Lower extremity - Ankle and foot

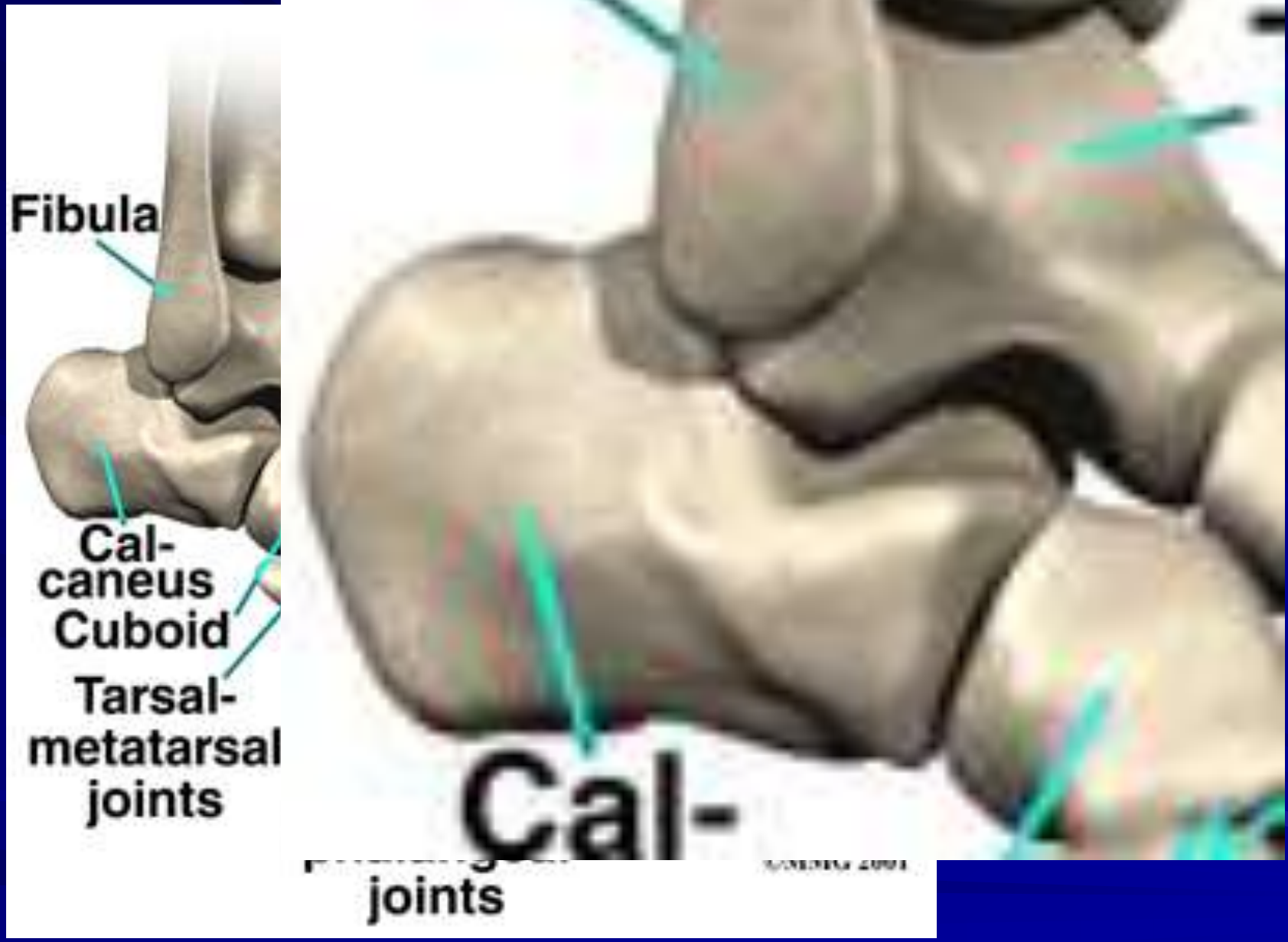
Department of Radiology
UCSD

UCSD

Foot and Ankle

- Anatomy

- Pathology



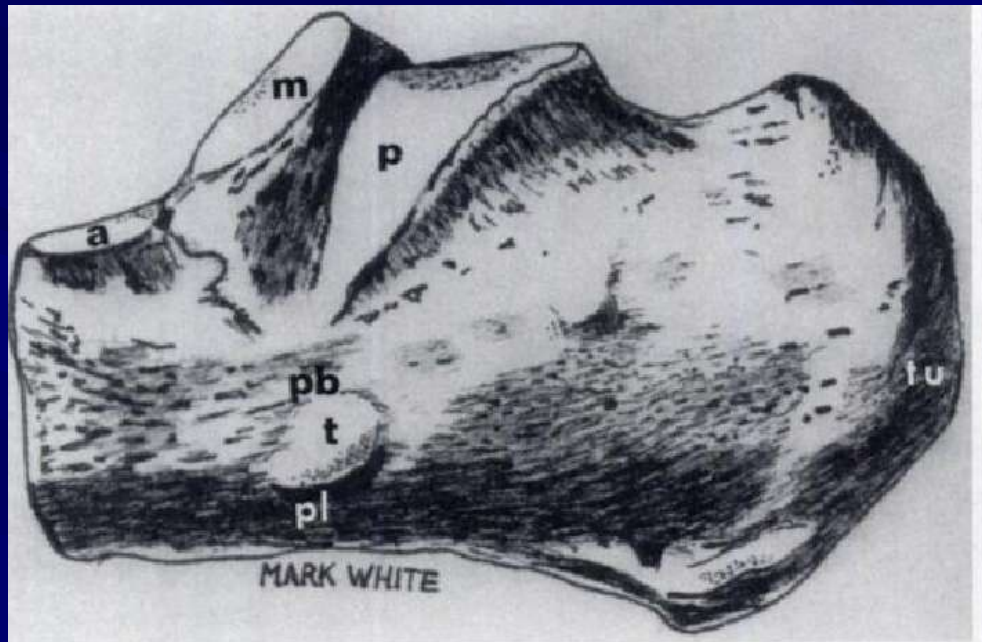
Ref: sika.ecolad.com

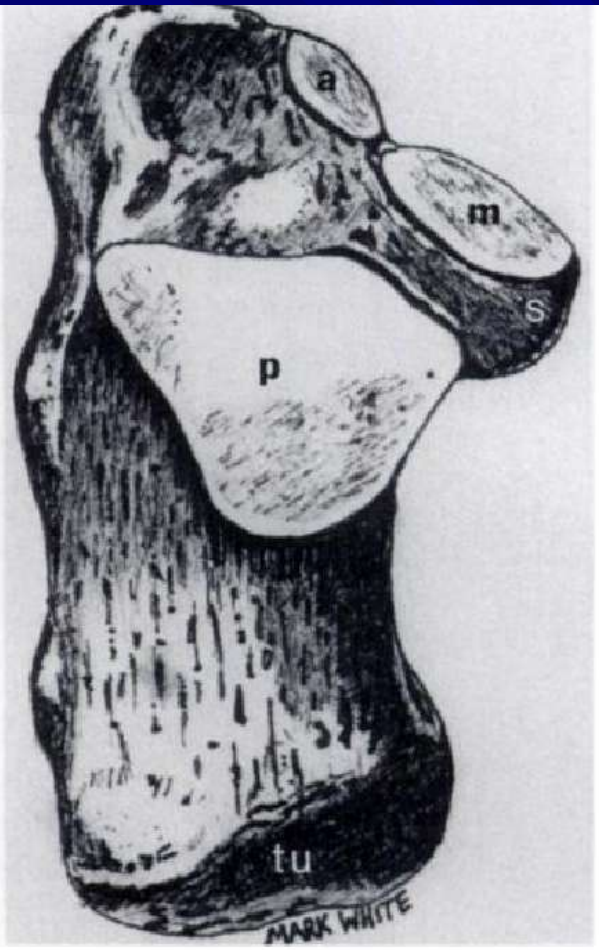
OBJECTIVES

- Review the osseous anatomy, major normal variants, and clinically important contours of the calcaneus and talus
- Review traumatic pathology of the calcaneus and talus with an emphasis on pathomechanics and accurate description

Sonography-Embryonic hindfoot

Anatomy- Calcaneal articular surfaces

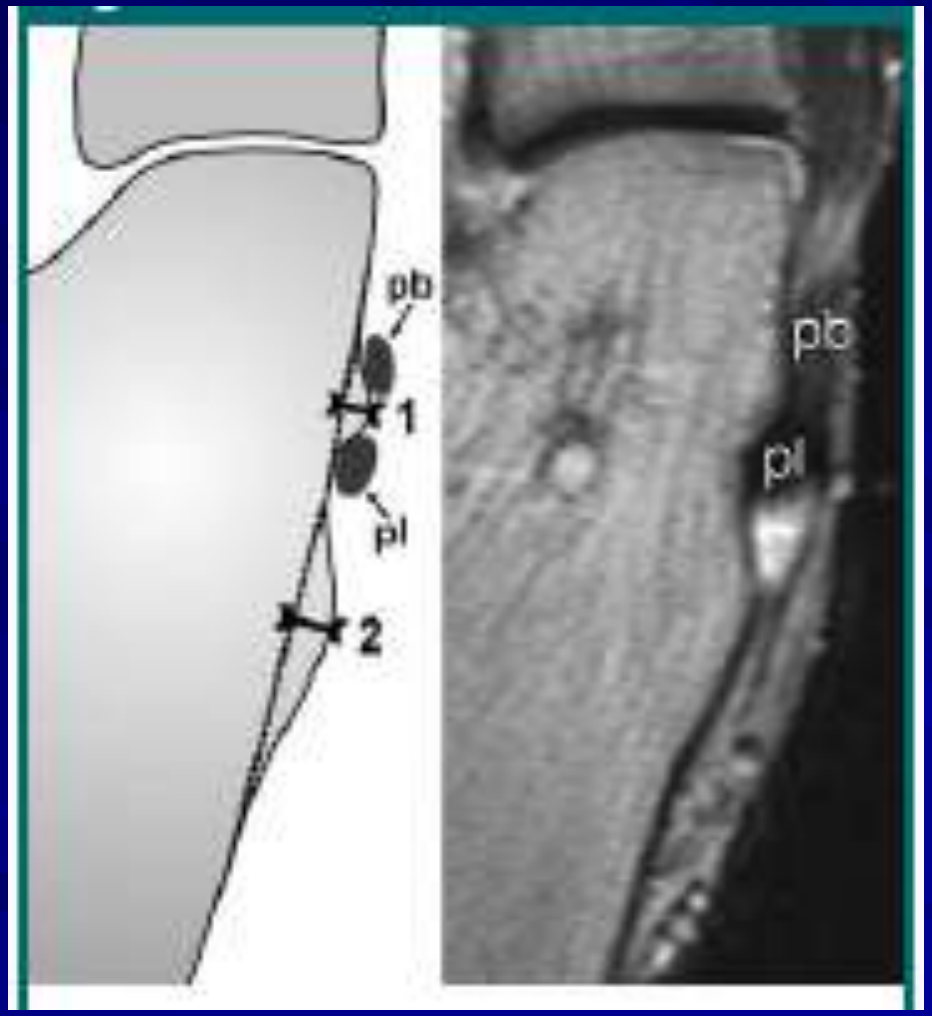




a.

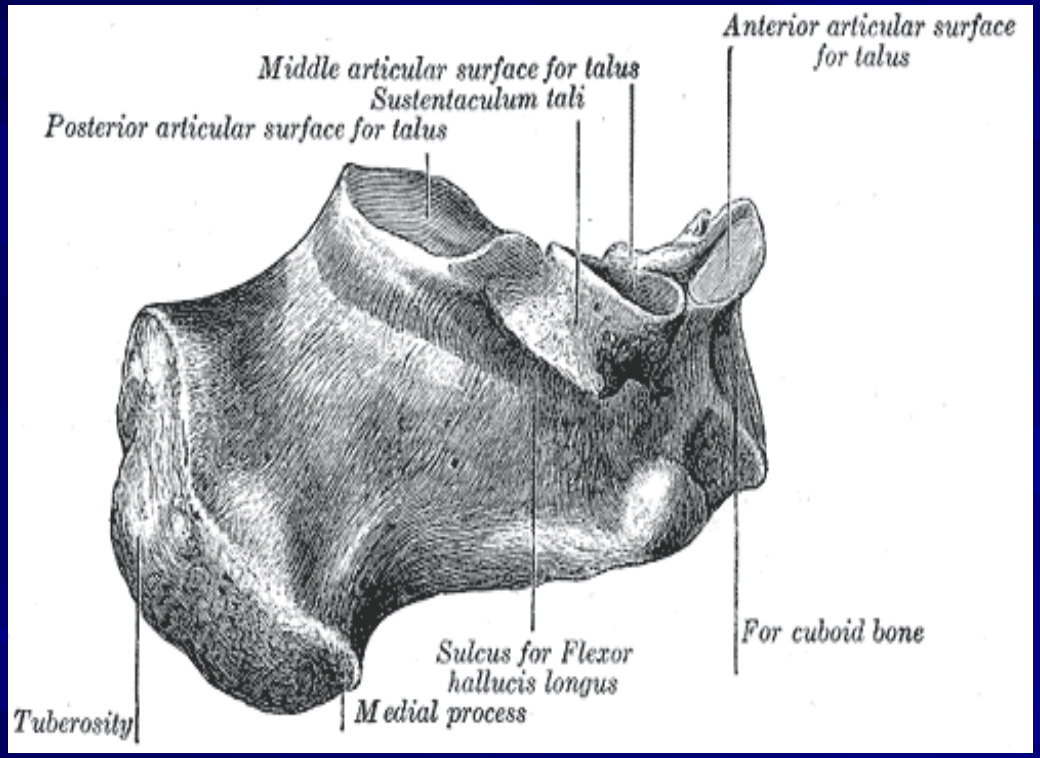
Figure 1. Drawings of the calcaneus. **(a)** Lateral surface. **(b)** Superior surface. *a* = anterior articular facet, *m* = medial articular facet, *p* = posterior articular facet, *pb* = groove for peroneus brevis, *pl* = groove for peroneus longus, *s* = sustentaculum tali, *t* = tubercle (trochlear process), *tu* = tuberosity.

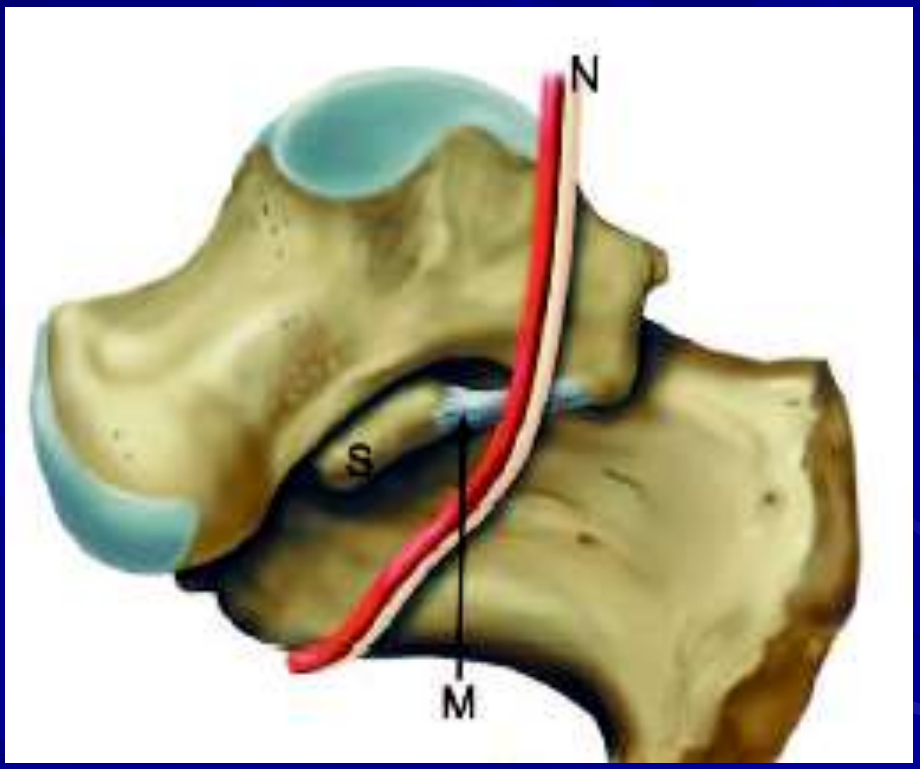
Anatomy- Lateral Contours Calcaneus



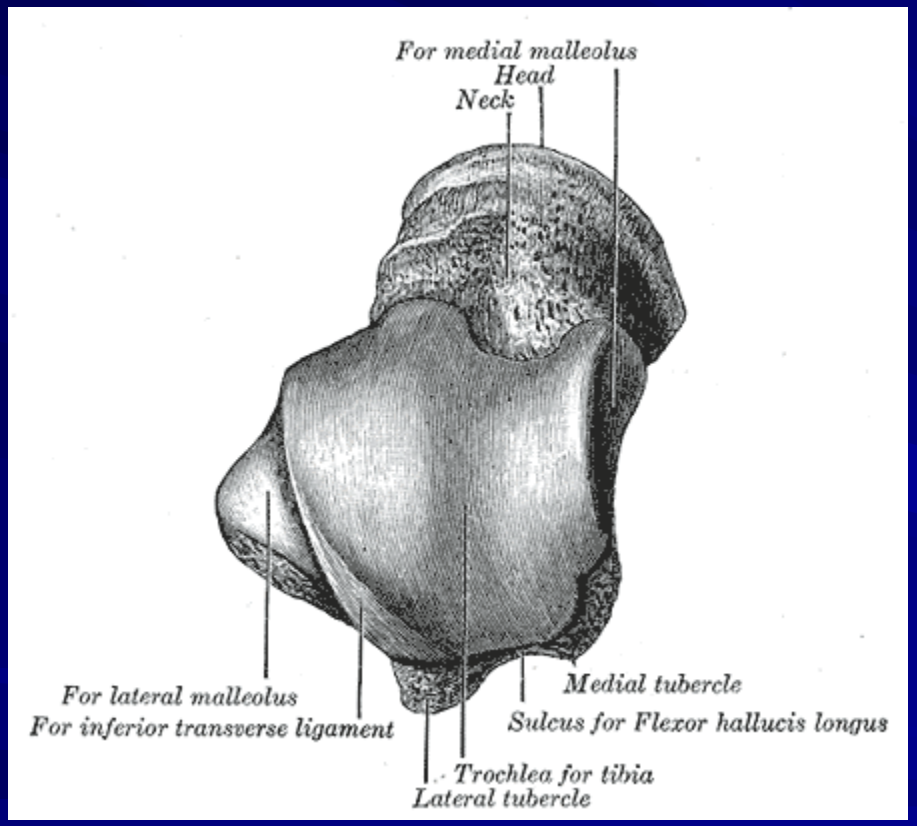
Saute et al. Radiology 242(2):509-517 Feb. 2007

Medial Surface Calcaneus

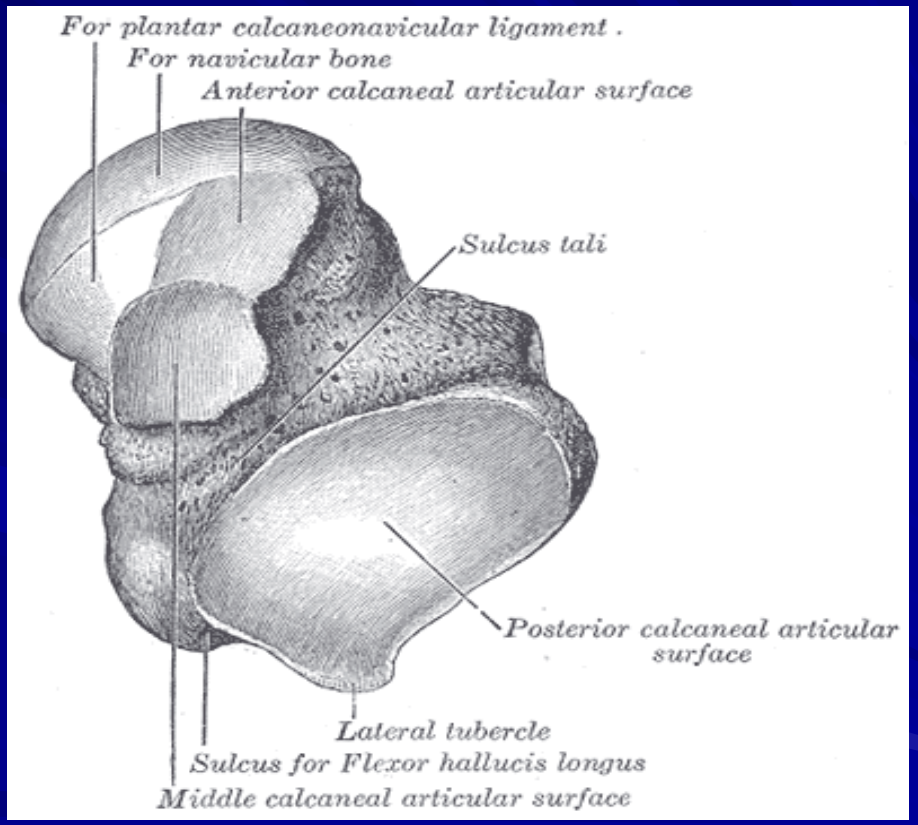




Normal anatomy- Talus

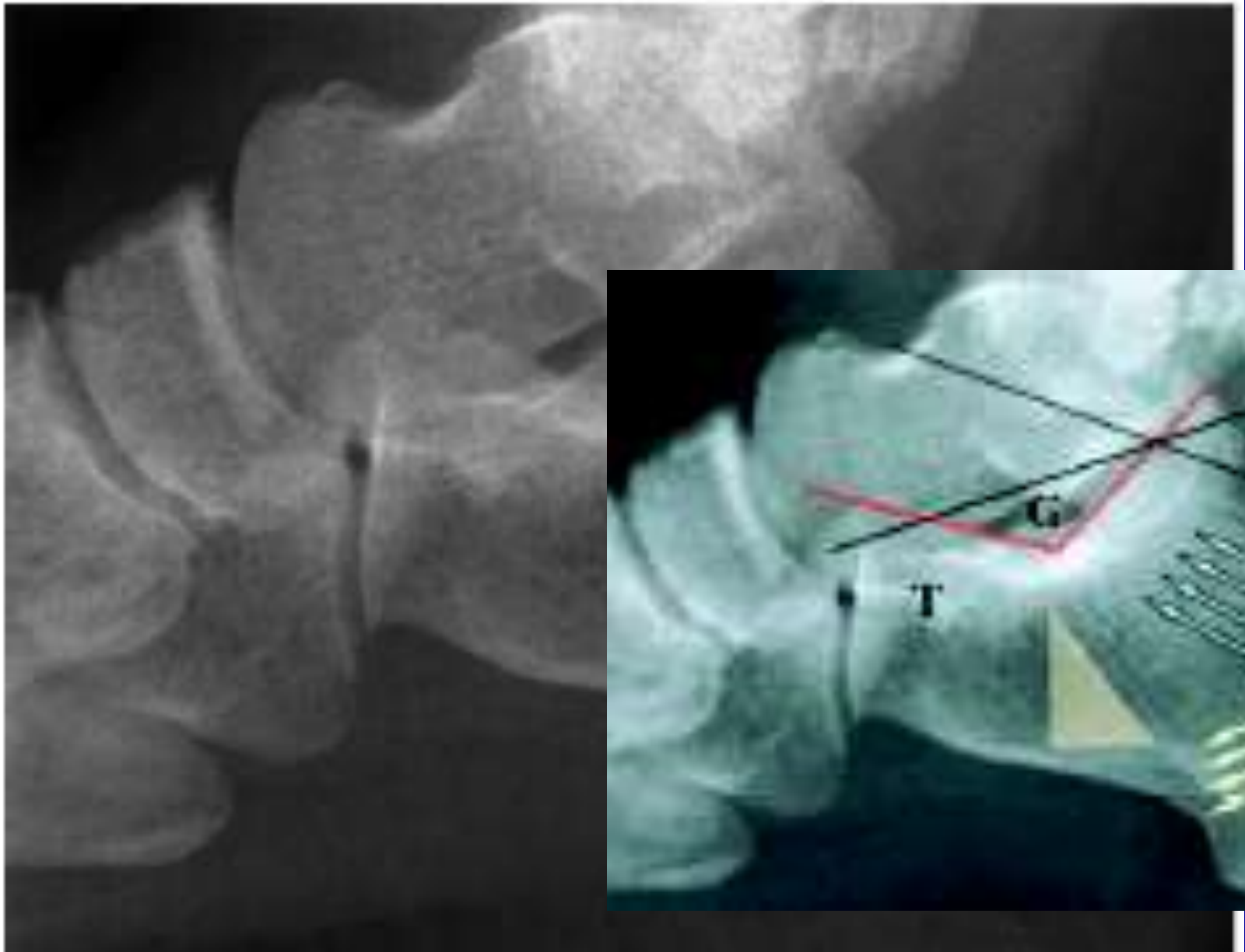


From above

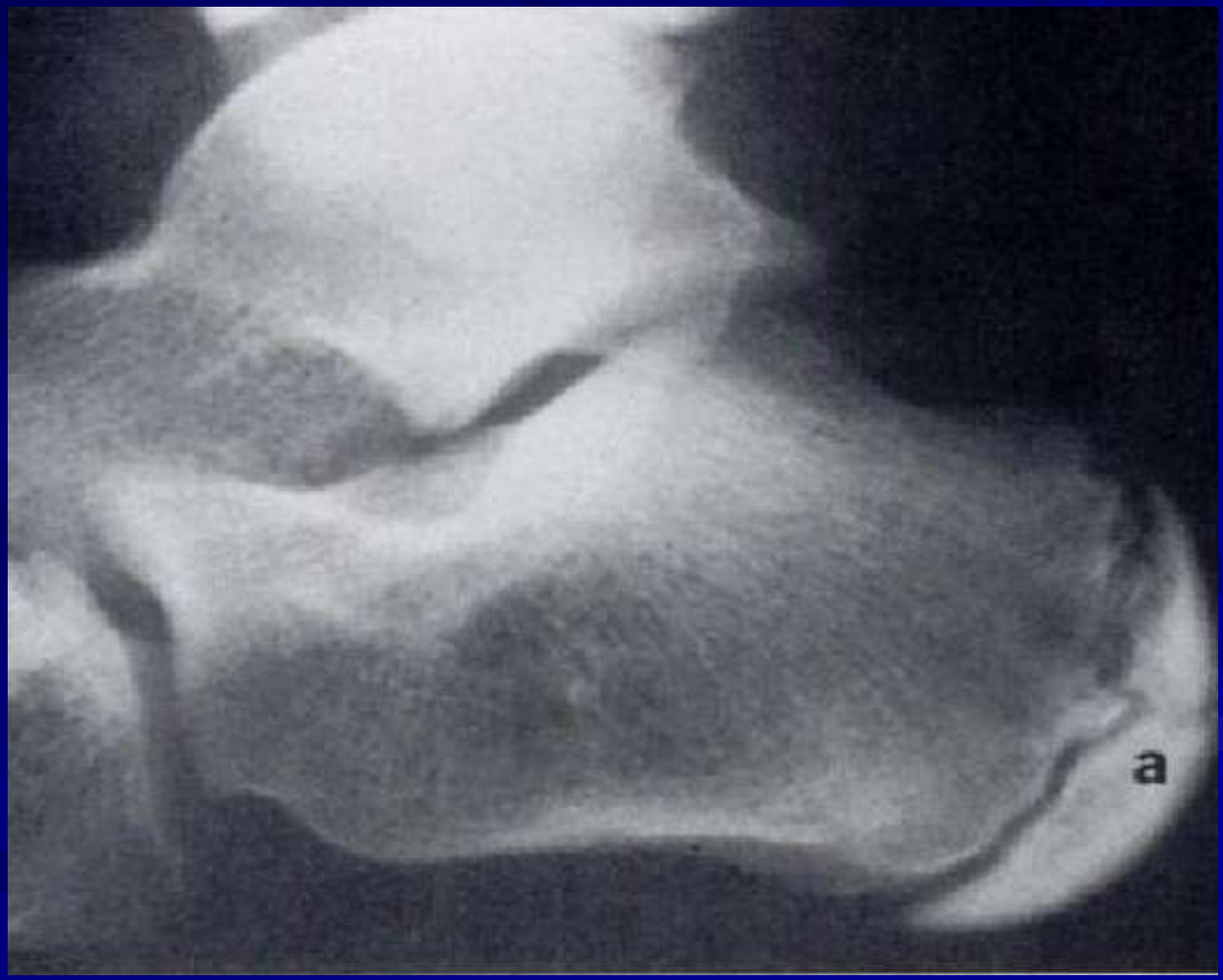


From below

Radiographs



Normal Variation



Calcaneal apophysis- fuses at age 12-15 in both sexes

Transient Calcaneal Spur

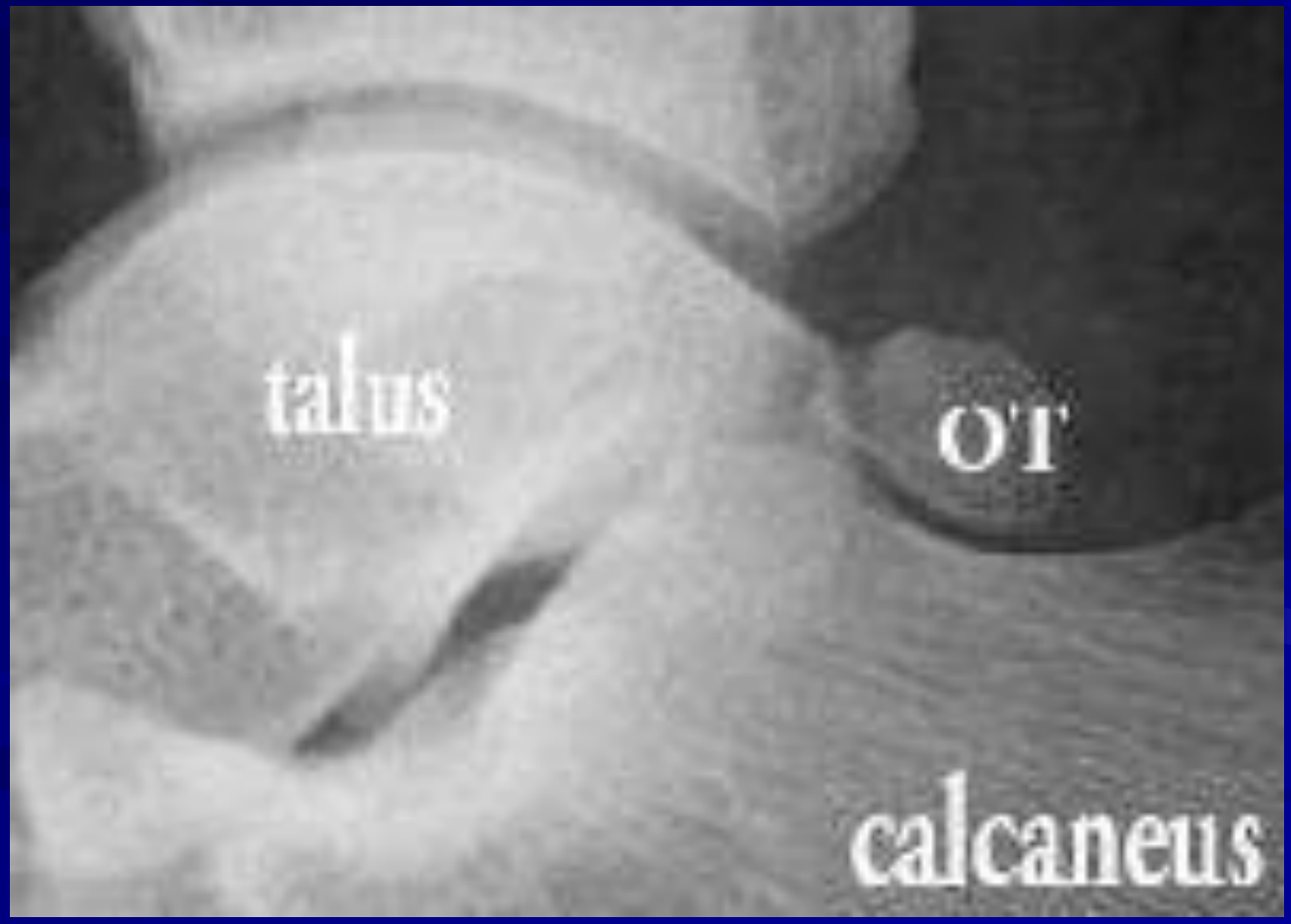
Disappears by age 1!

Normal Variant- Pseudocyst

Prominent Vascular Remnant

AJR:185, December 2005

Os Trigonum



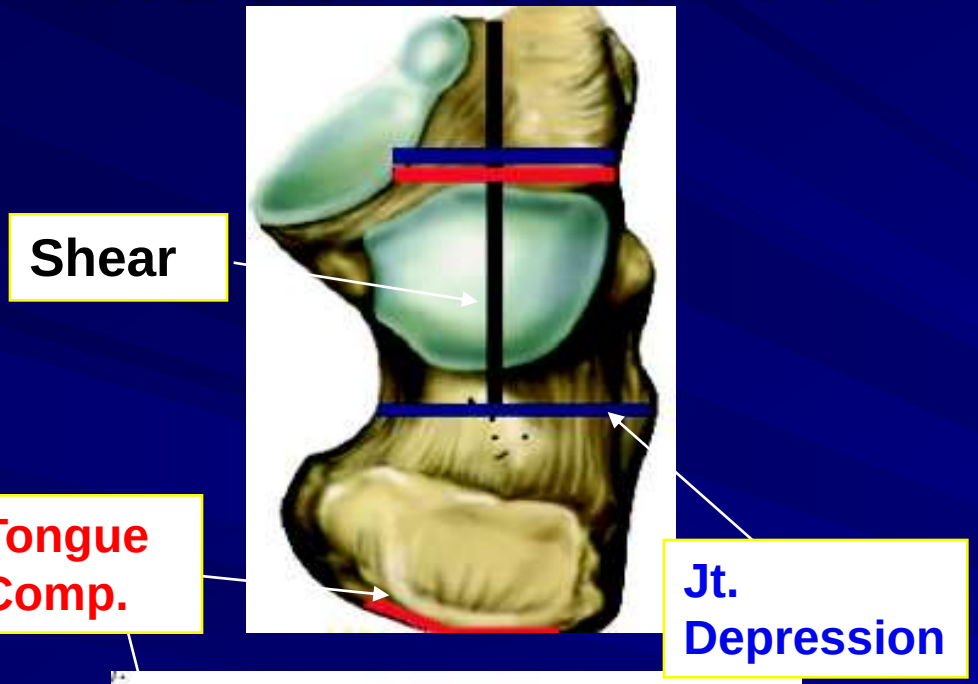
Os Supratalare- ?Normal Variant

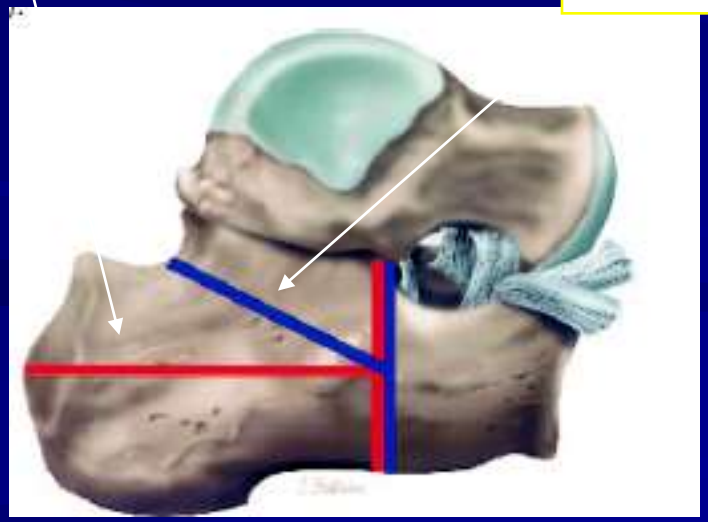
Trauma

Calcaneus Fractures

- Most common tarsal fracture
- Accounts for 2% of all fractures
- 70-75% Intraarticular
- 20-25% Extrarticular
- Historically poor prognosis
- No consensus on management due to lack of standard, unified classification system and understanding of fracture pathoanatomy
- High variability in fracture pattern based on magnitude and direction of impacting force, foot position, muscle tone, and bone mineralization

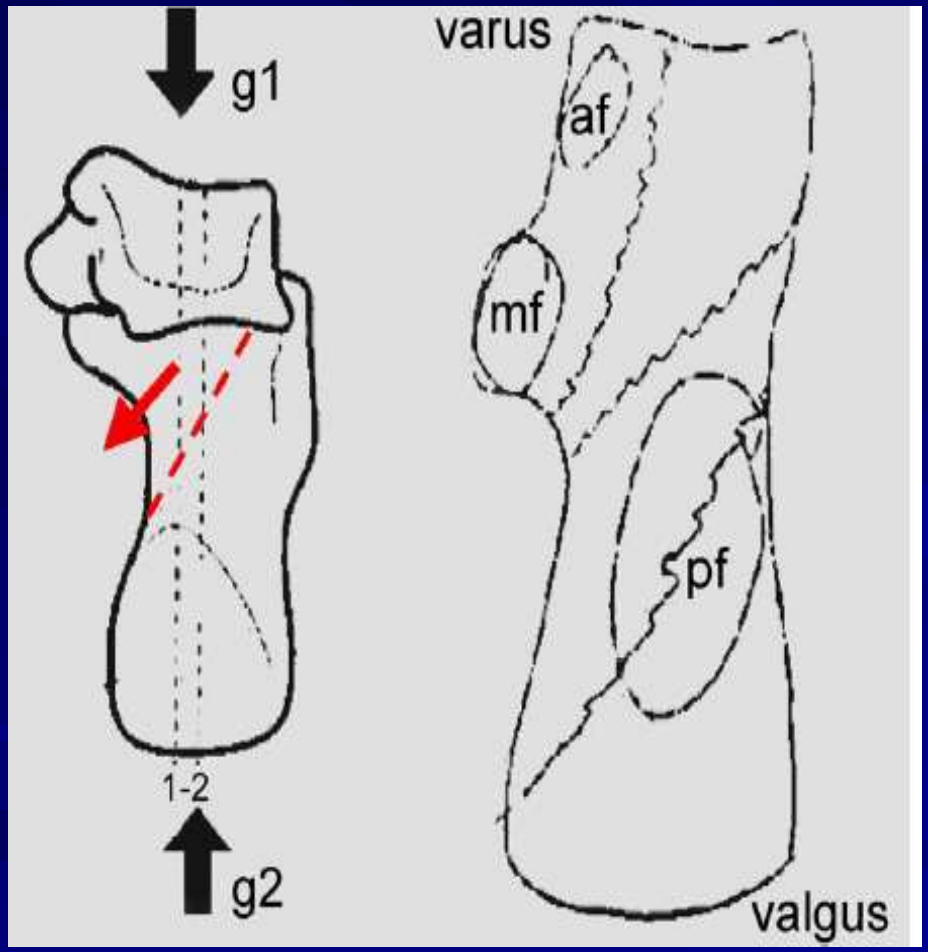
Intraarticular Fx-Pathomechanics





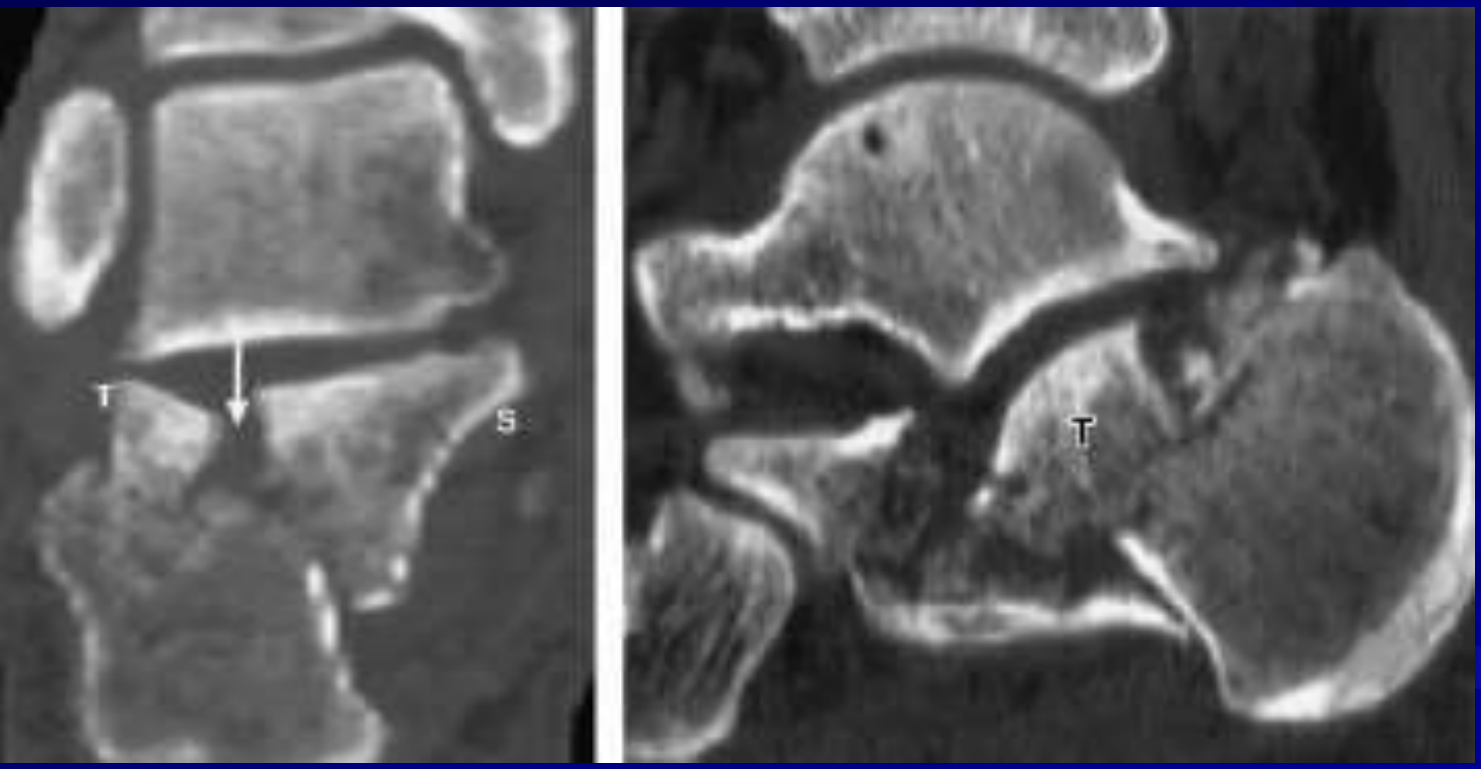
- Axial loading mechanism results in typical pattern of the primary shear (sagittal) and secondary compression (coronal) type fracture lines
- Sagittal fracture (parallel to long axis of the calcaneus) - occurs due to wedge force of the talus on calcaneus
- If energy of impact is not expended completely, compression or secondary fracture lines may occur and may result in a “tongue” type or “joint depression” type fracture

Pathoanatomy

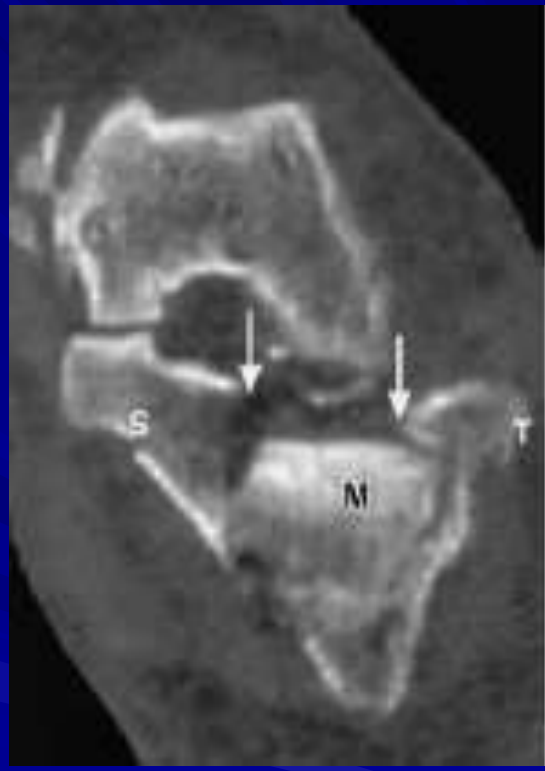


- Diverging axis of the calcaneus and talus results in shear separation of the sustenatacular and tuberosity portions
- Hindfoot varus- medial fx line
- Hindfoot valgus-lateral fx line

Calcaneus Fracture- Shear Force



Shear- Typical Split



Shear- Unusual Double Split

Calcaneus Fractures

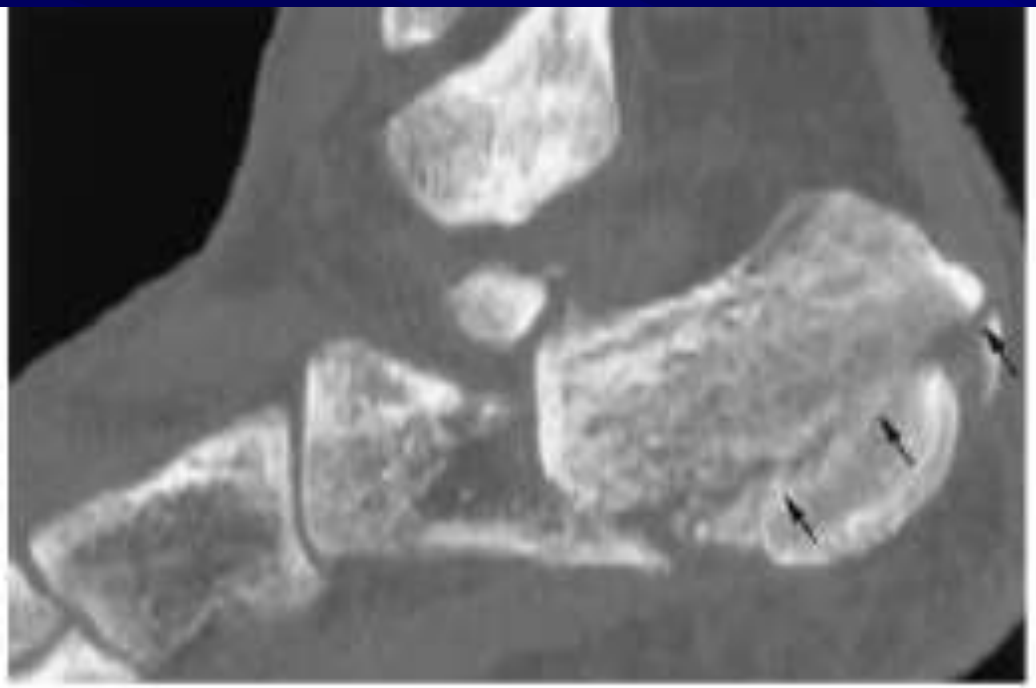
- Marked rotation of mobile posterolateral tuberosity fragment resulting in marked widening of the calcaneuss

Calcaneus Fractures- Compression

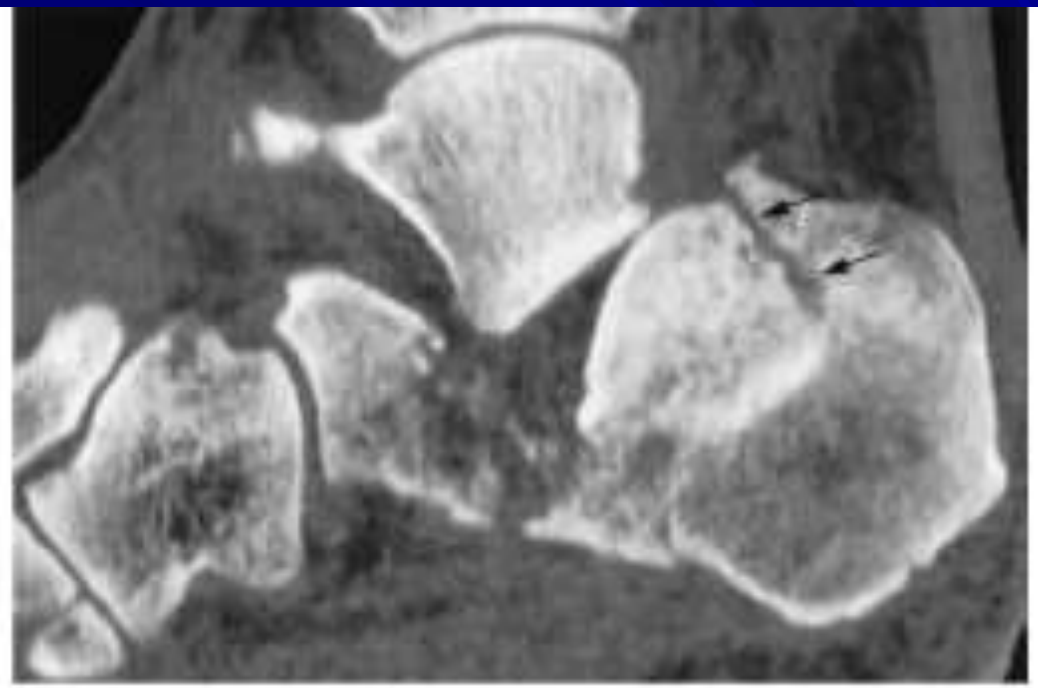
Tongue Type Fracture

Intraarticular depressed

CT Appearance



Tongue type



Intraarticular Depressed

Classification

Schmidt-Weiner Classification of Calcaneal Fractures and Their Prevalence

Type	Description	Prevalence (%)
1A*†	Fracture of calcaneal apophysis	6
1B*	Sustentaculum tali fracture (intraarticular)	3
1C*	Anterior process fracture (intraarticular)	15
1D*	Inferolateral fracture (intraarticular)	1
1E*	Avulsion fracture	
2A‡	Beak fracture	4
2B‡	Achilles tendon avulsion	
3§	Linear extraarticular fracture	19
4§	Linear intraarticular fracture	10–25
5A§	Tongue-type fracture	5
5B§	Joint depression or comminuted fracture	40–60
6‖	Posterior calcaneal fracture including tuberosity and Achilles tendon with extensive soft-tissue damage	<1

Source.—Reference 11.

* Caused by avulsion or twisting injury and usually has a benign course.

† Occurs in children.

‡ Caused by direct trauma.

§ Usually occurs following a fall from heights.

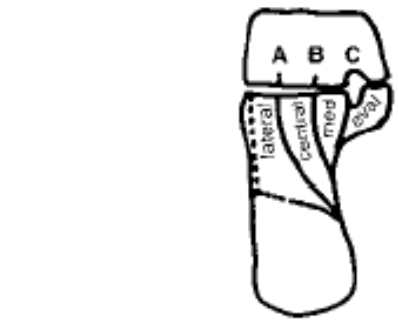
‖ Usually seen in victims of lawn-mower accidents, especially children.

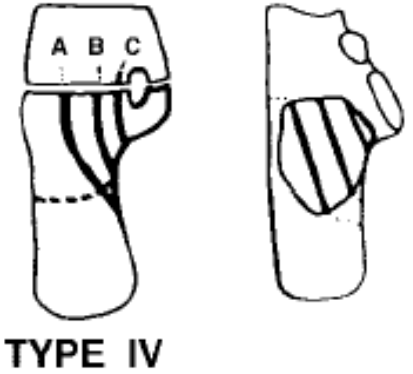
Classification

Modified Essex-Loprestie Classification of Calcaneal Fractures

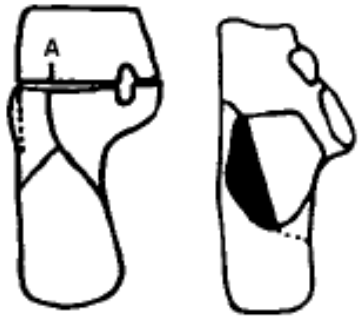
- Extraarticular fractures
  - Calcaneal tuberosity fractures
    - Beak type
    - Vertical
    - Horizontal
    - Medial avulsion
  - Intraarticular fractures
    - Subtalar joint involvement
      - Undisplaced
      - Displaced
      - Comminuted
    - Calcaneocuboid joint involvement

SANDERS CLASSIFICATION (CT)

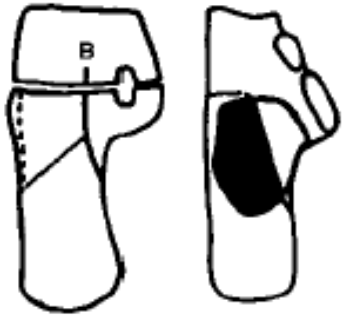




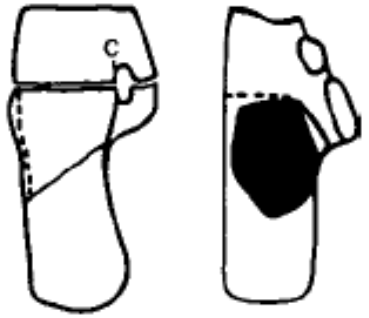
TYPE IV



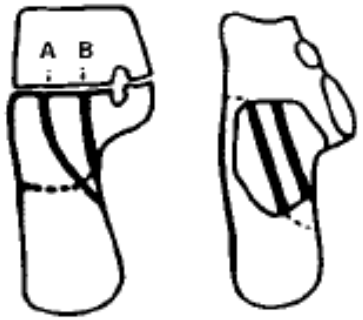
TYPE IIA



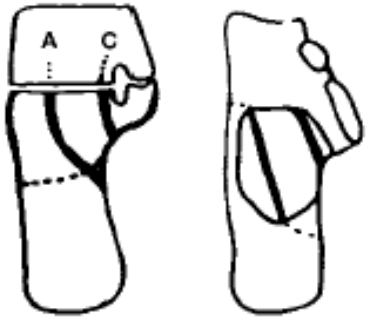
TYPE IIB



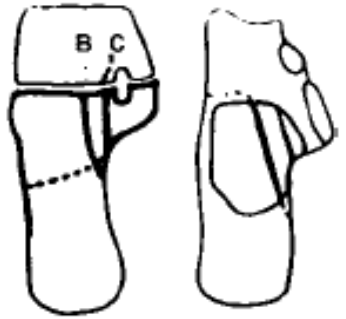
TYPE IIC



III AB



III AC



III BC

Sanders Classification

- Most useful system for intraarticular fracture classification
- Improved interobserver variability
- Has both clinical and prognostic implications
- Type 1: Excellent results with conservative management
- Type 2 and 3: Excellent results with surgical management
- Type 4: Poor results with surgical managment

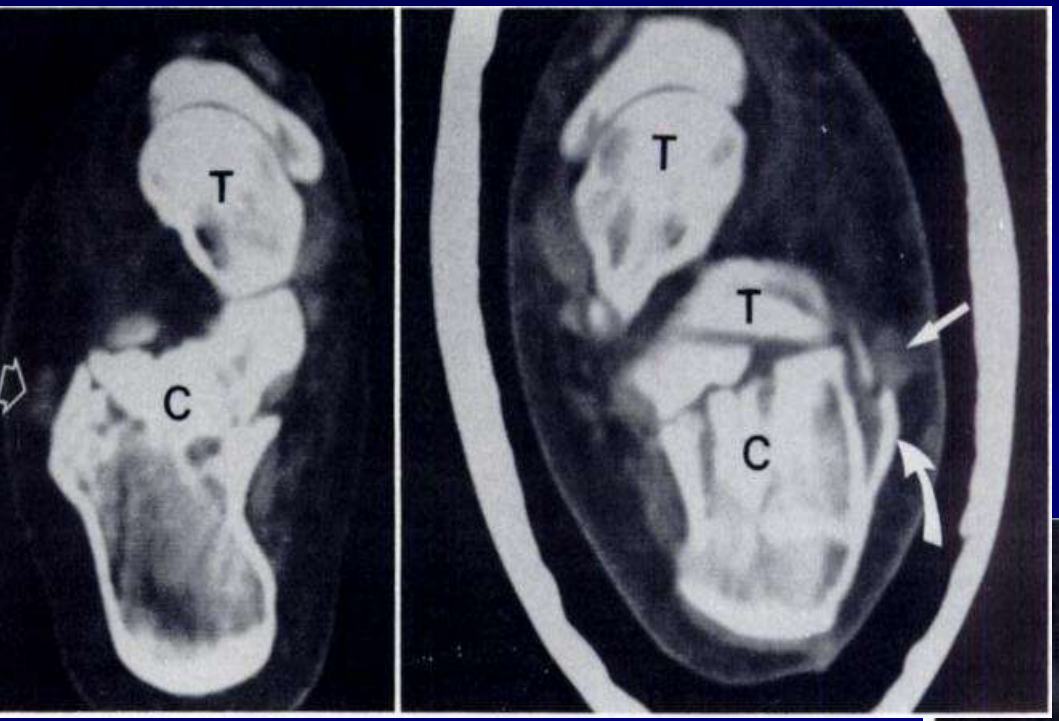
Intraarticular Fractures: Typical Osseous Features

- Loss of Height due to impaction and/or rotation of the more mobile tuberosity fragment
- Widening due to displacement of tuberosity fragment
- Posterior subtalar joint disruption
- Axial loading associated with TL burst fractures
- Superior peroneal retinacular avulsions

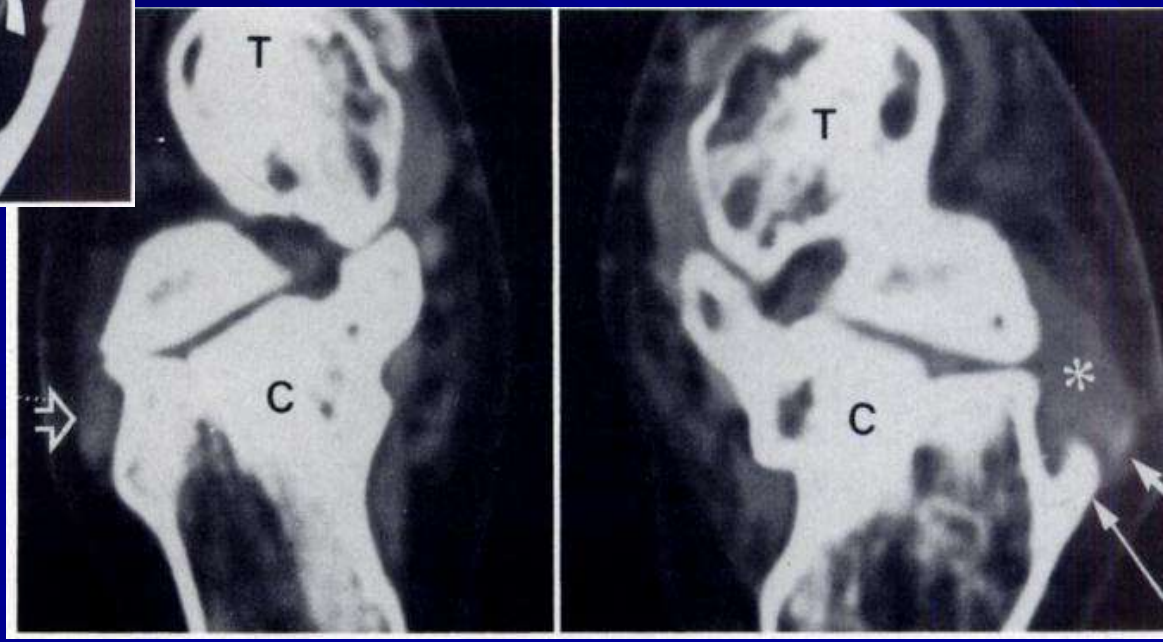
Intraarticular Calcaneus Fractures- Extraosseous Associations

Peroneal tendon entrapment

Entrapment Complication



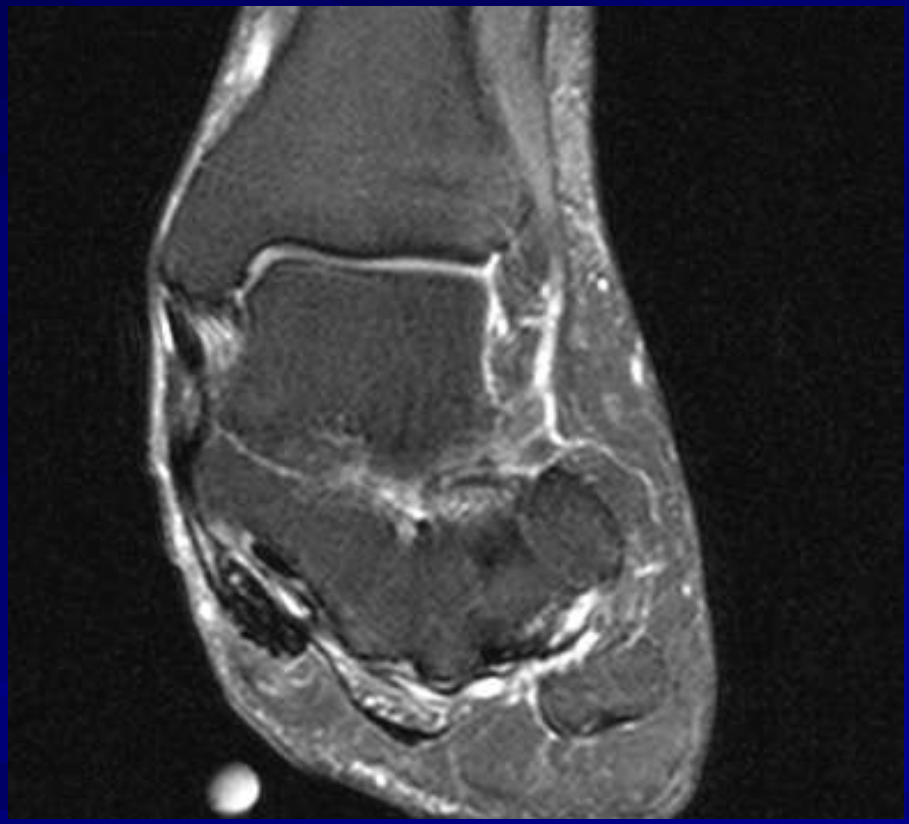
Fibrosing tenosynovitis related to untreated peroneal tendon entrapment

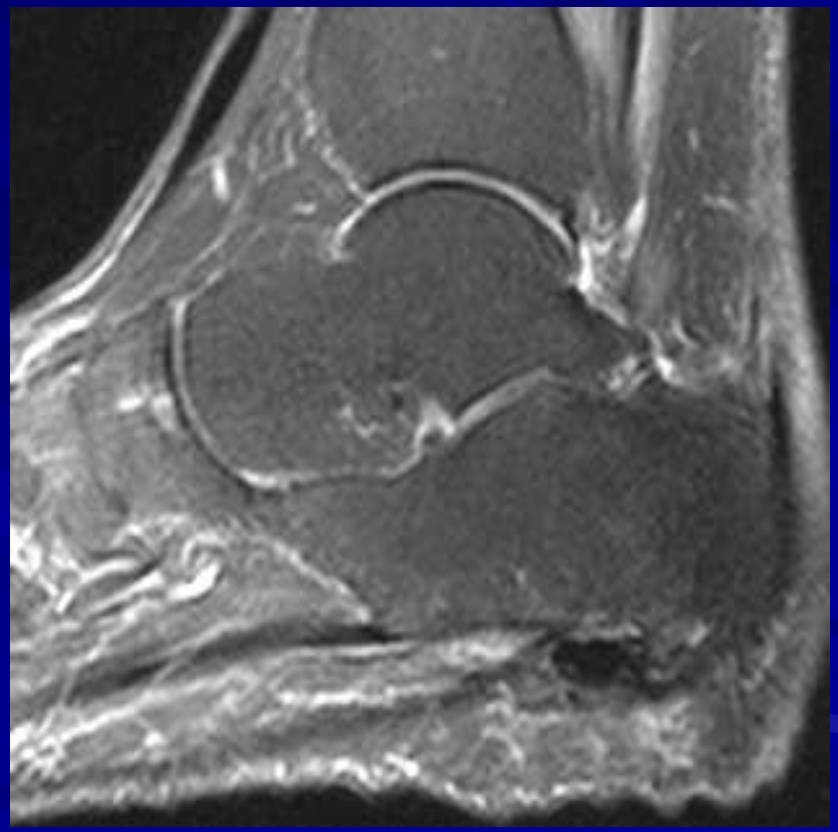


Associated injury- SPR Avulsion

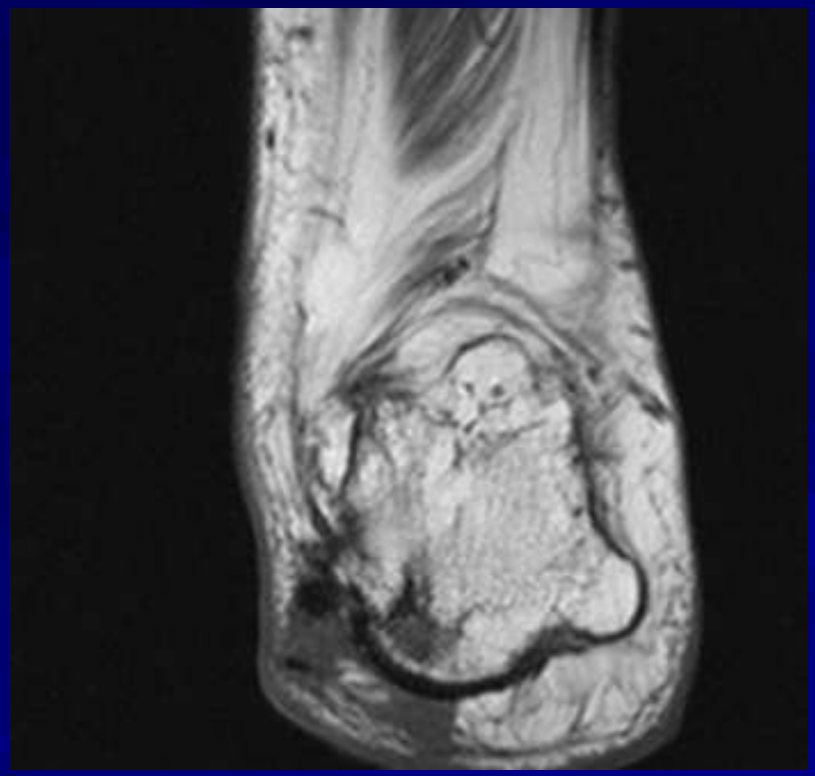
Intraarticular calcaneus fractures- Extraosseous Findings

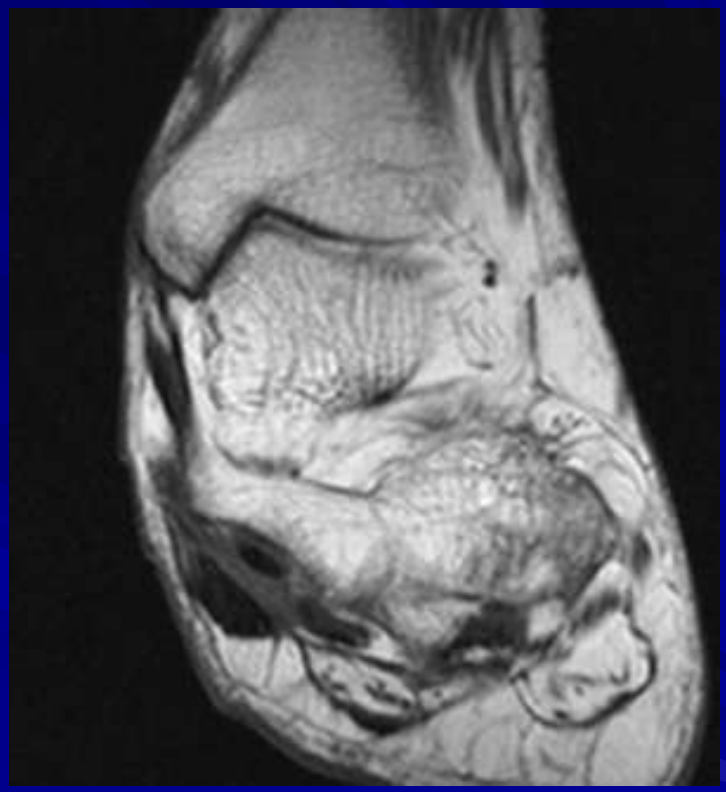
MR Imaging





MR Imaging





Diagnosis: Calcific Myonecrosis related to a remote compartment syndrome

Calcific myonecrosis

- Relatively rare, late sequela of trauma
- Plate/Sheet-like calcifications are characteristic
- Only 1 case reported in the foot in the English literature
- May erode adjacent bone
- Spontaneous draining sinus-tracts and culture positive infections may develop
- Appropriate treatment: compartmental excision or debridement

Miscellaneous Calcaneus fx

Isolated sustentacular fracture

Axial loading with extreme hindfoot varus or inversion

May be intra or extra articular depending on if the fracture line involves the calcaneal facet

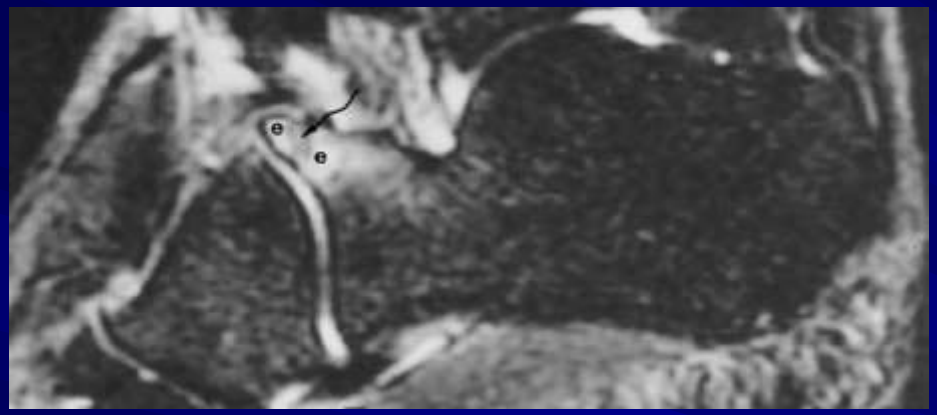
Conservative treatment

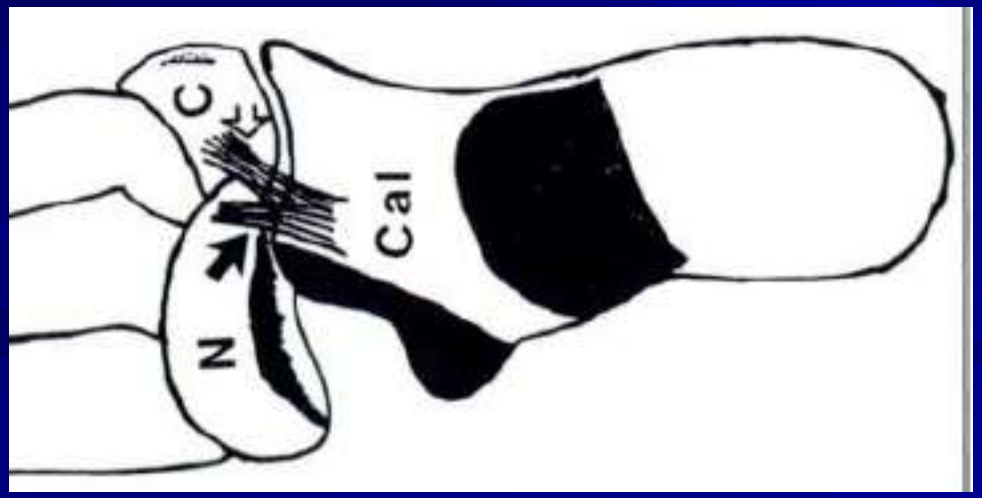
Miscellaneos fx

Isolated medial tubercle fx- axial load
In extreme hindfoot valgus

Extraarticular, conserative treatment

Miscellaneous- Anterior Process Calcaneus Fracture





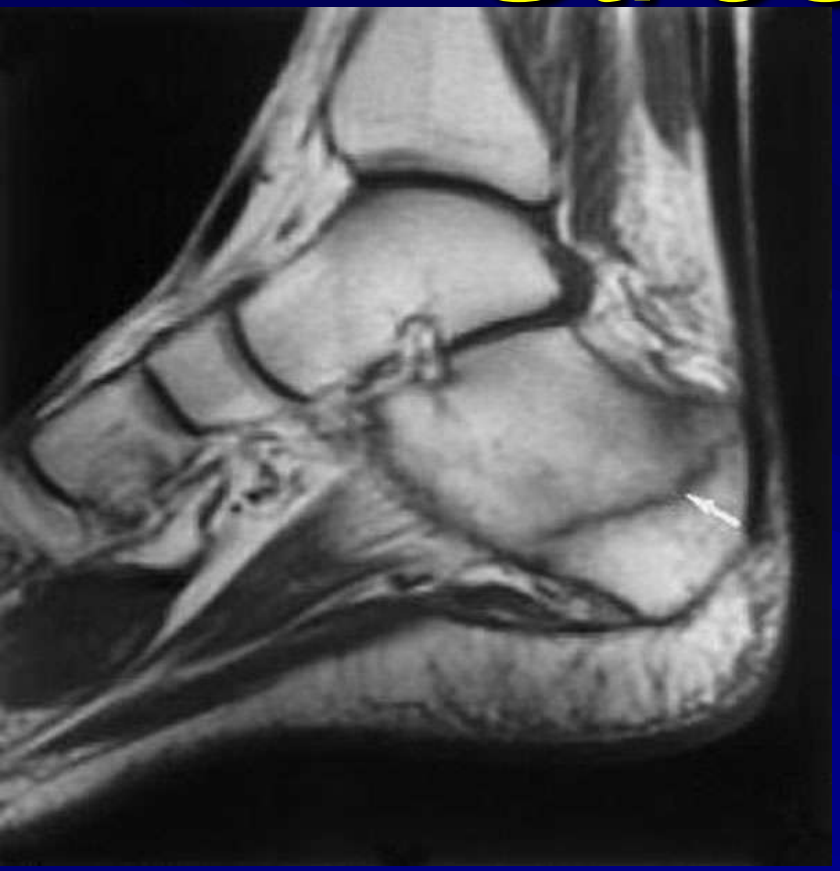
- Type 1: Forced plantar flexion and inversion resulting in Bifurcate ligament injury and avulsion. Clinically mimics ankle sprain
- Type 2: Eversion and dorsiflexion with shear injury to anterior process
- Both susceptible to nonunion/AVN with recurrent pain
- Early detection can prompt surgical management- displaced fractures involving more than 25% of the calaneocuboid are treated surgically

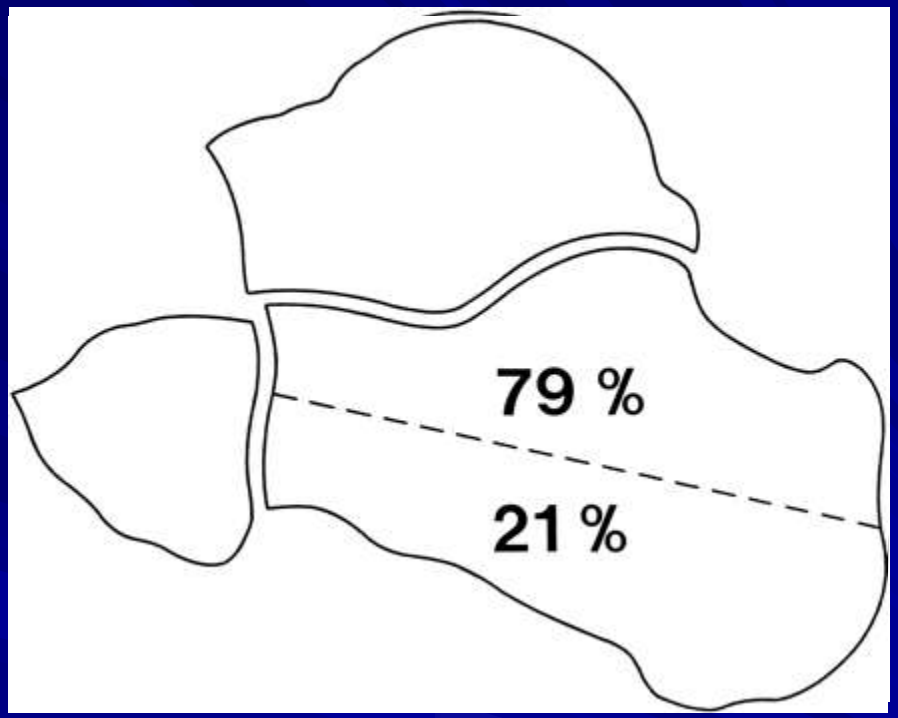
Beak Fracture

Treated surgically

Greater displacement = greater functional loss of the the Achilles tendon

Stress fracture





How can we make the report sound sweet and help with management?

- Intraarticular/extrarticular?
- Think about the mechanism and why the fracture appears the way it does
- Describe the displacement and comminution of the various named fragments (tuberosity, sustenacular, middle)
- Describe the position of the IA fracture line with respect to the posterior calcaneal facet (Sanders)
- Bohler's and Gissane's angle
- Soft tissue entrapment

Talus Fractures

- Fractures divided into head, neck and body fractures
- Approximately 50 % of talar fractures involve the neck
- Most common body fractures are osteochondral, less common involve the lateral or posterior process

Talar Neck Fractures

Hawkins Classification
of Talar Neck Fractures

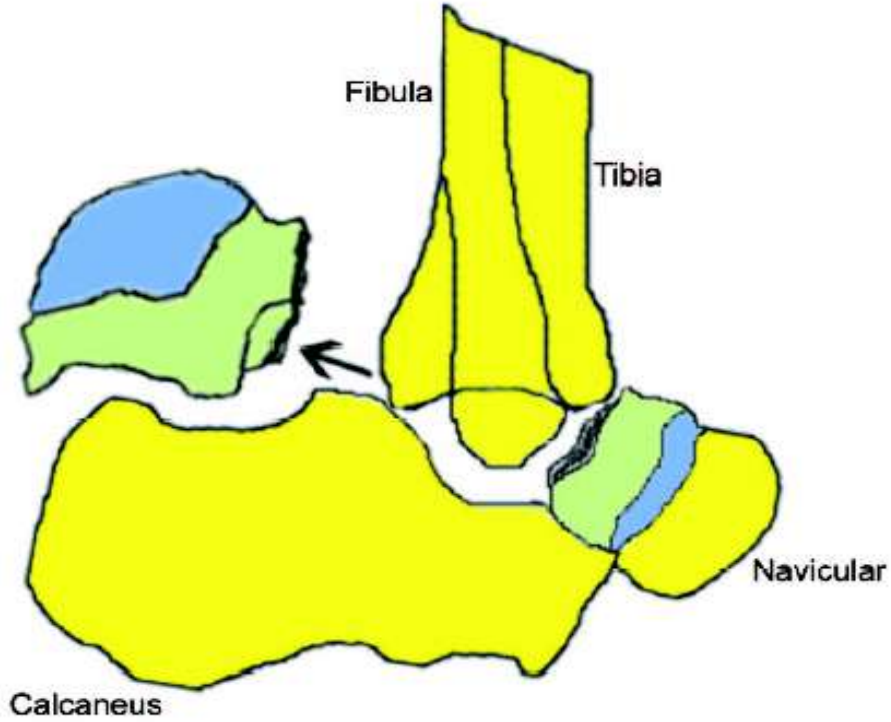
	Radiographic findings	Risk of AVN
Type I	Nondisplaced fracture line	0-13%
Type II	Displaced fracture, plus subluxation or dislocation of subtalar joint	20-50%
Type III	Displaced fracture, dislocation subtalar AND tibiotalar joints	69-100%
Type IV	Displaced fracture and disruption of talonavicular joint	high


Navicular
Calcaneus

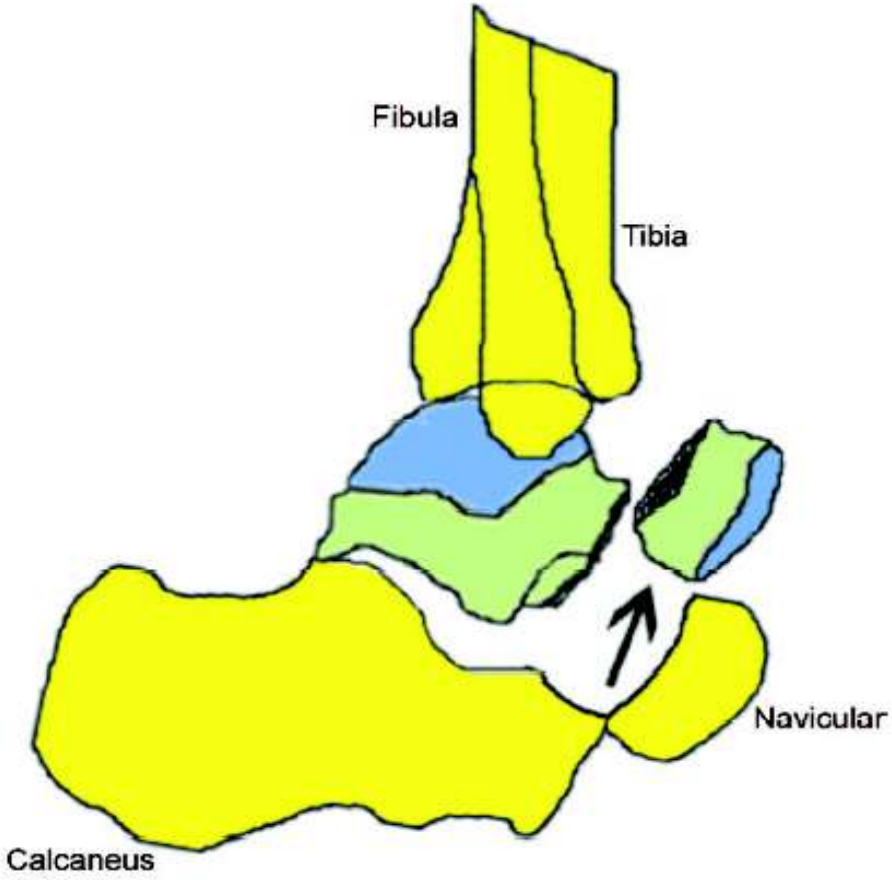
a.


Navicular
Calcaneus

b.


Fibula
Tibia
Navicular
Calcaneus

c.


Fibula
Tibia
Navicular
Calcaneus

d.

Talar Neck Fractures(Aviator's Astragalus)

- Most common mechanism: Dorsally directed force on a braced foot (MVA)
- Complication - Since most of the blood supply to the talar body comes via the talar neck, fractures of the neck place the patient at risk for AVN

Hawkins Type III

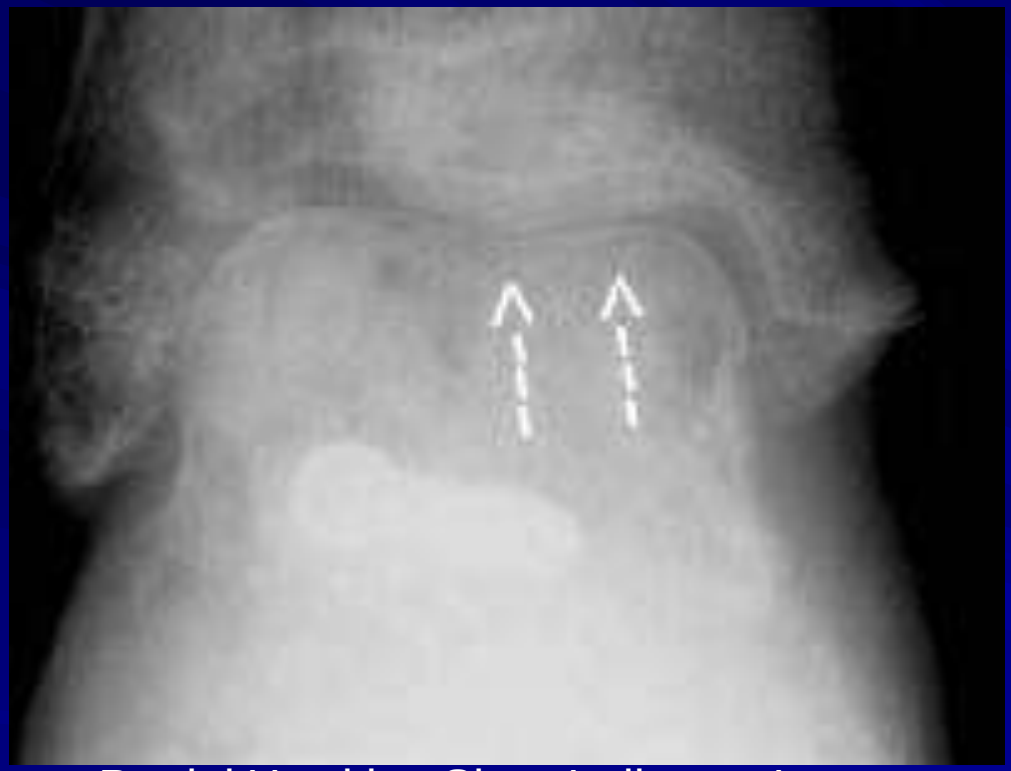
Talar Neck Fractures

Hawkins
Type II

Talar Neck Fractures

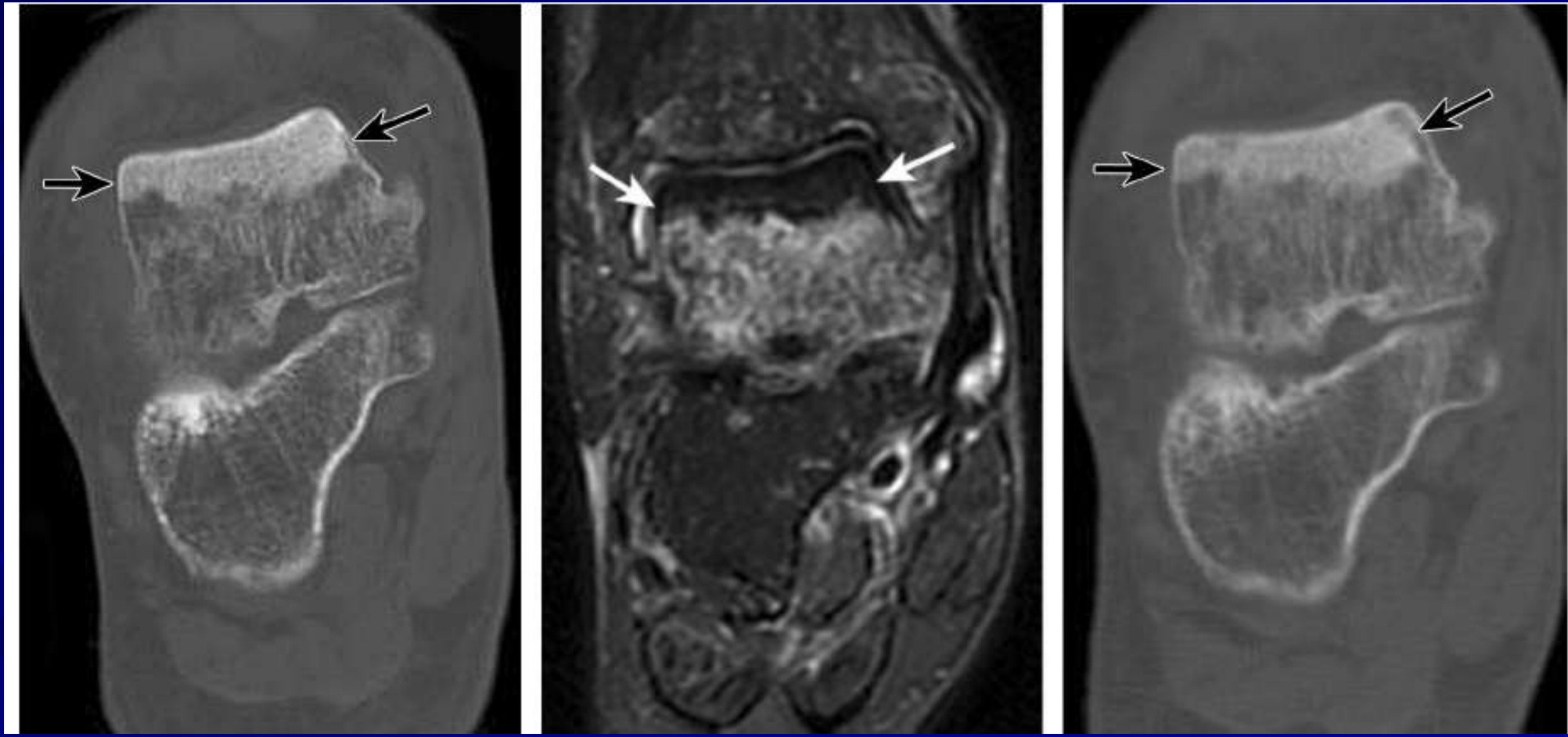
Hawkins Type I

Postoperative Talar Neck-Complication



Partial Hawkins Sign- Indicates Intact Vascularity on side and ischemia on the other

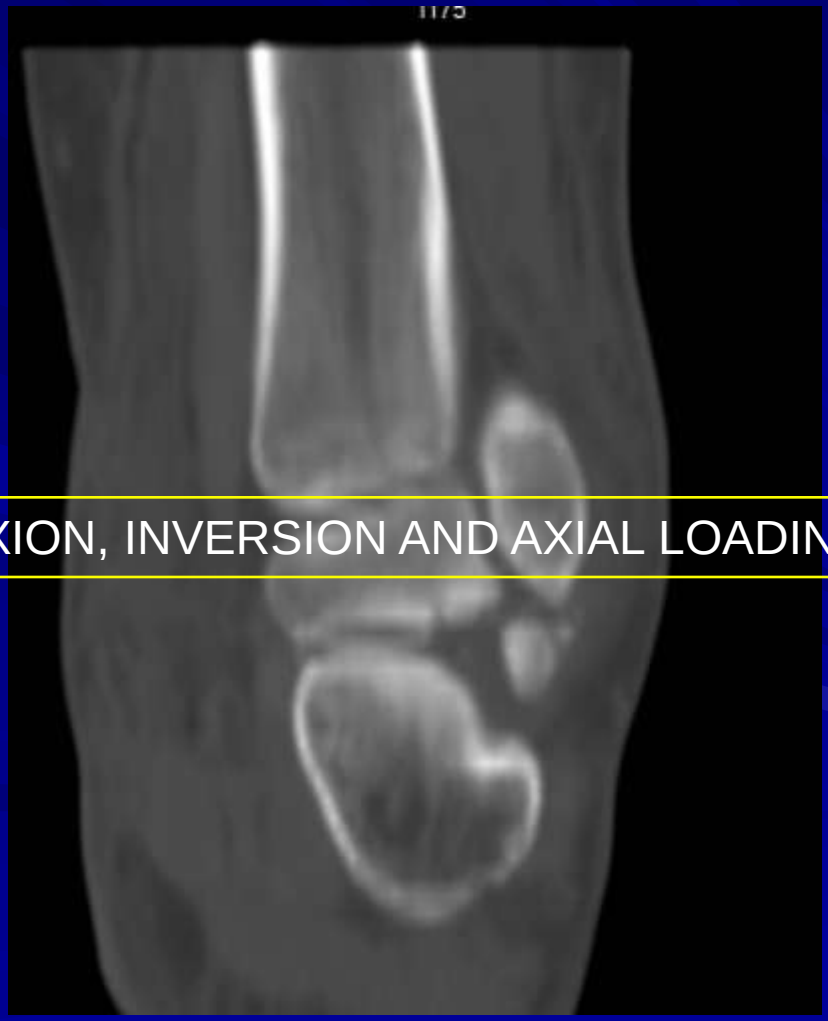
Complication- AVN



Peree et al. Radiographics 25: 399-410. 2005

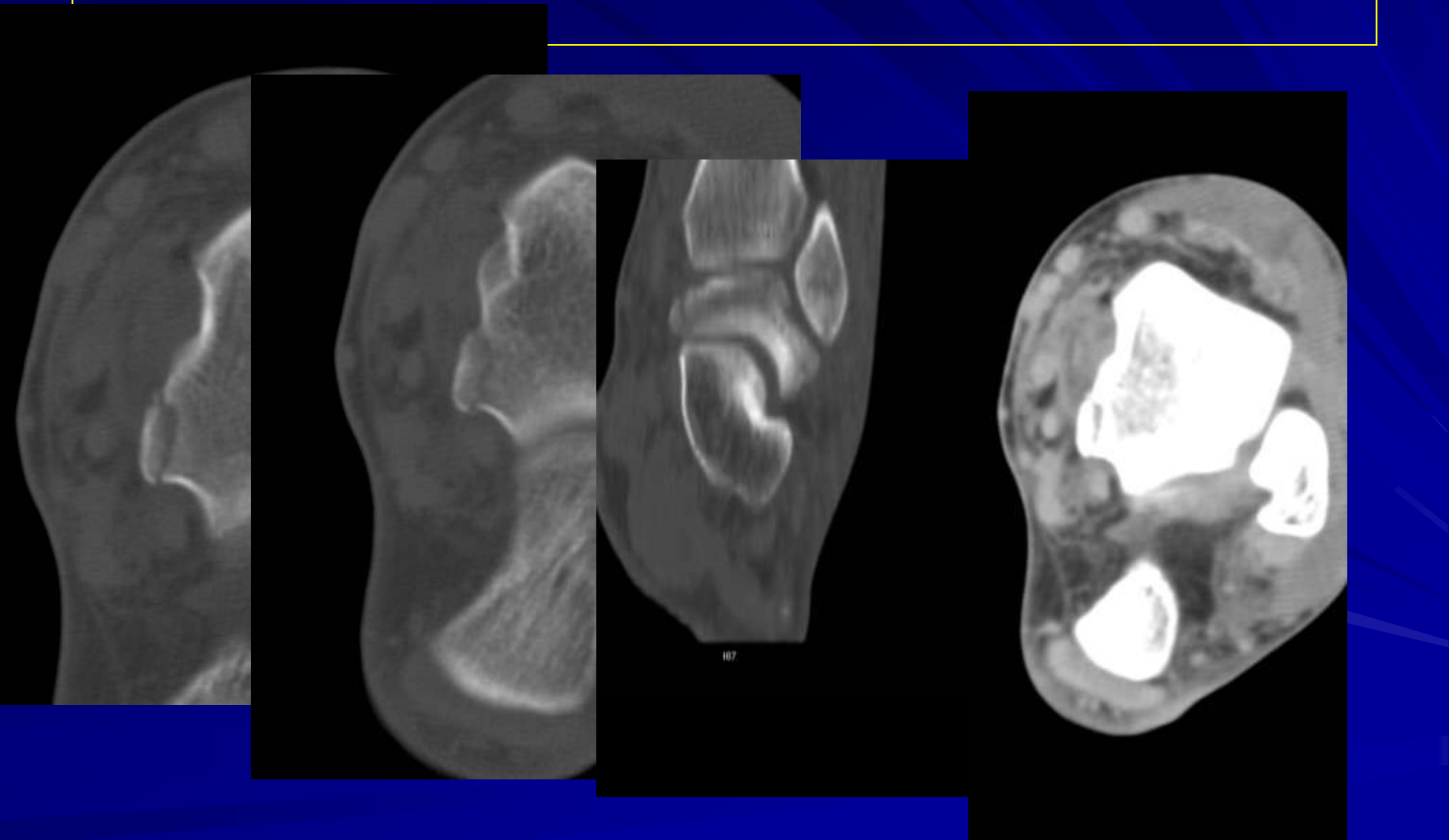
Lateral Process of the Talus- Radiography

Lateral Process Talus Fracture



PURE DORSIFLEXION, INVERSION AND AXIAL LOADING

CEDELL FRACTURE

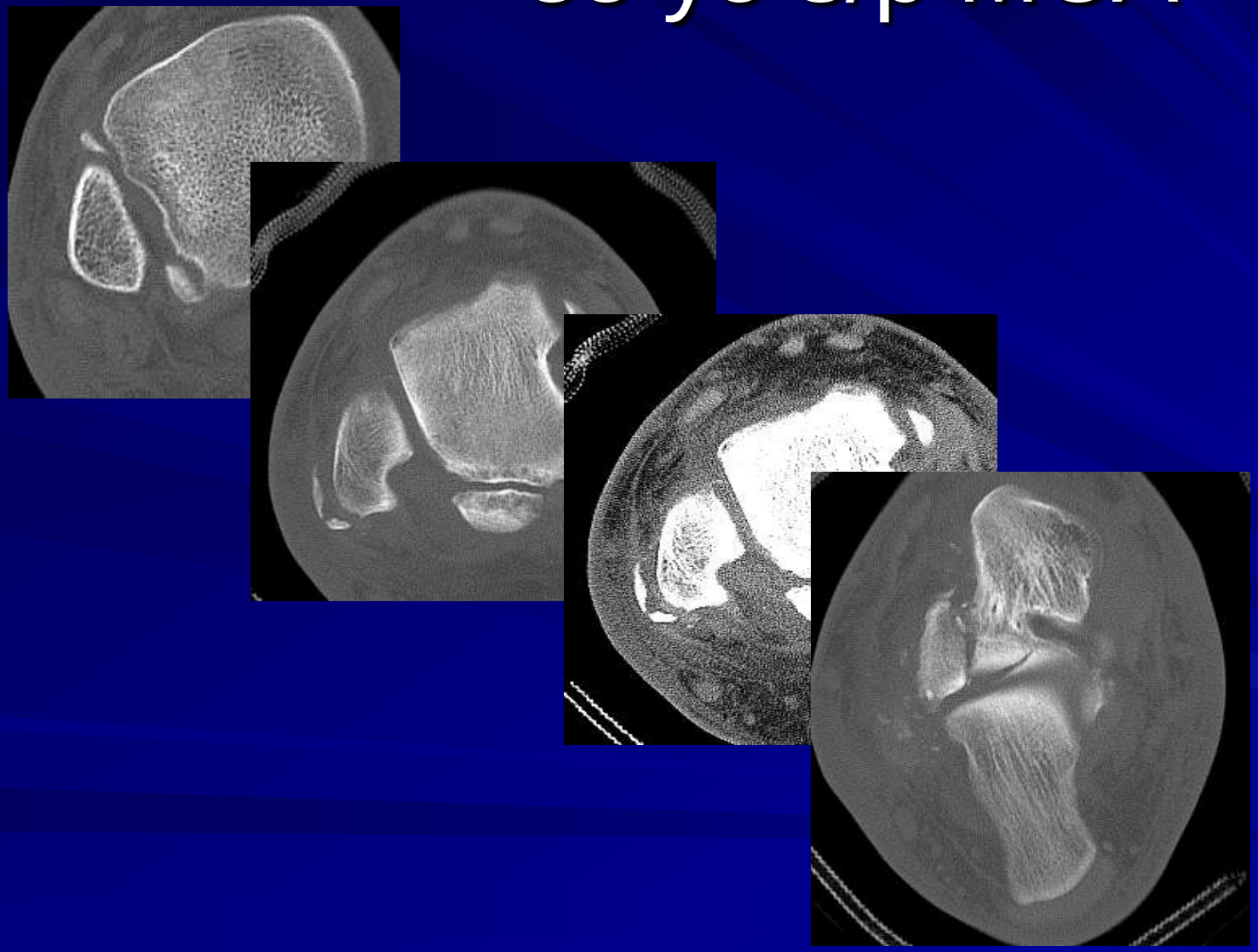


Osteochondral Fractures

Inversion Injuries

	Radiographs	MRI T2WI *	Arthroscopy
1	Normal	Diffuse high-signal intensity	Normal, or softening of cartilage
2	Semicircular lucent line	Semicircular low-signal line	Break in cartilage, fragment not displacement
2a	Subcortical round lucency(cysts)	High-signal fluid within fragment	None
3	Same as 2	High-signal fluid surrounds fragment	Displaceable fragment
4	Loose body	Defect talar dome, possibly loose body	Defect plus loose body

35 yo s/p MCA



35 yo s/p MCA

Conclusion

- Osseous anatomy of the talus and calcaneus can seem complex
- Using a systematic approach

Distal fibular fracture

Weber A

Bi-malleolar fracture


Ref: www.xray200.co.uk

Maisonneuve fracture

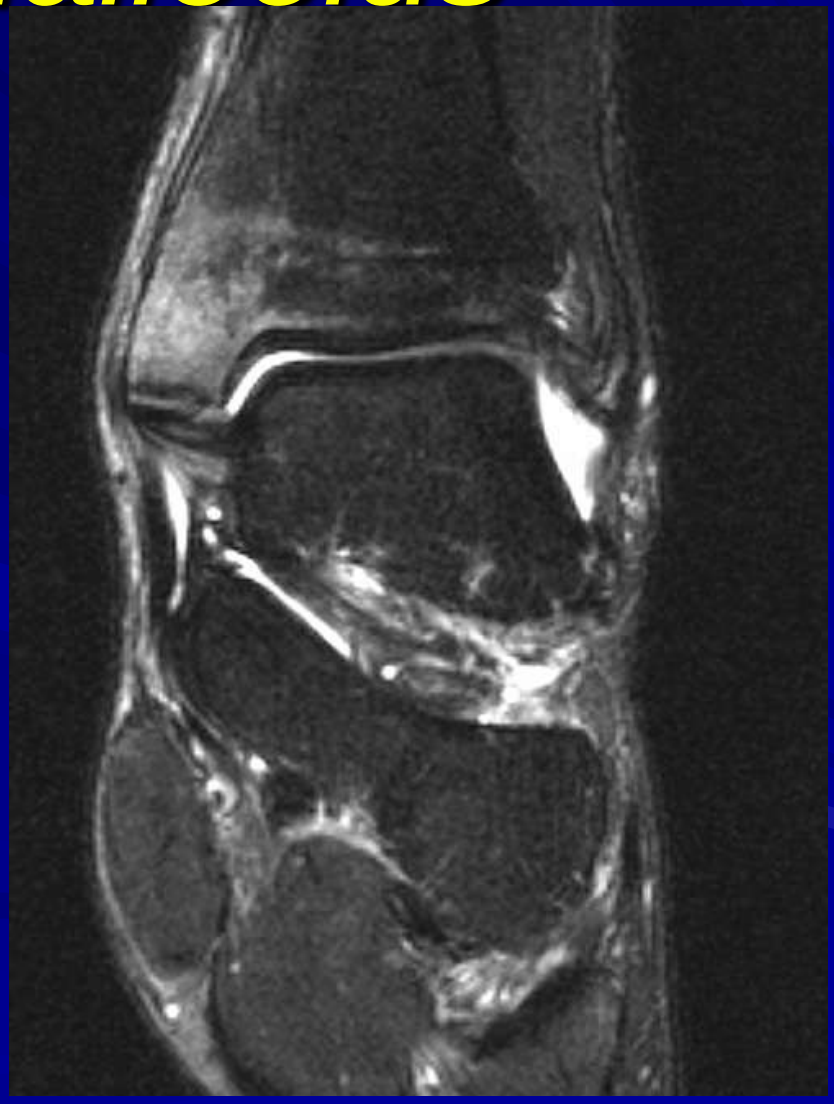
Weber Classification

- Determine level of fracture with respect to the syndesmosis.
- Correlates with prognosis and treatment.
- Type A= transverse fracture of lateral malleolus below syndesmosis.
- Type B= oblique fracture at the level of the ankle joint; partial disruption of syndesmosis.
- Type C= fibular fracture proximal to the ankle joint with tear of tibiofibular ligaments and syndesmosis.

Metatarsal fractures

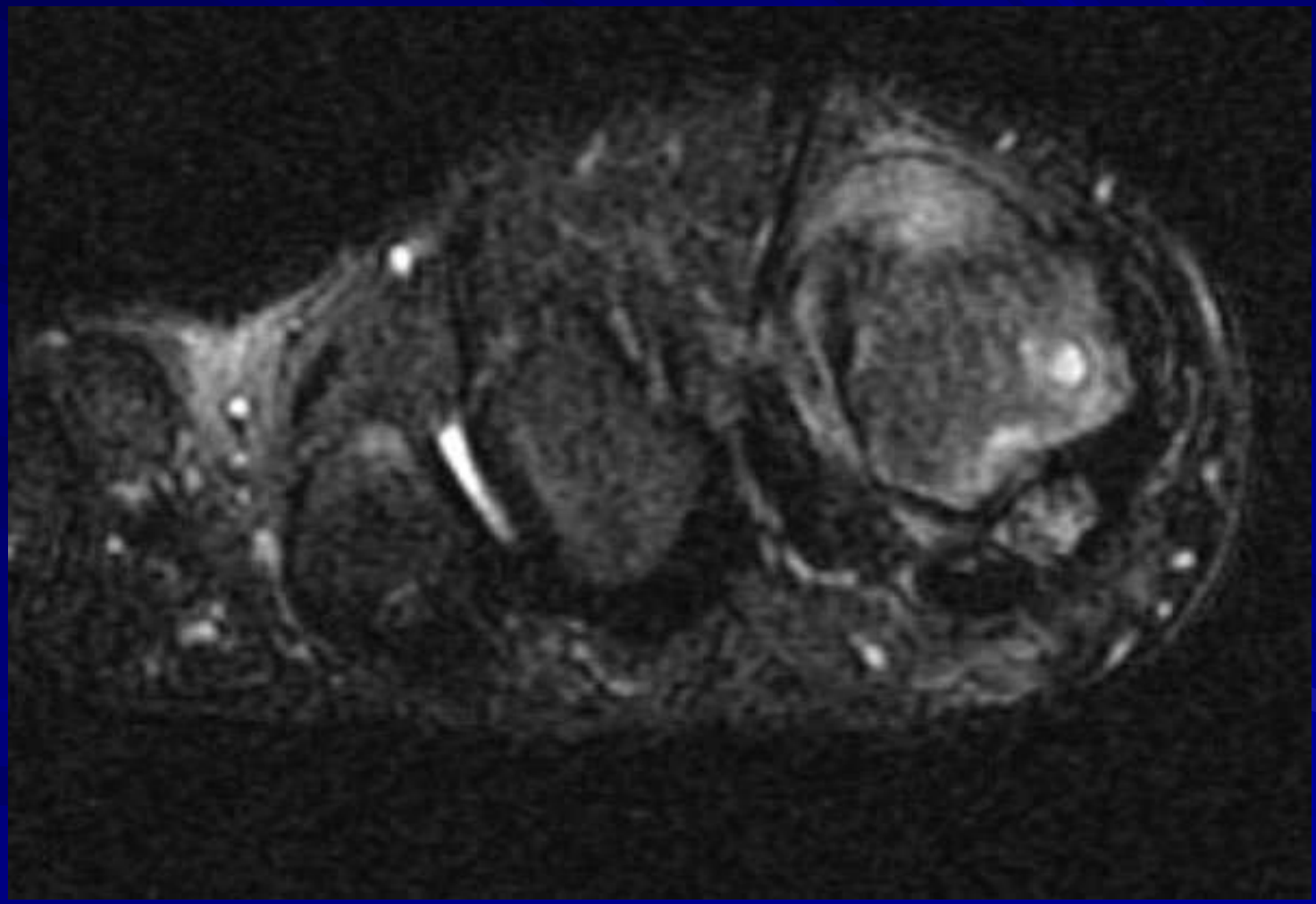
Stress fracture foot

Stress fracture medial malleolus

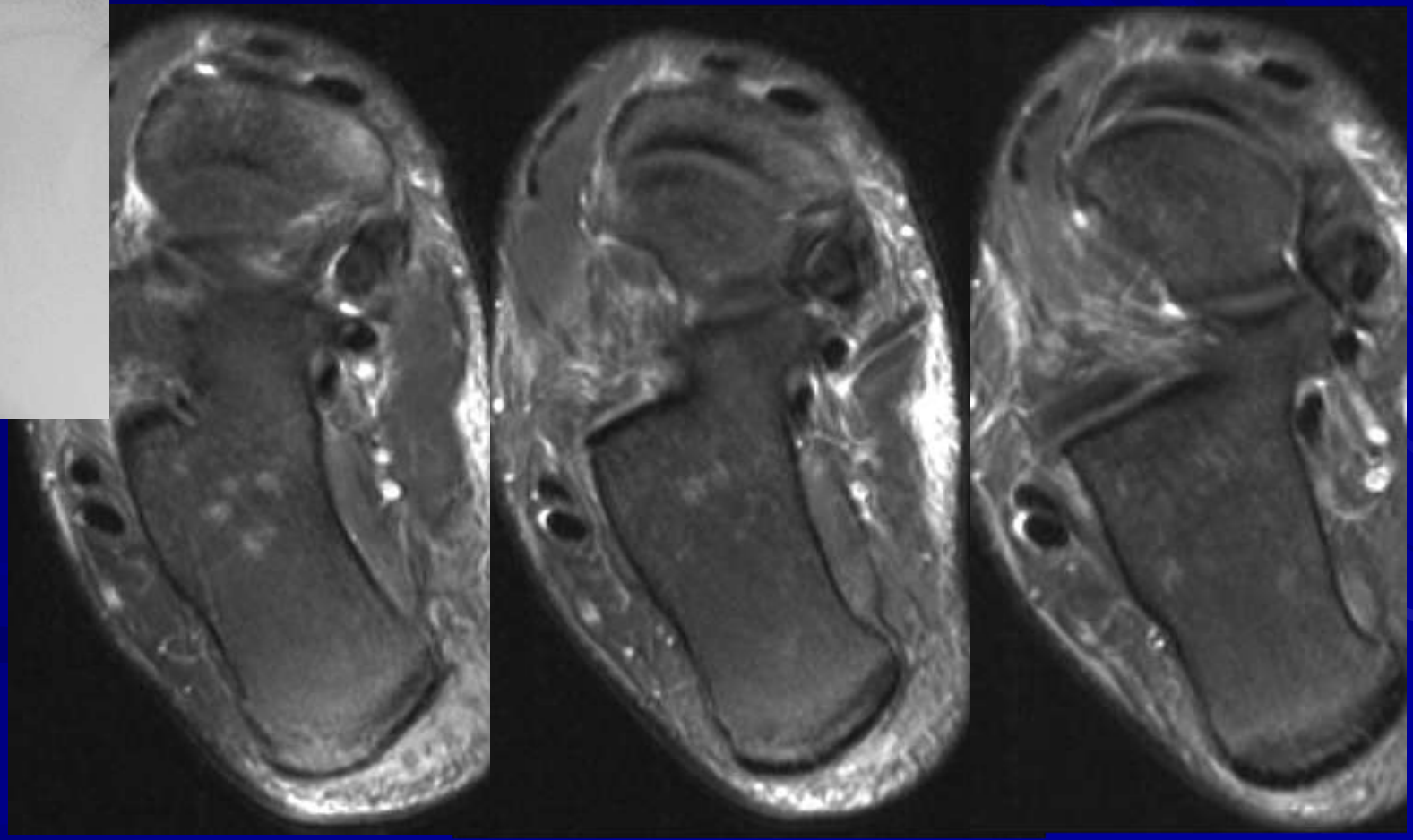


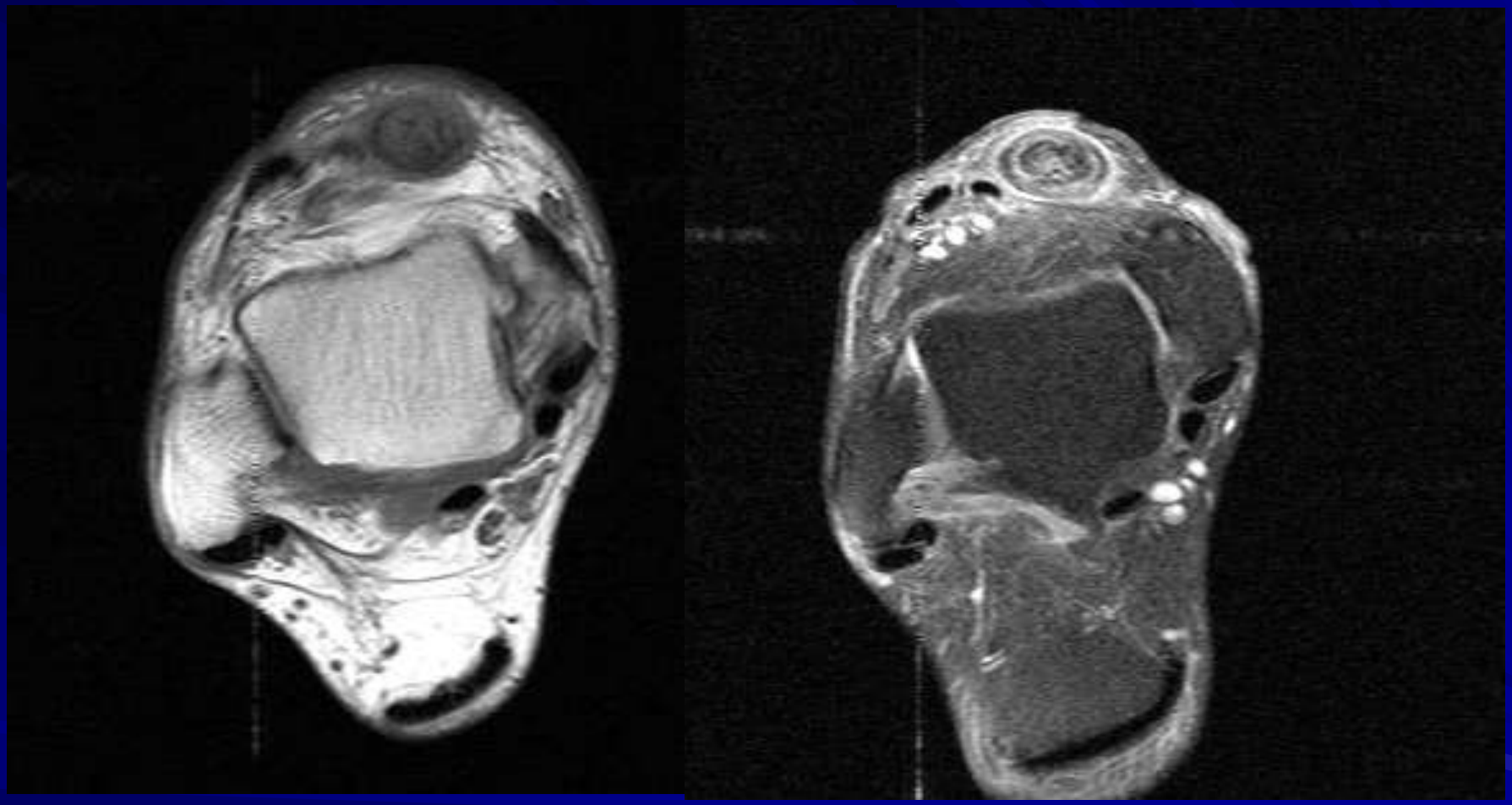
fracture 5th proximal phalanx - renal osteodystrophy

fracture sesamoid



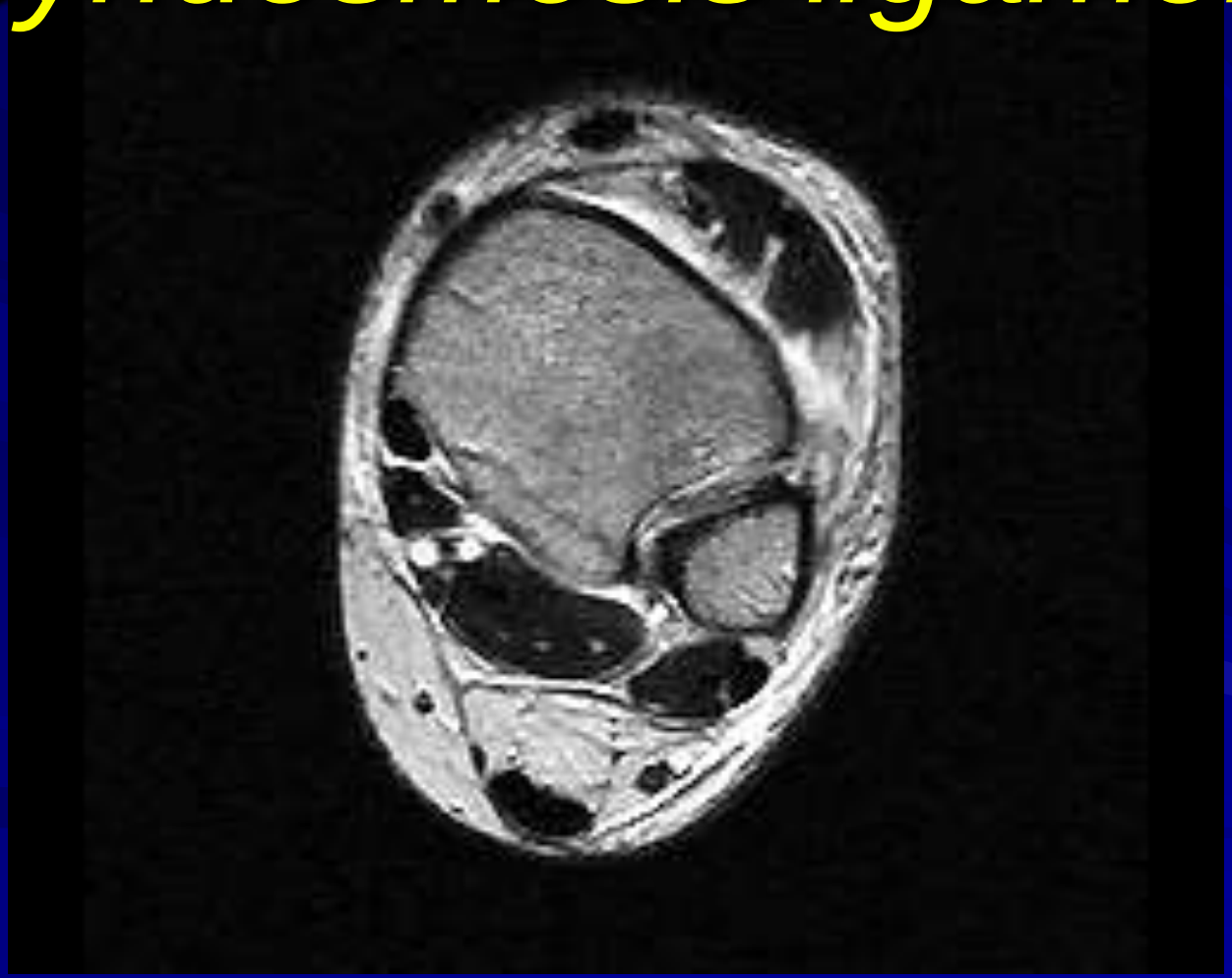
Avulsion tib.post. tendon





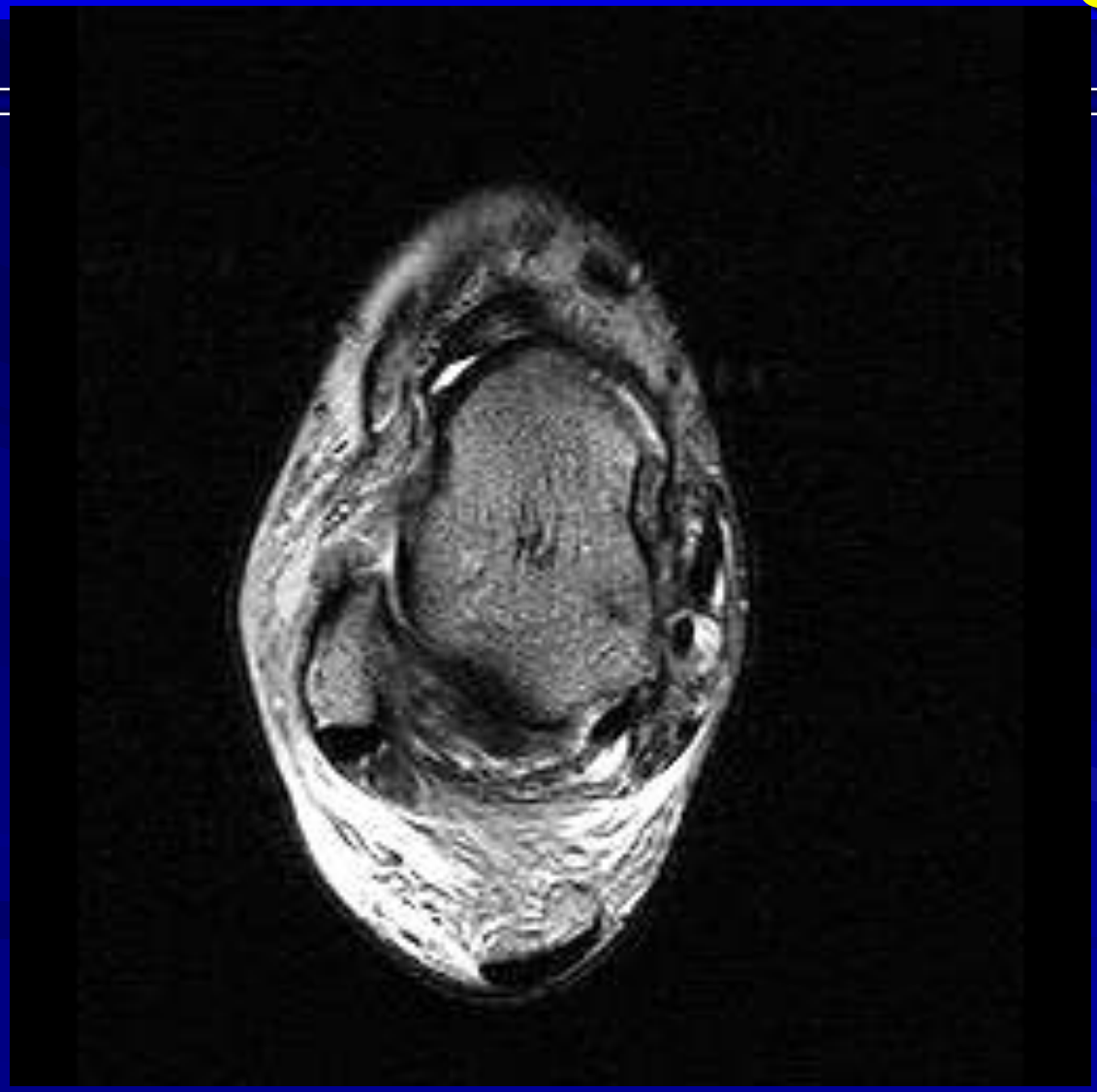
Tibialis anterior tendon tear

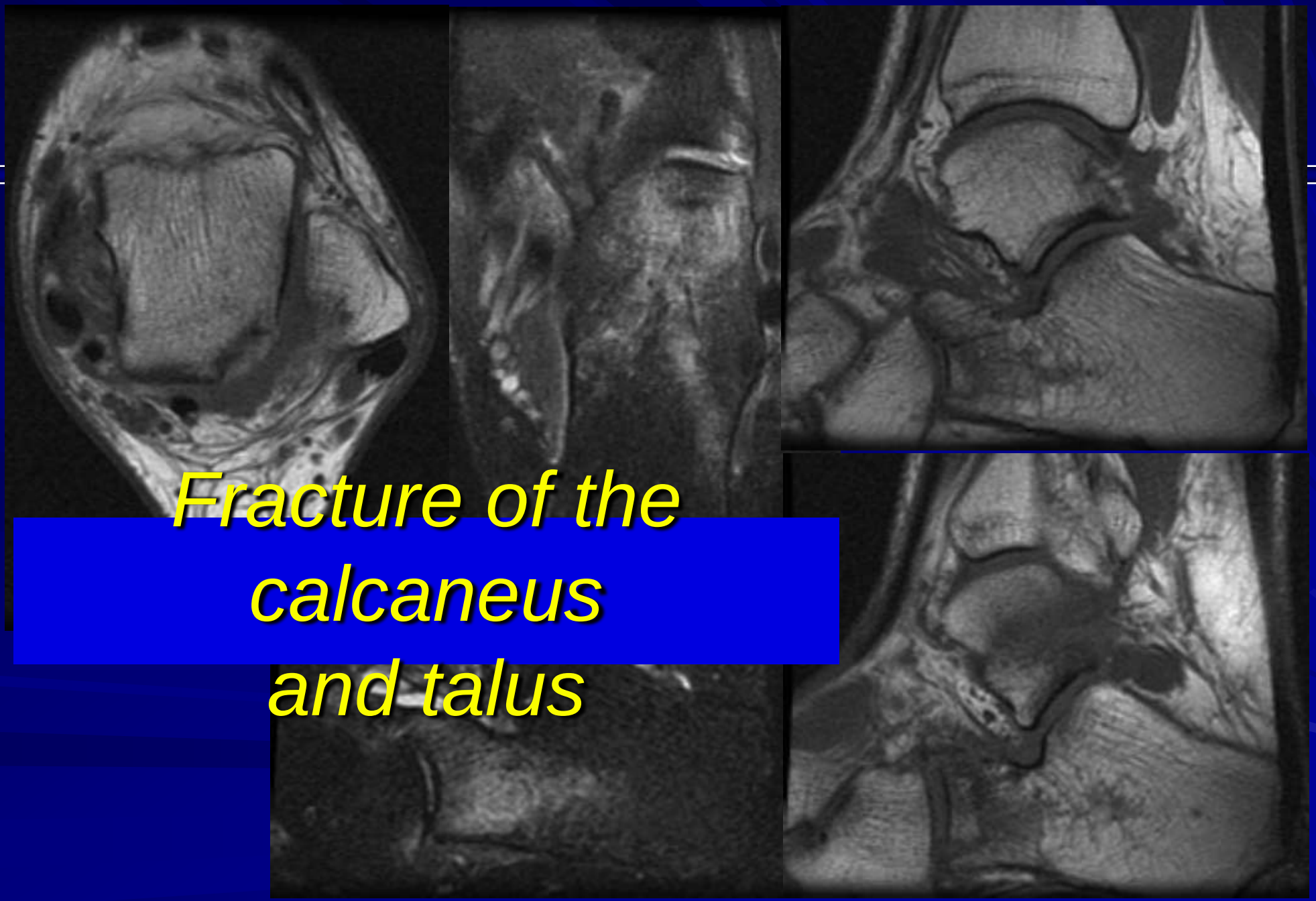
Tear of the anterior Syndesmosis ligament



Achilles tendon tear

Tear ant. talofibular lig

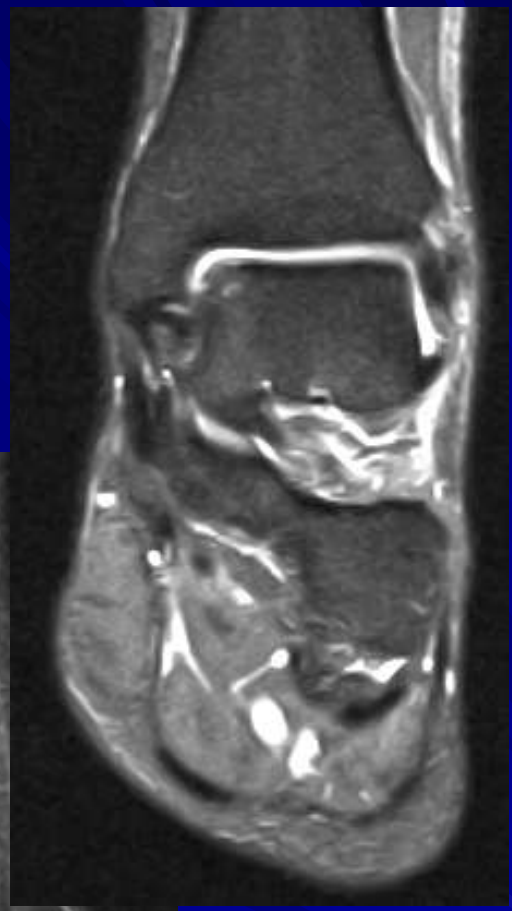




Fracture of the calcaneus and talus


L
LM

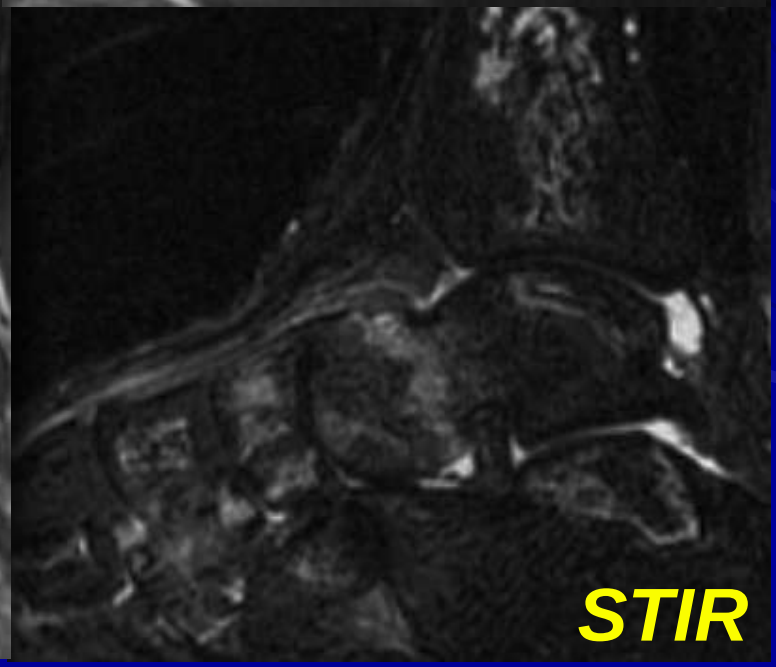




Osteochondritis dissecans

- Repeated microtrauma causes injury
- Occurs in typical locations at the knee and ankle.
- In the ankle the talar dome is typical location.

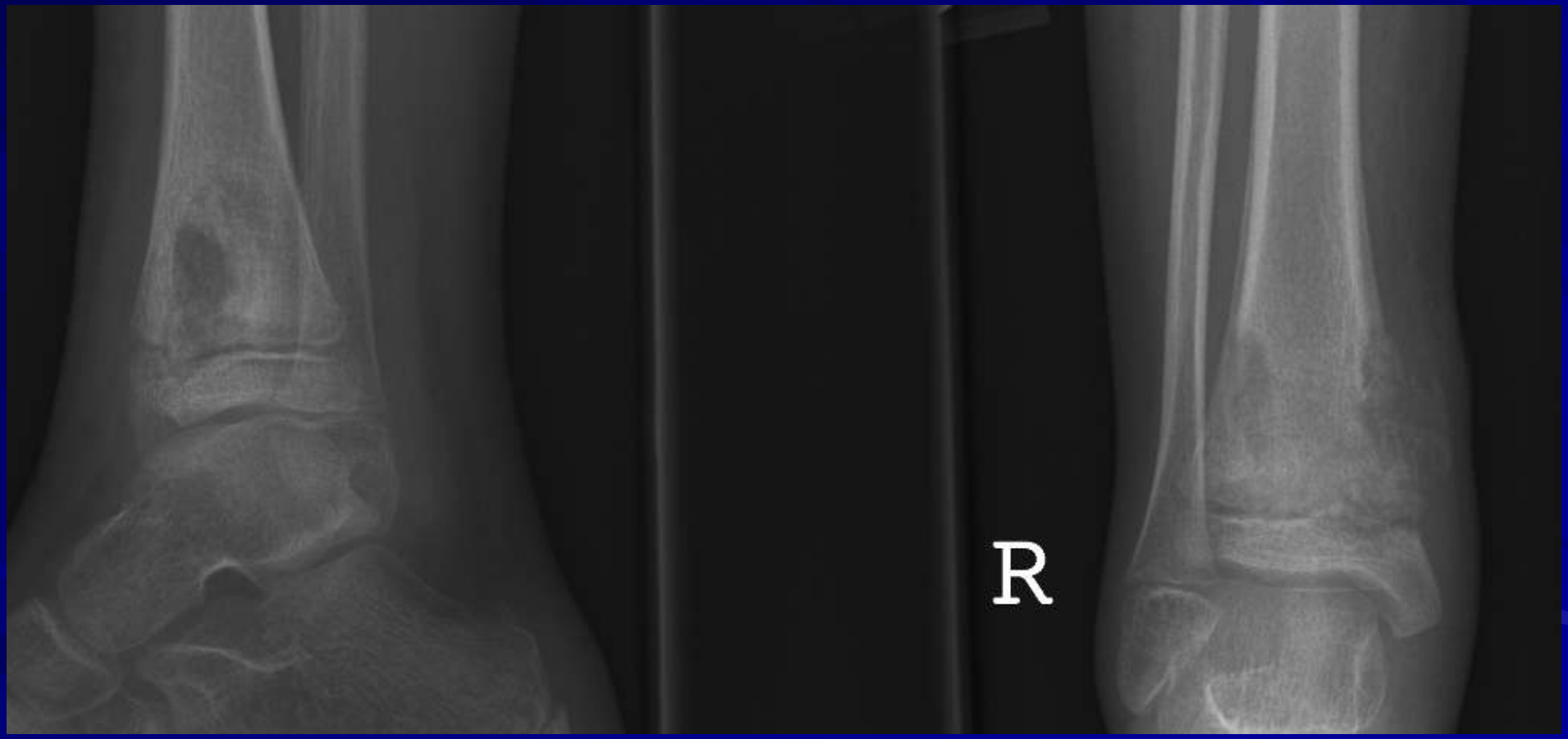
Bone marrow infarction and stress fracture in 50 yo patient with chemotherapy for lymphoma



Inflammation

Osteomyelitis / Arthritis foot

Osteomyelitis ankle



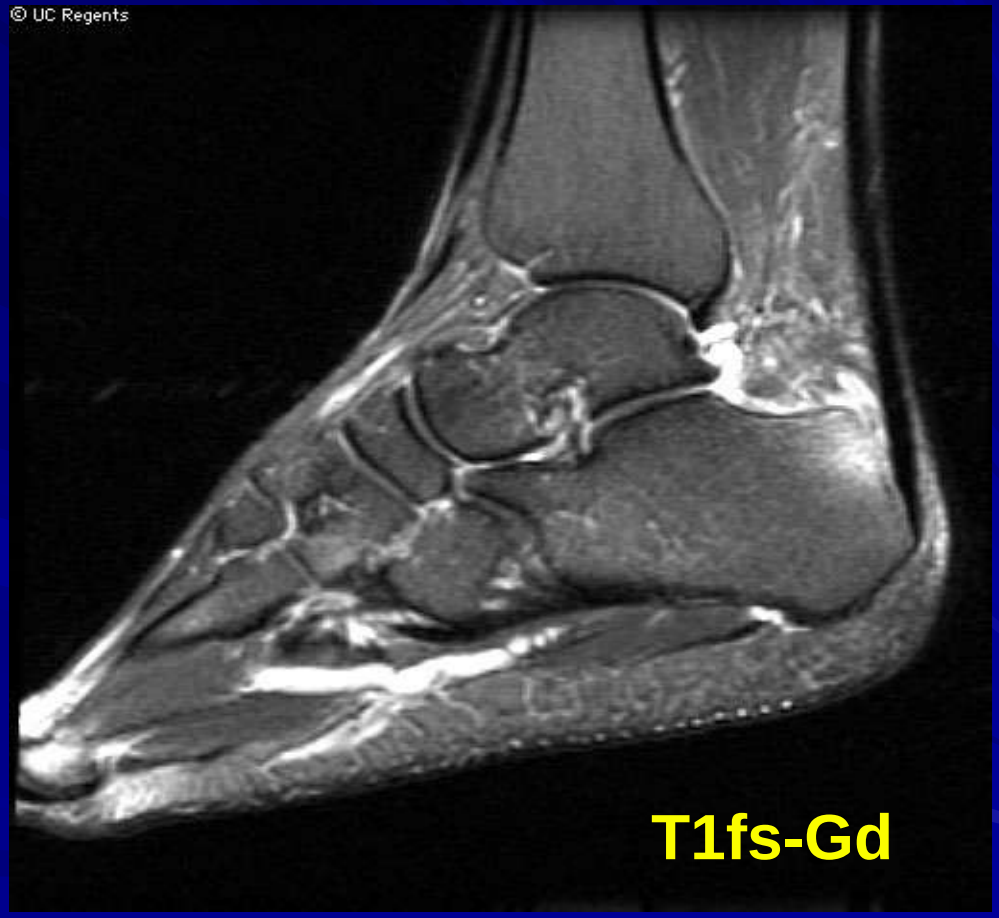
Tuberculous dactilitis

- *frequent in children*
- *multiple foci in 25-30%*
- *Soft tissue swelling*
- *Periostitis*
- *May be cystic = spina ventosa*

Rheumatoid arthritis

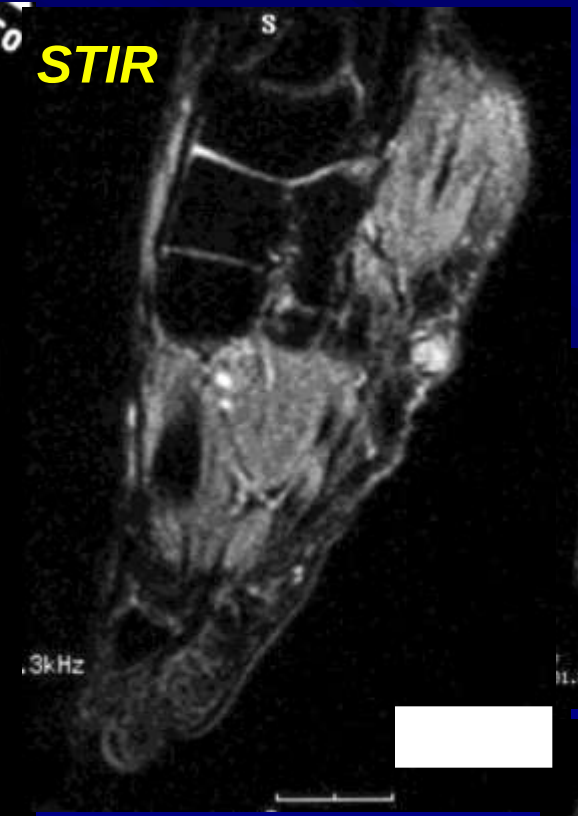
Gout

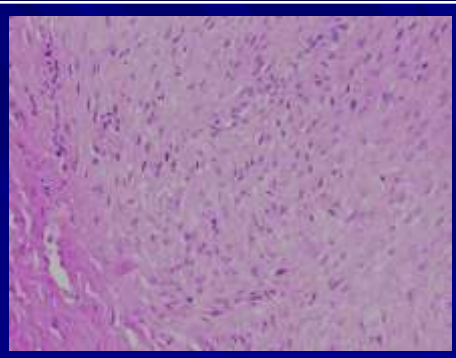
Reactive arthritis - Reiter's syndrome

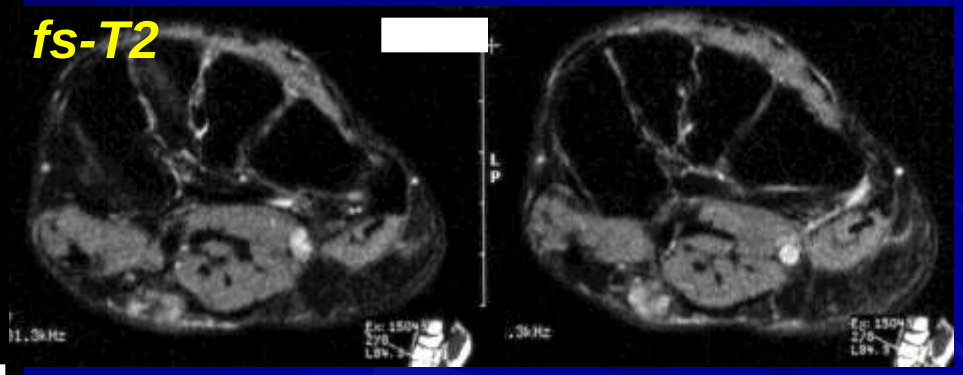


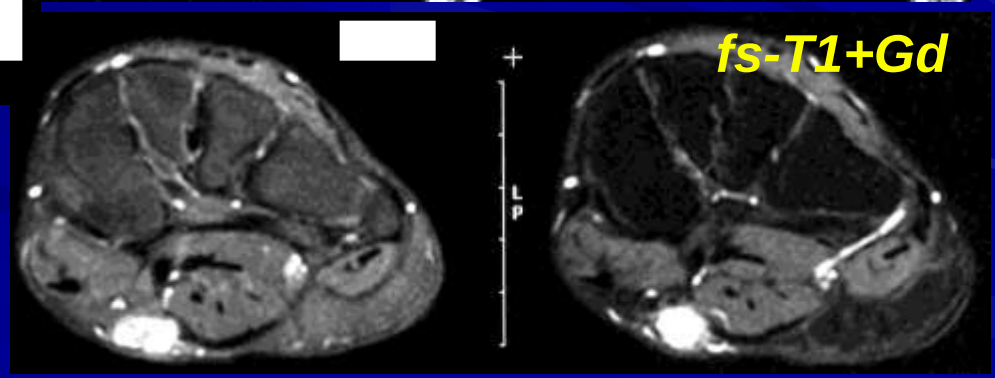
Tumor

Plantar fibromatosis



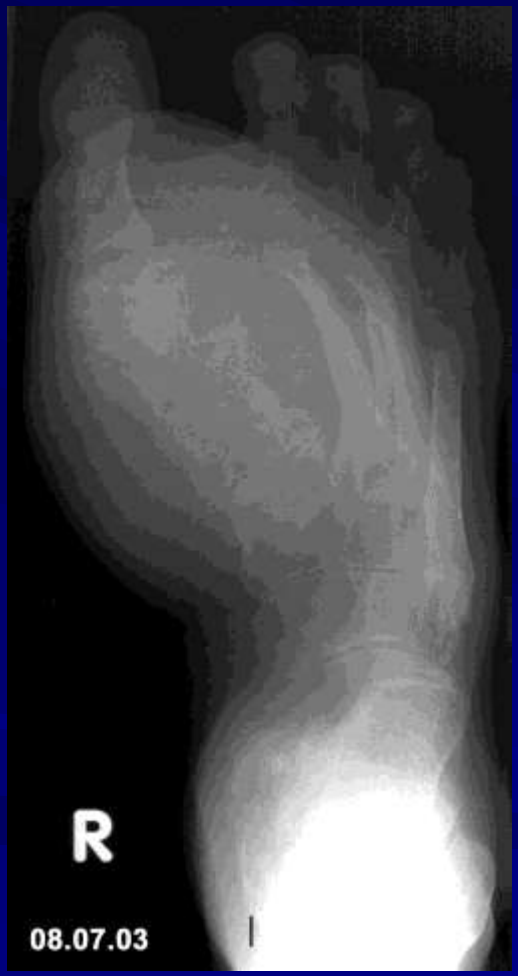


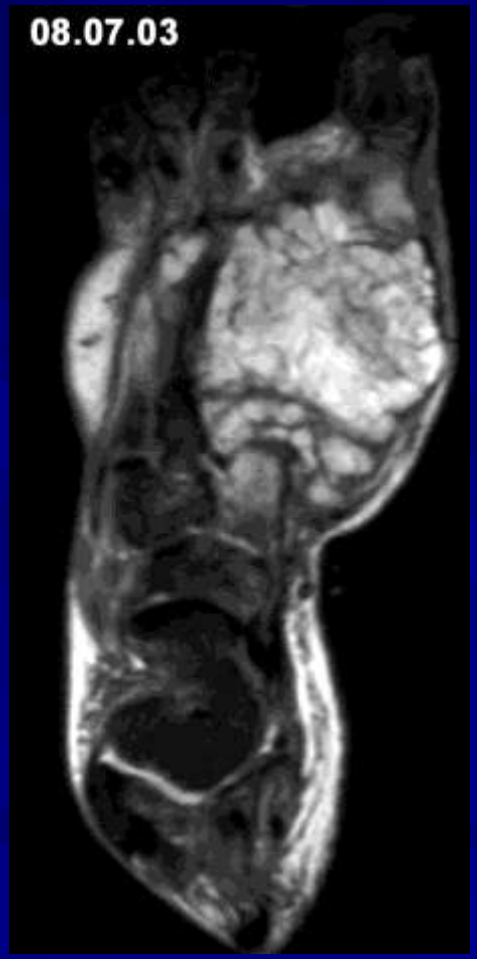


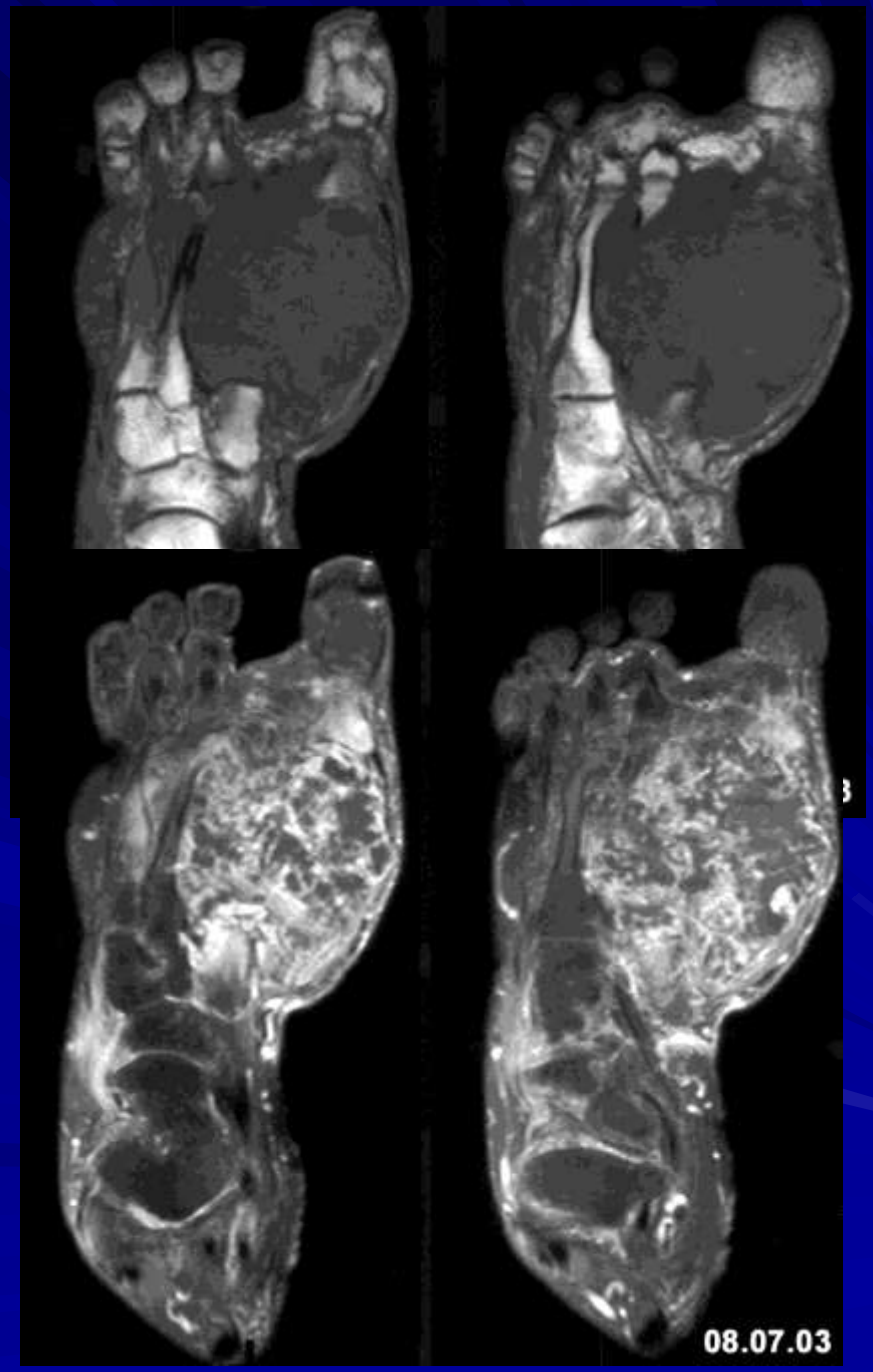


Metastatic Prostate Cancer

Chondrosarcoma

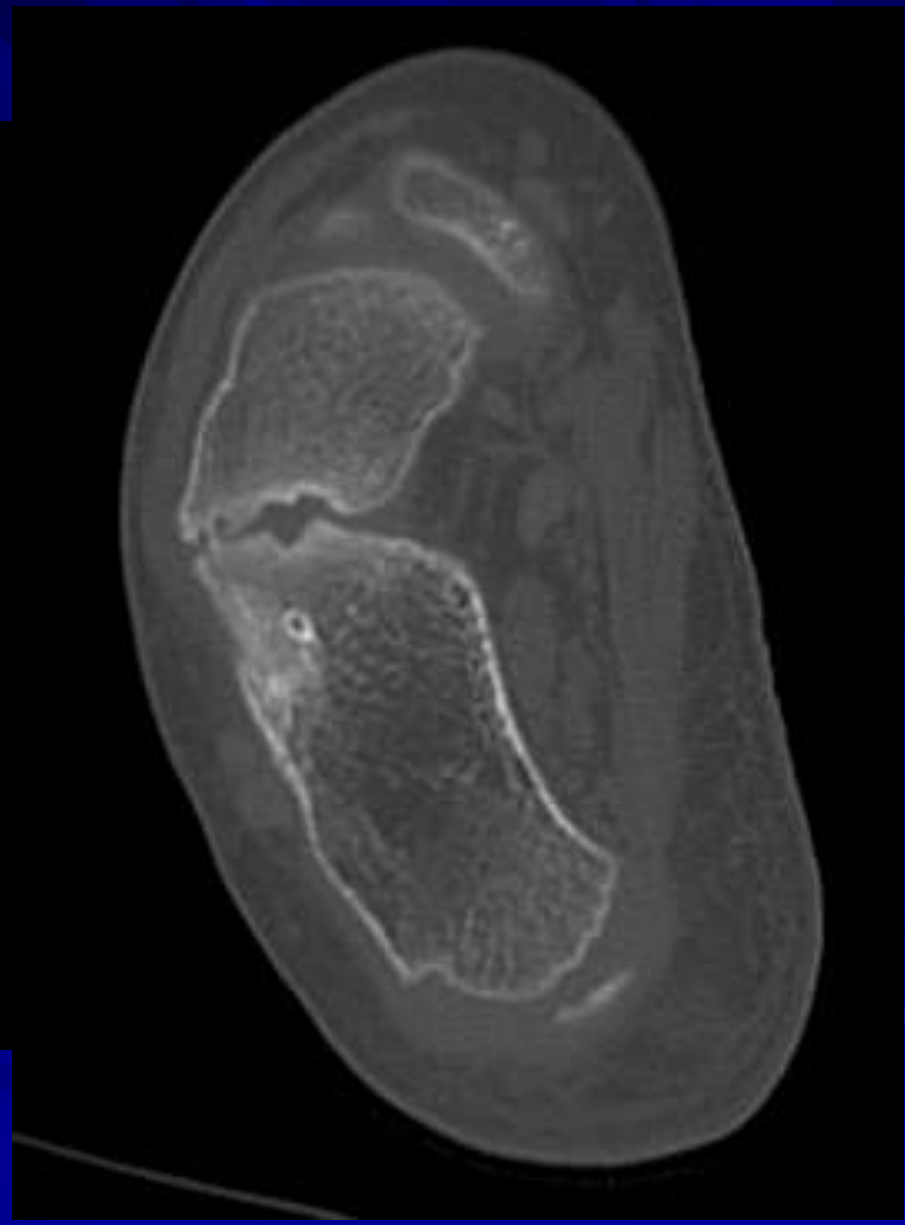






Various


LEF
RIGI



Calcaneonavicular coalition

- Fusion of tarsal bones
- Talocalcaneal and calcaneonavicular are most common types
- Fibrous, cartilaginous or osseous.
- Result in limited motion at these joints and over time pain, arthritis, tendonopathy develop.

Club foot

Clubfoot

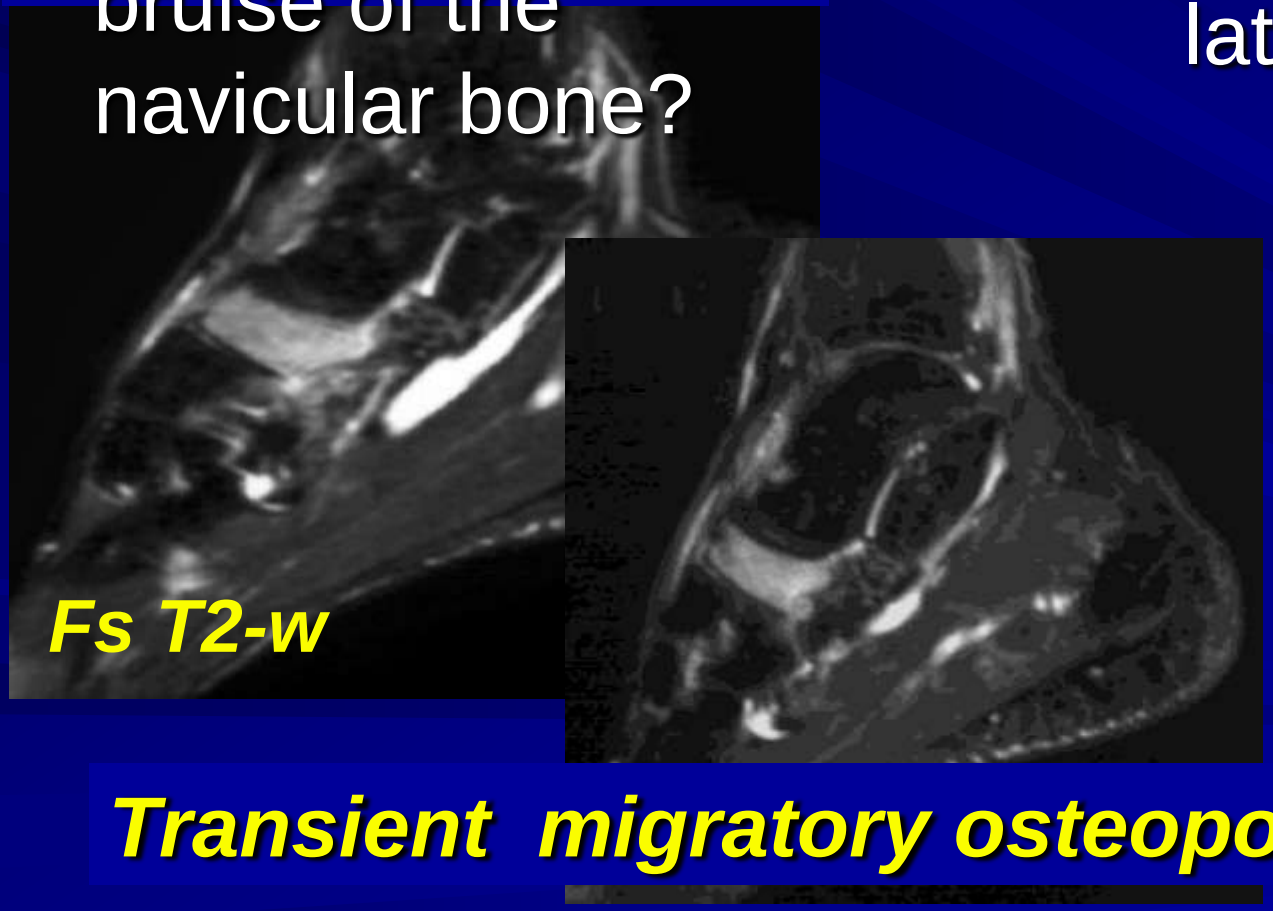
- 1 in 1000 births.
- Unclear etiology.
- Hindfoot equinus, hindfoot varus, and forefoot varus.

Osteogenesis imperfecta

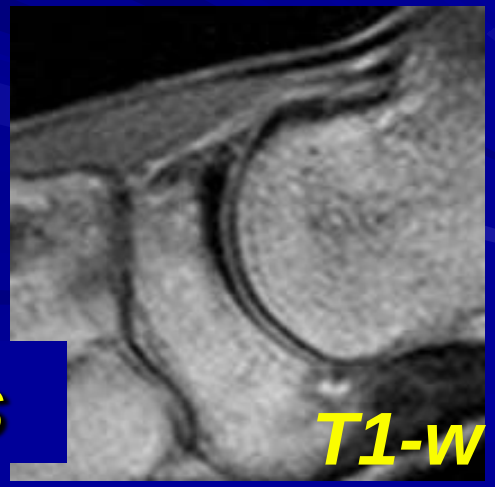
Chronic venous stasis

Bone marrow edema

Necrosis/bone bruise of the navicular bone?



Follow-up 6 months later



Transient migratory osteoporosis

Summary and Discussion

I. Anatomy

II. Pathologies

III. What pathologies are important at your level?