tibiofibular
- Posterior tibiofibular



# Ankle Medial ligament (Deltoid)



# Ankle Ring



אנדר-ויק

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- Integrity of the ring necessary for stability of the ankle
- Consists of the following:
  - Tibial plafond,
  - Medial malleolus,
  - Deltoid ligaments,
  - Calcaneus,
  - Lateral collateral ligaments
  - Lateral malleolus
  - Syndesmotic ligaments

# Ankle Injuries

- Types of injuries
- Ankle sprain/Ligamentous injury
- Ankle fracture/Bony injury
- Joint Dislocation



Neeta Lind, [flickr](#)

# Ankle Injury Pathophysiology

- Excessive inversion stress (85%) is the most common cause of ankle injuries for two reasons:
  - Medial malleolus is shorter than the lateral malleolus, allowing the talus to invert more than evert.
  - Deltoid ligament stabilizing the medial aspect is stronger
- However, given the above when eversion injuries occur there is often substantial damage

# Ankle examination

- Look at the ankle for signs of deformity, redness, or swelling
- Feel for tender areas, systematically checking:
  - 1. the anterior joint line
  - 2. the lateral gutter and lateral ligaments
  - 3. the syndesmosis
  - 4. the posterior joint line
  - 5. the medial ligament complex
  - 6. the medial gutter
- Feel for an effusion, synovitis, deformity, bony prominence and loose bodies.
- Examine for neurovascular compromise



# Ankle Joint Testing

- Drawer and Talar tilt examination techniques are used to assess ankle instability
- Anterior talofibular ligament
  - Anterior drawer test
- Calcaneofibular ligament
  - (Talar Tilt) Inversion stress test
- Deltoid ligament
  - (Talar Tilt) Eversion stress test



Grook Da Oger,  
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- Use of these techniques in acute injuries can be limited by pain, edema, and muscle spasm



## Anterior Drawer Test



openmichigan, [YouTube](#)

## Talar Tilt Inversion Stress Test



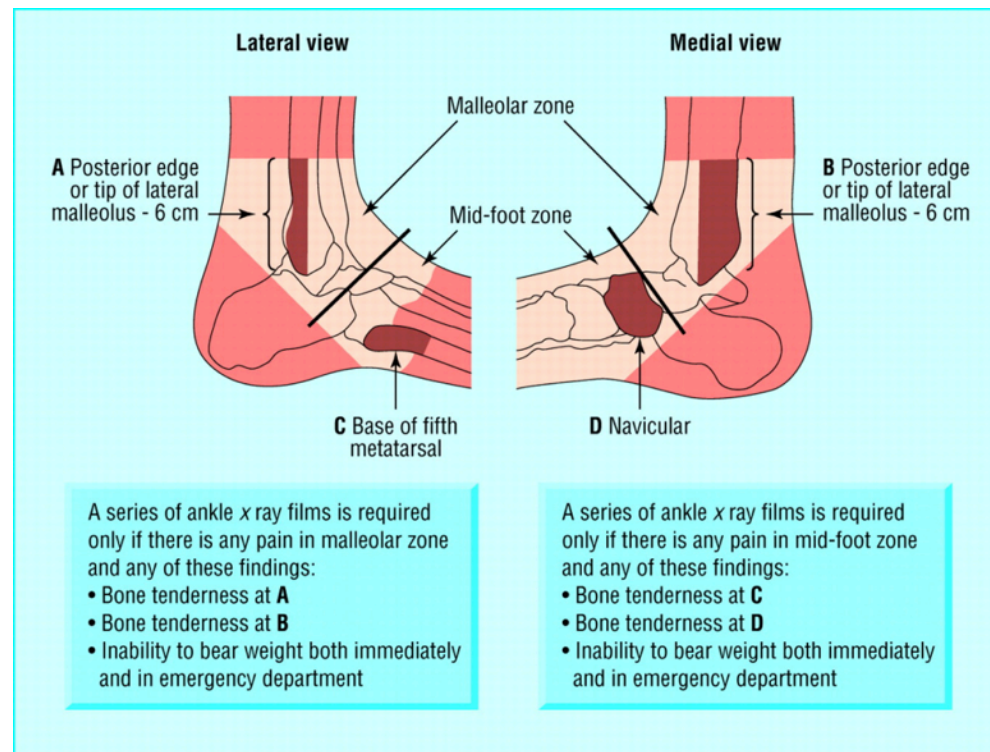
openmichigan, [YouTube](#)

# Ottawa Ankle/Foot Rules

- OK break into groups one more time and lets take 1 minute and list the criteria

# Ottawa Ankle Rules

- X-rays are only required if:
- There is any pain in the malleolar zone and:
- Bone tenderness along the distal 6 cm of the posterior edge of the tibia or tip of the medial malleolus
- Bone tenderness along the distal 6 cm of the posterior edge of the fibula or tip of the lateral malleolus
- An inability to bear weight both immediately and in the ED



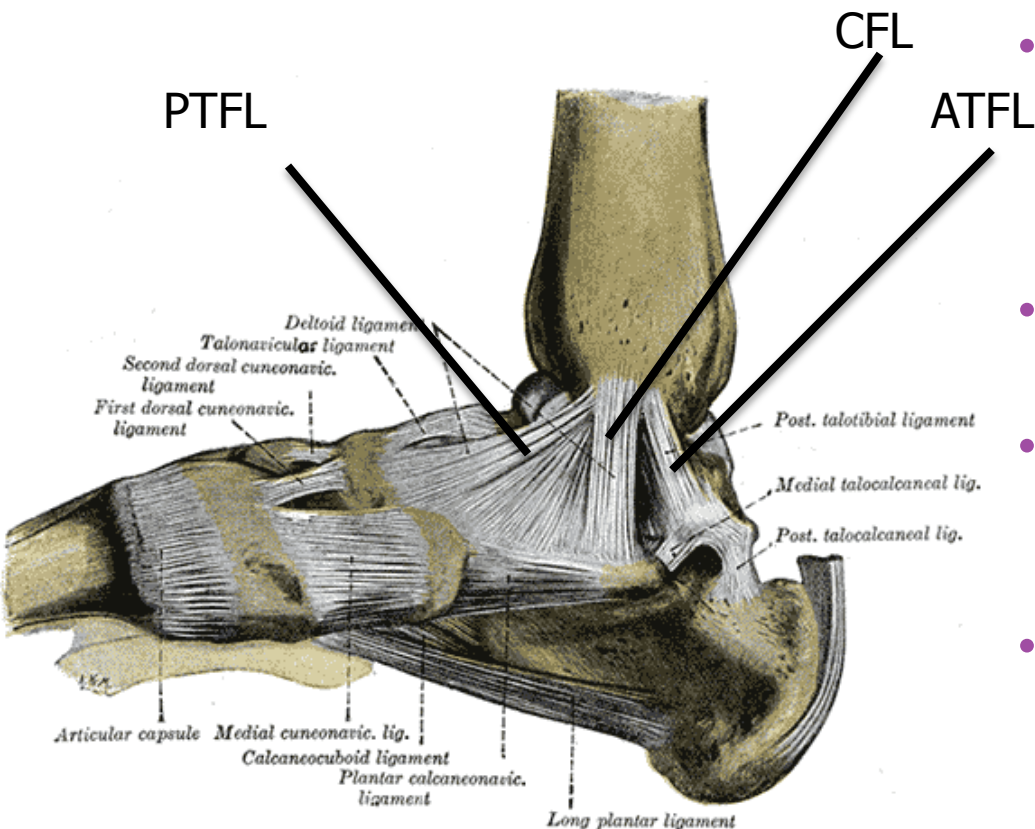
# Ottawa Ankle Rules: The Numbers

- In a meta-analysis the pooled negative likelihood ratios for the ankle and mid-foot were 0.08 (95% confidence interval 0.03 to 0.18) and 0.08 (0.03 to 0.20)
- Applying these ratios to a 15% prevalence of fracture gave a less than 1.4% probability of actual fracture
- Sensitivity of almost 100%
- Reduce the number of unnecessary radiographs by 30-40%

# Ankle Sprain Classification

- Grade 1: Ligament stretching with microscopic tearing but not macroscopic tearing.
  - Little swelling is present
  - Little or no functional loss and no joint instability
  - Able to fully or partially bear weight.
- Grade 2: Partial tear
  - Moderate-to-severe swelling, ecchymosis
  - Moderate functional loss, and mild-to-moderate joint instability
  - Difficulty bearing weight
- Grade 3: Complete rupture of the ligament
  - Immediate and severe swelling and ecchymosis
  - Moderate-to-severe instability of the joint
  - Cannot bear weight without experiencing severe pain.

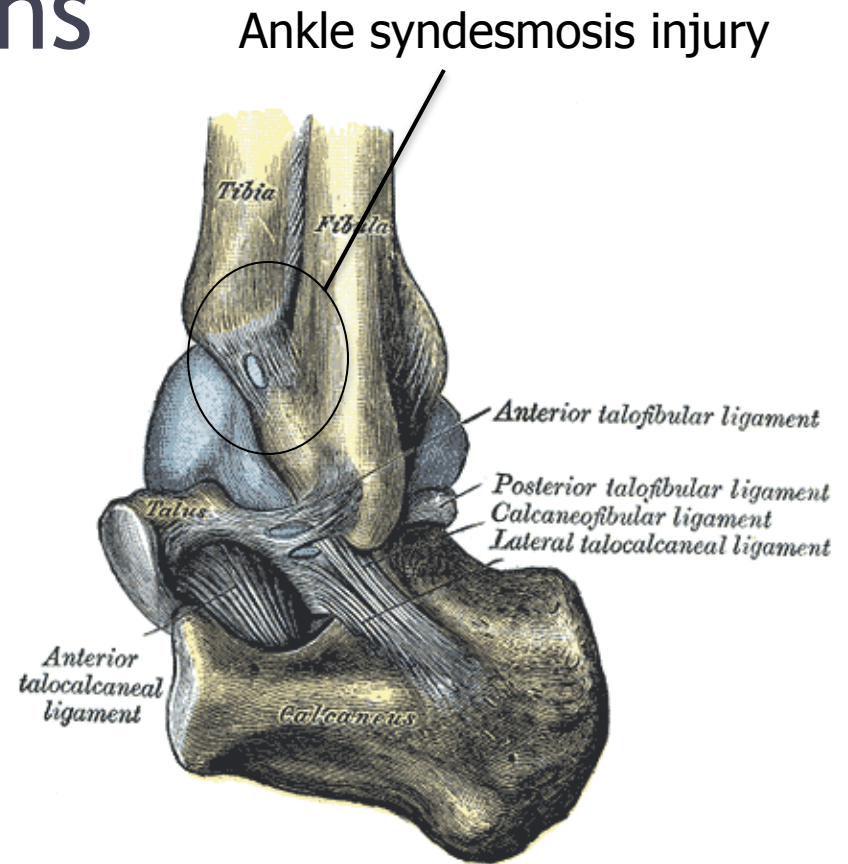
# Ankle Ligamentous Injury Types



- ATFL is the most likely component of the lateral ankle complex to be injured in a lateral ankle sprain
- In forced dorsiflexion, the PTFL can rupture
- External rotation can disrupt the deep deltoid ligament on the medial side
- Forced adduction in neutral and dorsiflexed positions can disrupt the Calcaneofibular (CFL)

# Syndesmosis Sprains

- Account 10% of all ankle sprains and as high as 18% of football players
- Excessive external rotation of the talus or forced dorsiflexion causes the talus to place pressure on the fibula
- Results in spreading of the distal syndesmosis as well as damage to anterior or posterior tibiofibular ligament





# Ankle Sprain Treatment

- **PRICES**

- Protection
  - Relative rest
  - Ice
  - Compression
  - Elevation
  - Support
- 
- Good return instructions also a must as always

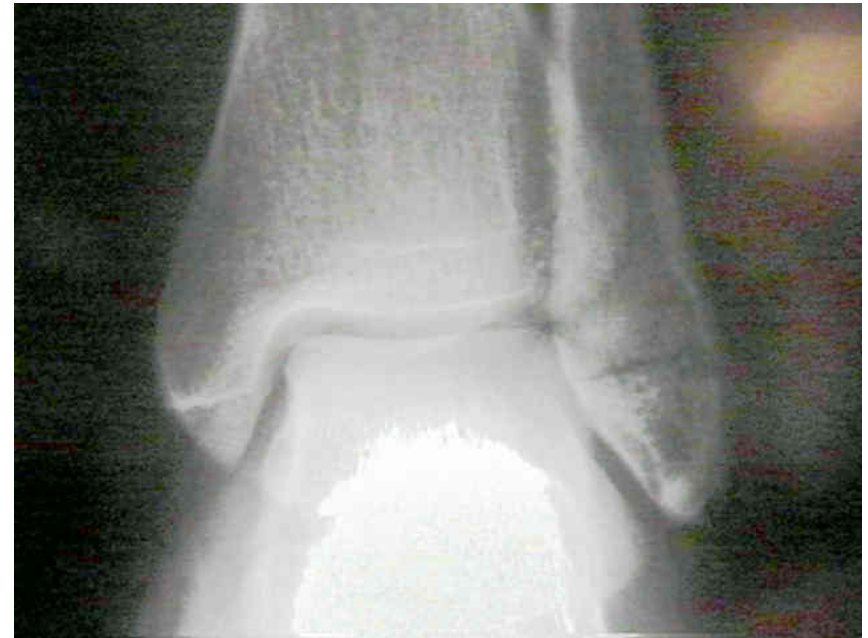


# Ankle Sprain Prognosis

- Most report full recovery at 2 weeks to 36 months (36-85%)
  - Independent of the initial grade of sprain
  - Most recovery occurs within the first 6 months
- After 12 months, the risk of recurrent ankle sprain returns to pre-injury levels
- Re-sprains occur in up to 36% of patients, athletes are at increased risk

# Isolated Malleolar Fracture (Unimalleolar)

- ED Docs describe based off number fractures
  - unimalleolar, bimalleolar, trimalleolar
- Distal fibula or less common tibial fracture
- Fractures below the Tibiotalar line (T-t, distal to the tibial plafond) are usually stable



<http://www.wheelsonline.com/image7/ank120.jpg>

# Bimalleolar fracture

- Involves the lateral and medial malleolus
  - ED Treatment involves fracture reduction and realignment
  - Initial ED management is usually followed by surgical fixation
  - Ortho consult in ED
- Source Undetermined



# Trimalleolar Fracture



- Involves the lateral malleolus, medial malleolus, and the distal posterior aspect of the tibia
- Unstable, loss of lateral control
- Surgical repair is required
- Ortho consult in ED

# Ankle Fracture Classifications

- Danis-Weber classification often used by Ortho
  - Some correlation with need for operative stabilization
  - Lauge-Hansen alternative classification system
- Type A: Transverse fibular avulsion fracture, occasionally with an oblique fracture of the medial malleolus
  - From internal rotation and adduction
  - Usually stable fractures
- Type B: Oblique fracture of the lateral malleolus with or without rupture of the tibiofibular syndesmosis and medial injury
  - From external rotation
  - May be unstable
- Type C High fibular fracture with rupture of the tibiofibular ligament and transverse avulsion fracture of the medial malleolus
  - From adduction or abduction with external rotation
  - Usually unstable and require operative repair

# Pilon Fracture



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- Fracture of the distal tibial metaphysis combined with disruption of the talar dome.
- Result of an axial loading mechanism drives the talus into the tibial plafond
  - Foot braced against a floorboard in an auto collision.
  - Skiers coming to an unexpected sudden stop
  - Free fall from heights
- Fractures often open and can be associated with lumbar spine injuries

# Maisonneuve fracture

- Proximal fibular fracture coexisting with a medial malleolar fracture or disruption of the deltoid ligament
- Associated with partial or complete disruption of the syndesmosis
- Important to perform a physical exam or xrays to assess for this in ankle injuries



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<http://www.wheelessonline.com/image7/mason1.jpg>

# Tillaux fracture



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- Salter-Harris (SH) type III injury of the anterolateral tibial epiphysis
- Caused by extreme eversion and lateral rotation
- Incidence is highest in adolescents because the fracture occurs after the medial aspect of the epiphyseal plate closes but before the lateral

<http://emedicine.medscape.com/article/824224-clinical#showall>



# Ankle Dislocation

- Associated fractures are the rule rather than the exception with ankle dislocations
- Neurovascular injury is the principal concern
- Tented skin may be subject to ischemic necrosis
- Immediate reduction in the ED is often required



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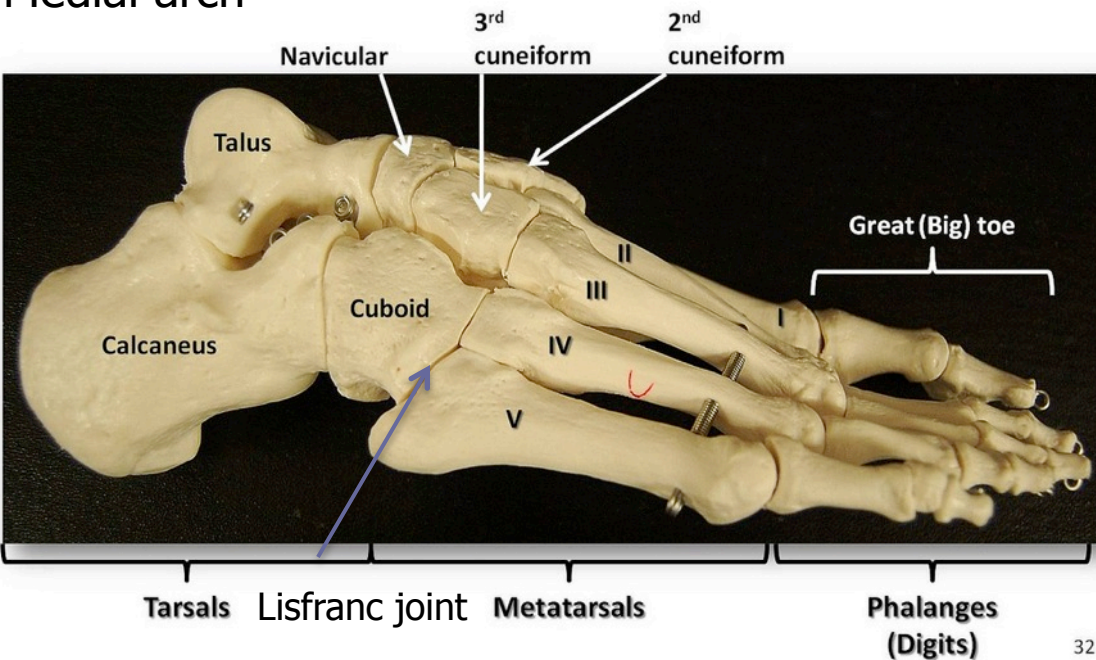
# Demonstration and Review

# Foot Anatomy

## Foot & ankle.

Right medial view

### Medial arch

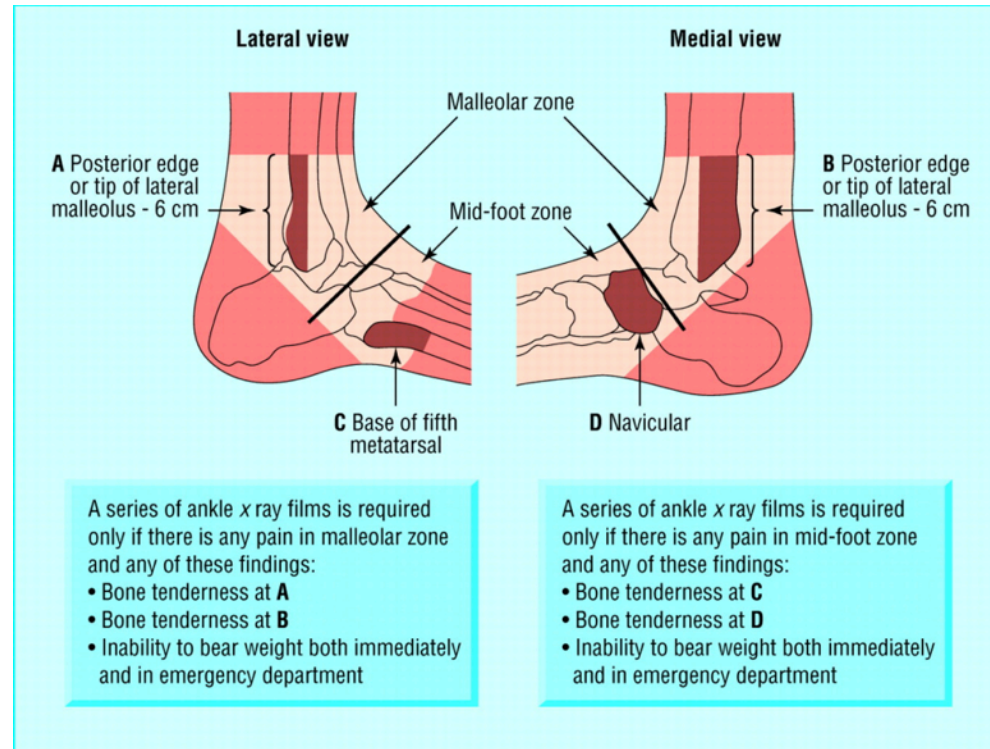


- Phalanges
  - proximal, middle, distal
- Metatarsals
- Tarsals
  - Calcaneus
  - Talus
  - Navicular
  - Cuboid
  - Cuneiforms
- Medial/lateral longitudinal and transverse metatarsal arches

### Lateral arch

# Ottawa Foot Rules

- X-ray series is indicated if there is any pain in the midfoot zone and any one of the following:
- Bone tenderness at the base of the fifth metatarsal (for foot injuries)
- Bone tenderness at the navicular bone (for foot injuries)
- An inability to bear weight both immediately and in the emergency department for four steps.



# Foot Injuries

- Toe Injuries
- Metatarsal fracture
- Jones' fracture
- Lisfranc fracture
- Navicular fracture
- Calcaneal fracture

# Toe fractures

- Buddy tape the broken toe to an adjacent, uninjured toe
- Apply a rigid flat-bottom orthopedic shoe
- Union of fracture segments occurs in 3-8 weeks
- Symptoms usually improve much earlier
- Irreducible fractures sometimes require open reduction and internal fixation



Buddy-taped toes

spaceninja,[flickr](#)

# First metatarsal fracture



- Least commonly fractured metatarsal
- Bears twice the weight of other metatarsal heads.
- Treat minimally displaced or nondisplaced fractures with immobilization without weight bearing
- Displaced fractures usually require open reduction and internal fixation

[http://www.mdmercy.com/footandankle/conditions/trauma/fractures\\_metatarsals.html](http://www.mdmercy.com/footandankle/conditions/trauma/fractures_metatarsals.html)

# Internal metatarsal fracture

- Nondisplaced and displaced fractures usually heal well, with weight bearing as tolerated, in a cast or rigid flat-bottom orthopedic shoe.
- Elastic support bandages may be equivalent or superior to casts
- Must look for Lisfranc Injury as this is a game changer
- March fracture is a stress fracture of the second or third metatarsal that occurs in joggers.



# Jones' fracture

- Transverse fracture of the 5<sup>th</sup> metatarsal
- Must be at least 15 mm distal to proximal end
- High rate of malunion
- As above contact Ortho
- Pseudo-Jones: avulsion fracture of tuberosity at 5<sup>th</sup> metatarsal



# Lisfranc fracture

- Site of articulation between the midfoot and forefoot
- Dislocation at the TMT joint
- Result of direct blow to the joint or by axial loading along the metatarsal, either with medially or laterally directed rotational forces
- Fracture at the base of second metatarsal should raise concern for this type of injury
- Often need weight bearing films to see displacement



# Lisfranc fracture: Xrays



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<http://www.aafp.org/afp/980700ap/burrough.html>

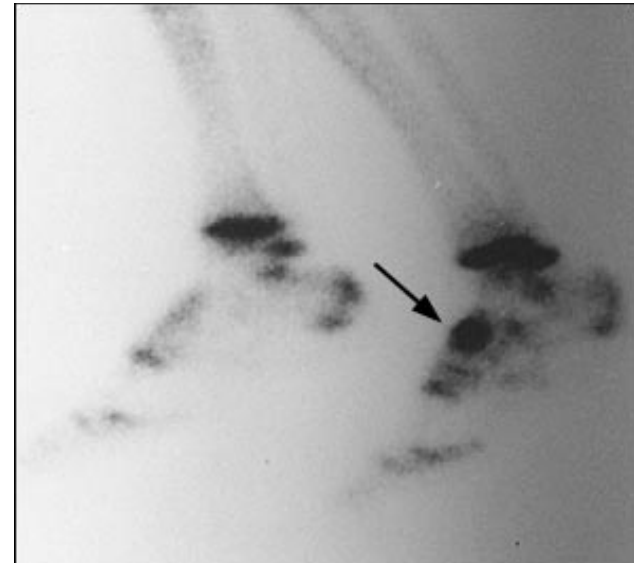


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<http://www.aafp.org/afp/980700ap/burrough.html>

# Navicular Fracture

- Avulsion fracture most common
- Type 1: coronal fracture with no dislocation
- Type 2: dorsolateral to plantomedial fracture with medial forefoot displacement
- Type 3: comminuted fracture with lateral forefoot displacement
- Most patients are placed in a non-weight-bearing cast for 6 weeks
- All navicular body fractures with 1 mm or more of displacement require open reduction and internal fixation.



# Calcaneal fracture-Bohler's angle



Thomas Steiner,  
[Wikimedia Commons](#)

- Calcaneus fractures most often occur in males 5:1
- Peak age: between 30 and 50 years.
- Associated injuries (Lumbar spine vertebral compression fractures)
- Treatment: Operative vs Casting
- Ortho Consult

# When to call Ortho for foot injuries

- Talus fractures
- Calcaneus fractures
- Navicular fractures, especially if intraarticular
- Cuboid fractures
- Lisfranc injuries
- Metatarsal shaft fractures with > 3 mm displacement or 10 degrees angulation
- Metatarsal head and neck fractures
- Jones fractures



Questions?

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