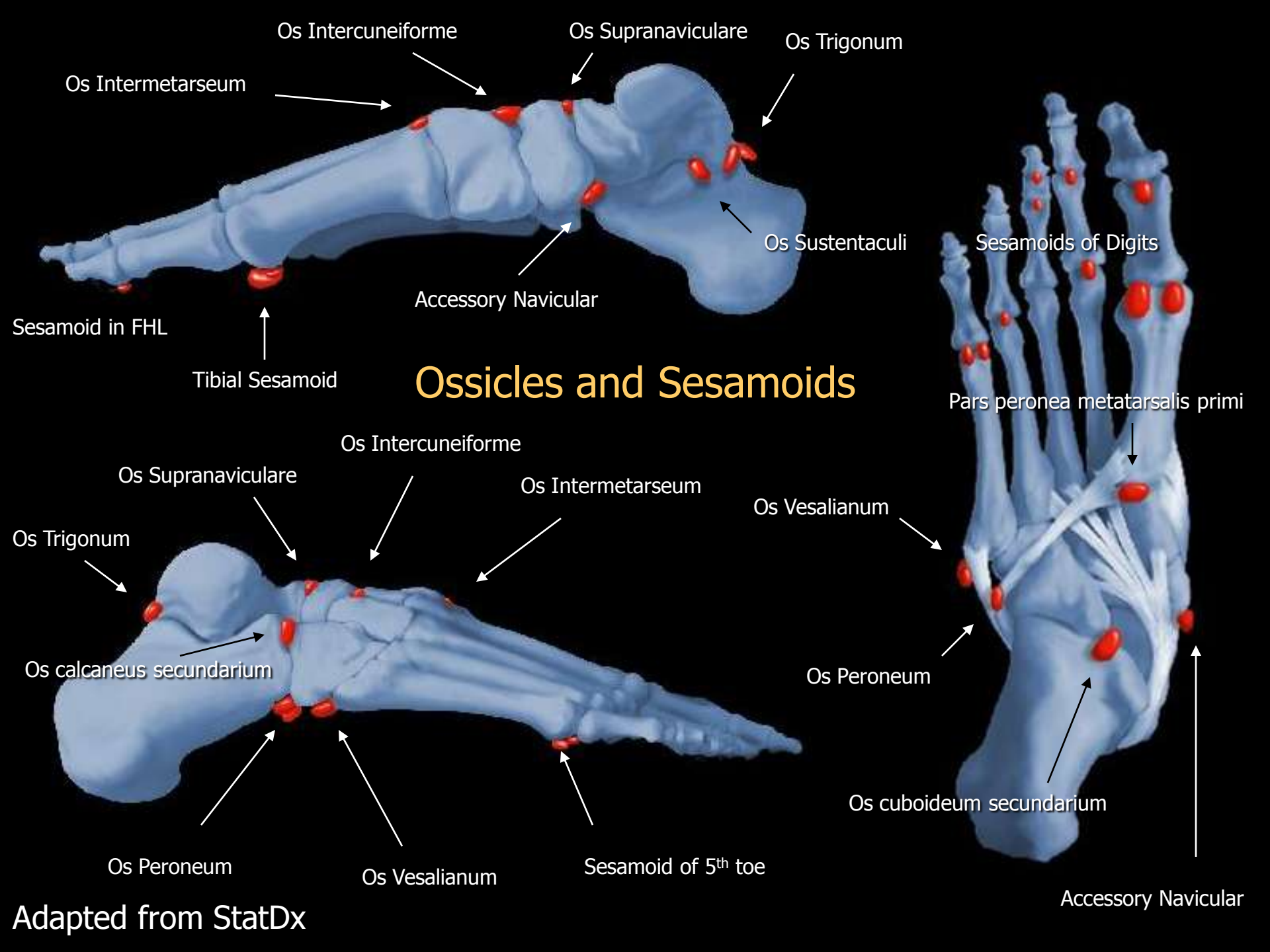
Accessory Ossicles and Sesamoids of the Foot and Ankle: Anatomy, Pathology and Pitfalls

Steve Chan MD

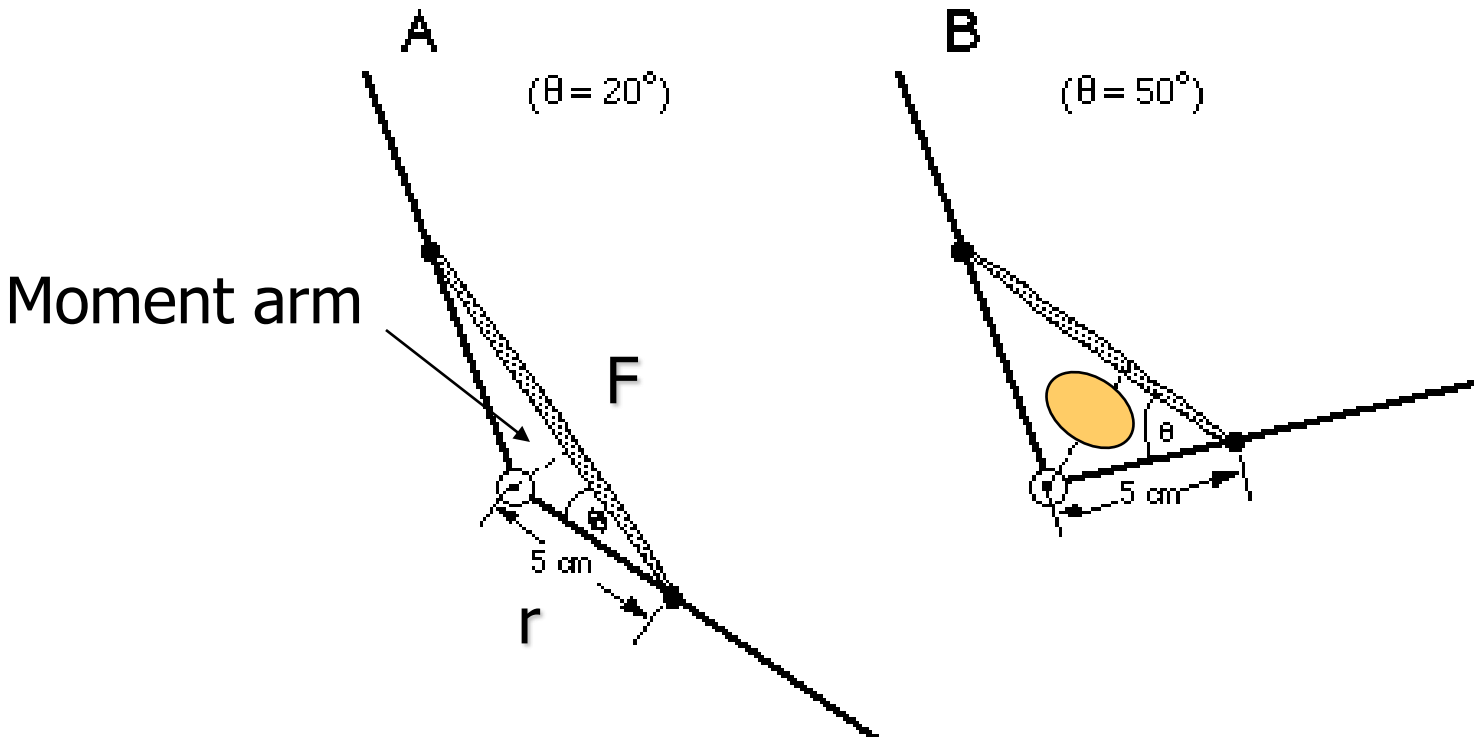

Os Intercuneiforme
Os Supranaviculare
Os Trigonum
Os Intermetarseum
Os Sustentaculi
Sesamoids of Digits
Accessory Navicular
Sesamoid in FHL
Tibial Sesamoid
Ossicles and Sesamoids
Pars peronea metatarsalis primi
Os Intercuneiforme
Os Supranaviculare
Os Intermetarseum
Os Vesalianum
Os Trigonum
Os calcaneus secundarium
Os Peroneum
Os cuboideum secundarium
Os Peroneum
Os Vesalianum
Sesamoid of 5th toe
Accessory Navicular
Adapted from StatDx

Sesamoids

Sesamoids

- Generally small bones partially or totally embedded within substance of corresponding tendon
- Function
  - Protects tendon
  - Increases distance of tendon from center joint, thus increasing moment arm
  - Prevents tendon from flattening against joint, thus maintaining more a uniform moment arm

Sesamoid Mechanics



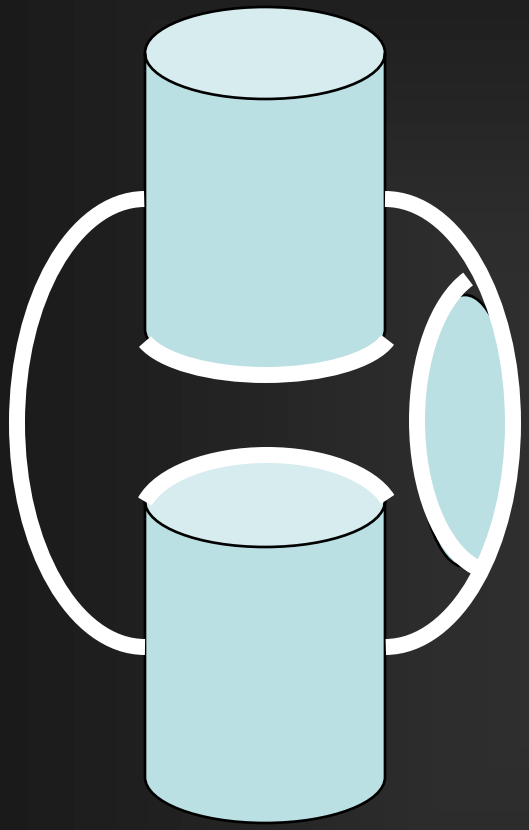
torque = F x (r)sinθ = force x moment arm

http://muscle.ucsd.edu/musintro/ma.shtml

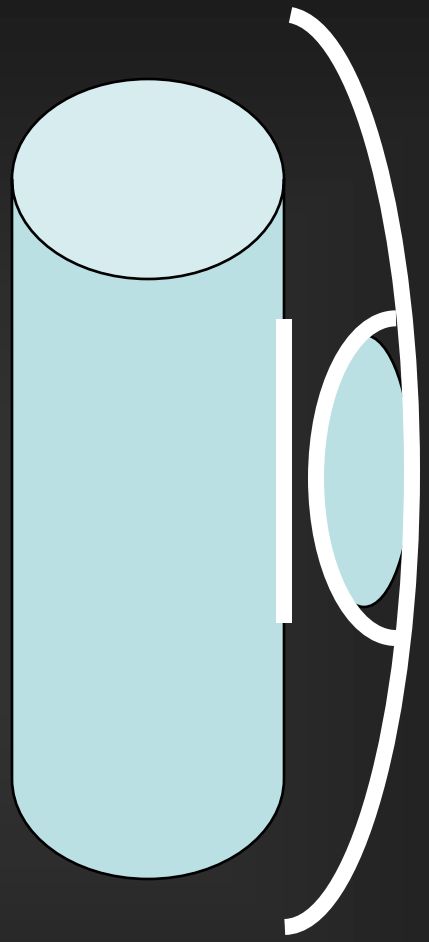
Sesamoids

- Type A – located adjacent to joint and its tendon is associated with joint capsule
  - Patella
  - Pollicis and Hallicis sesamoids
- Type B – located at sites where tendons are angled about bony surfaces; separated from underlying bone by synovium-lined bursa
  - Peroneus longus
  - Anterior tibialis @ medial surface of medial cuneiform
  - Posterior tibialis @ medial aspect of talus

Sesamoids



Type A – sesamoid located adjacent to an articulation



Type B – sesamoid separated from underlying bone by bursa


Hallux Sesamoids

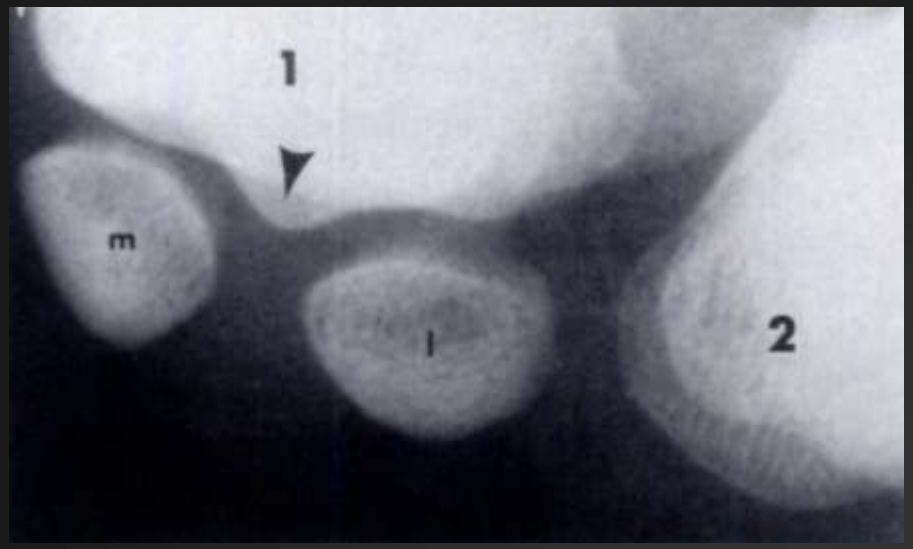
Hallux Sesamoid Bones

- Embedded within the medial and lateral slips of the flexor hallucis brevis tendon at the level of the first metatarsal head
- First metatarsal head has two surfaces with which the sesamoids articulate, and these are separated by an intersesamoidal ridge
- Metatarsosesamoid articulation is a true synovial joint; the articular surfaces are covered by hyaline cartilage and a plantar bursa is present on the medial side of the joint
- Medial (tibial) sesamoid is typically larger than the more rounded and smaller lateral (fibular) sesamoid

Hallux Sesamoid Function

- Provide mechanical advantage for the flexor hallucis brevis tendon via the elevation of the first metatarsal head
- Act as shock absorbers to the impact on the metatarsal head

Hallux sesamoid

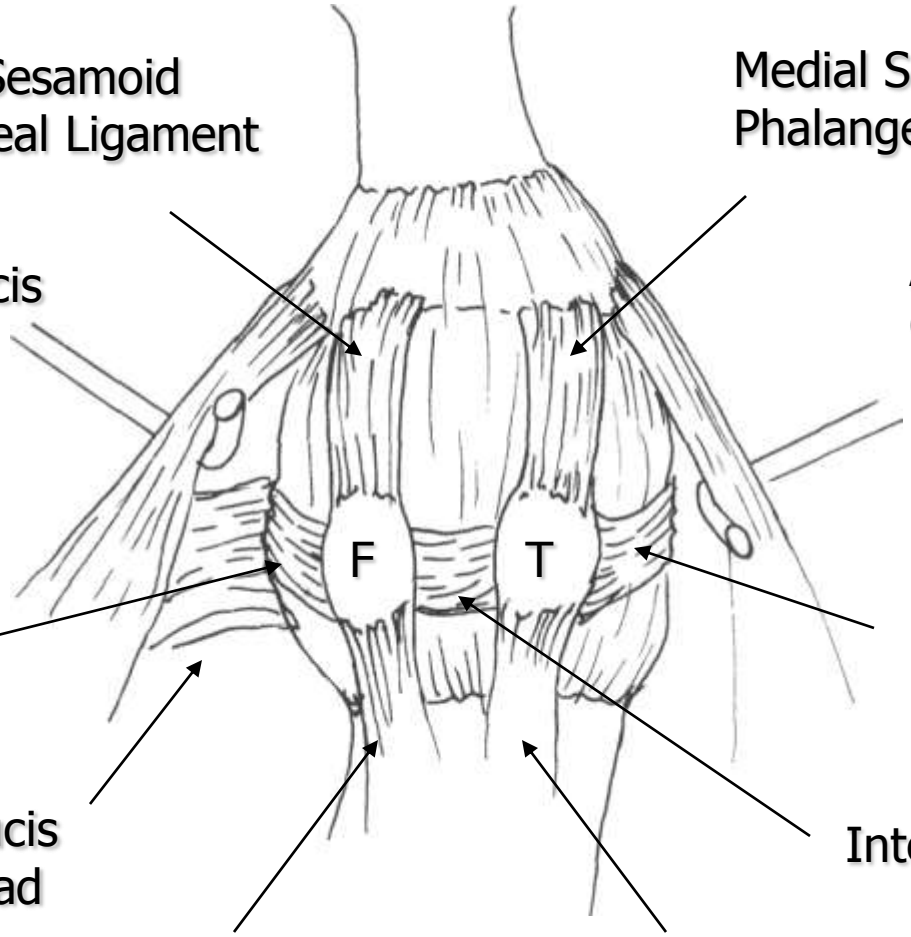


Normal anatomy. Dorsoplantar (a) and axial (b) radiographs reveal smooth, regular borders with regular, homogeneous bone opacity, l = lateral sesamoid bone, m = medial sesamoid bone, p = first proximal phalanx

Taylor et al. RadioGraphics 1993; 13:817-830

Anatomy

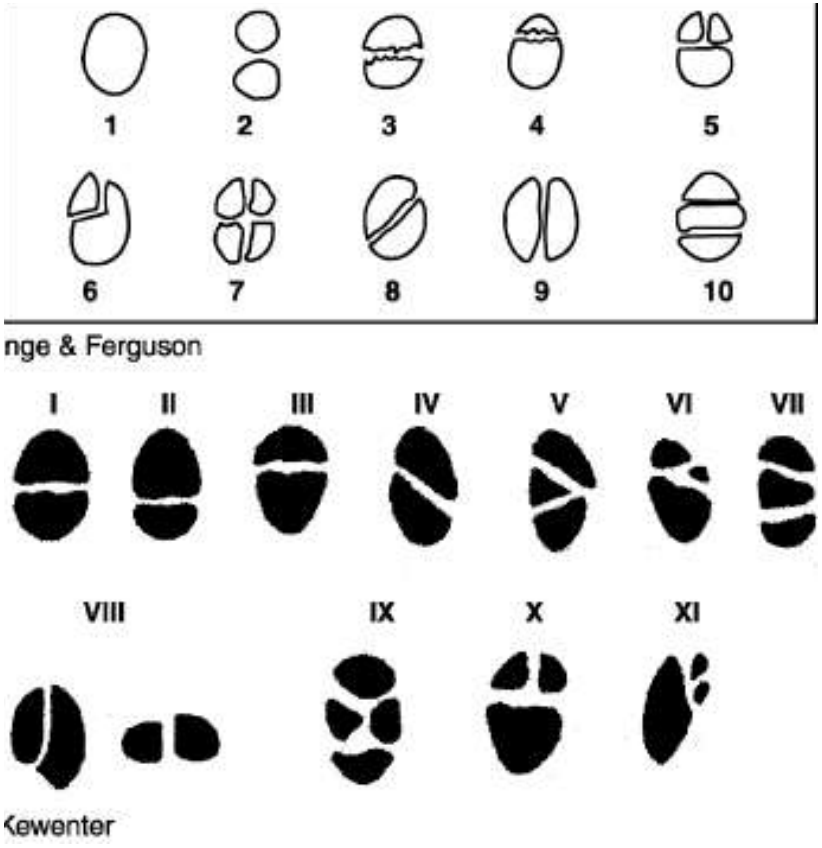
Hallux Sesamoid Complex



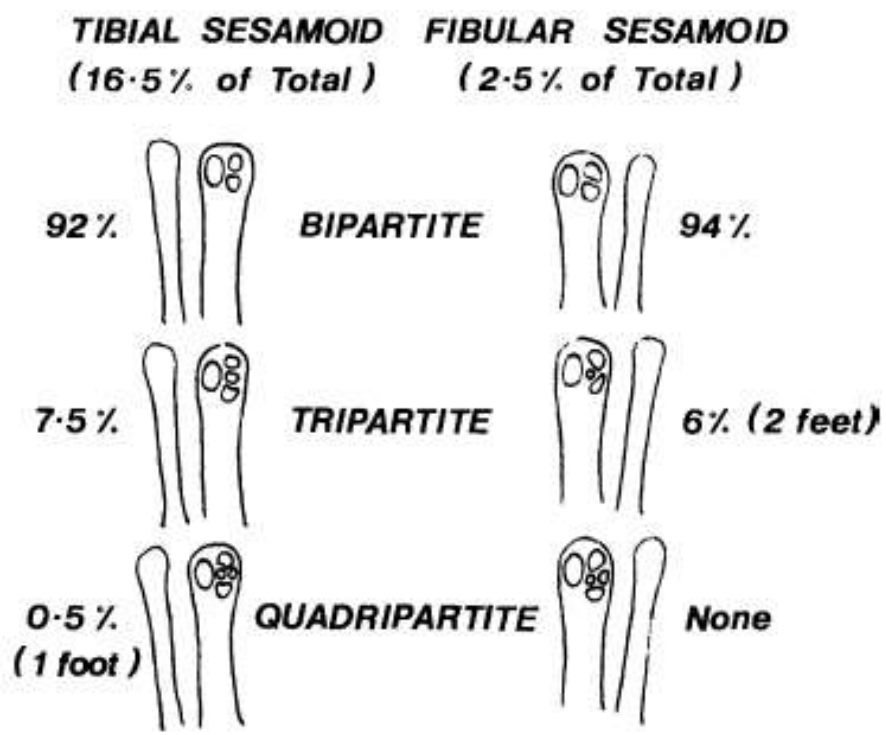
Adapted from McGlamery's Comprehensive Textbook of Foot and Ankle Surgery

Anatomy

Sesamoid Partition Variants



The different patterns of partition according to Kewenter and Inge and Ferguson.



Degree of partition. Overall, 16.5% of tibial, and 2.5% of fibular sesamoids were partite, making a combined incidence for both bones of 19%. Most of these were bi-partite, multi-partition being relatively uncommon, especially in the fibular sesamoid.

Karadaglis et al. Foot and Ankle Surgery 9 (2003) 165–167

Sesamoid Pathology

- Acute trauma
  - Osseous and soft tissue
- Chronic stress
  - Osteonecrosis, stress fractures, sesamoiditis
- Articular
  - Degenerative, RA, seronegative spondyloarthropathies
- Infectious

Trauma

- Usually related to sudden loading of the forefoot (e.g. jumping or fall from height)
- Fracture vs. partitioned sesamoid
  - Irregular, serrated line of division with sharp, pointed corners
  - Wide separation of the fragments or comminution
  - Callus formation or other signs of healing
  - Previous film showing no partition or closer approximation of the fragments
  - Bone size

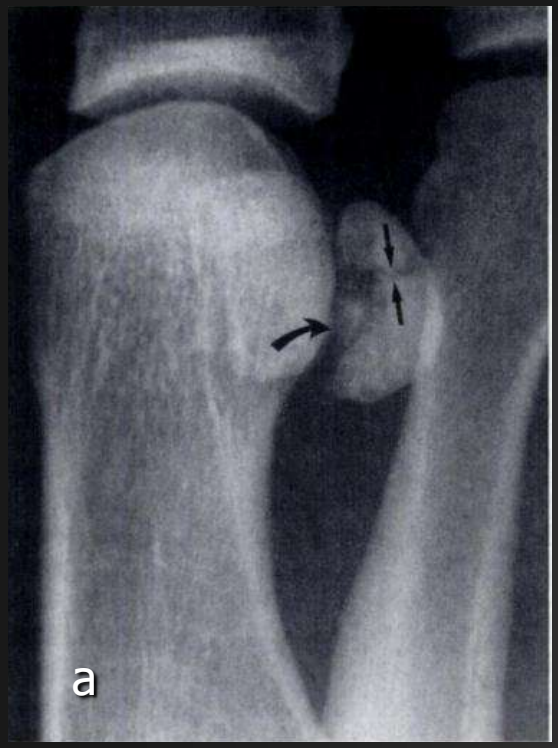
Acute Sesamoid Fracture

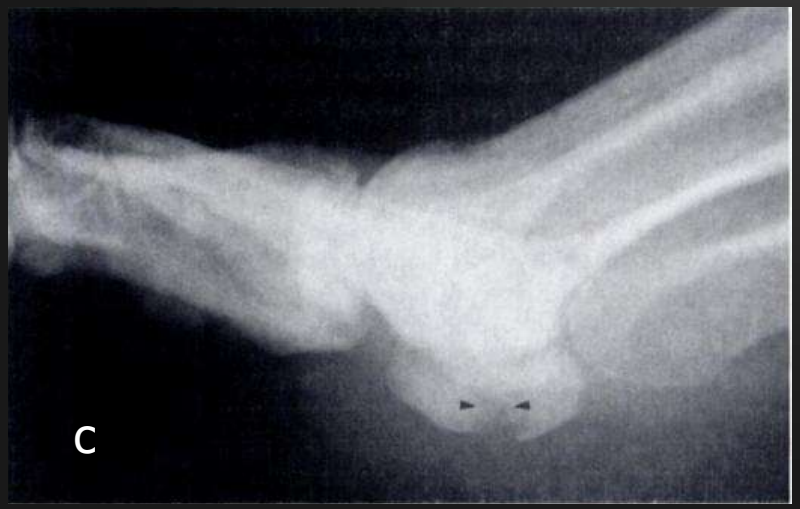
A 44-year-old woman with pain in the 1st metatarsophalangeal region. AP and lateral radiographs show a transverse fracture through the central portion of the tibial hallux sesamoid bone, with mild distraction of the 2 fragments (arrows).

Kalantari et al. Appl Radiol. 2007; 36(10):28-37

Pathology

Acute Sesamoid Fracture





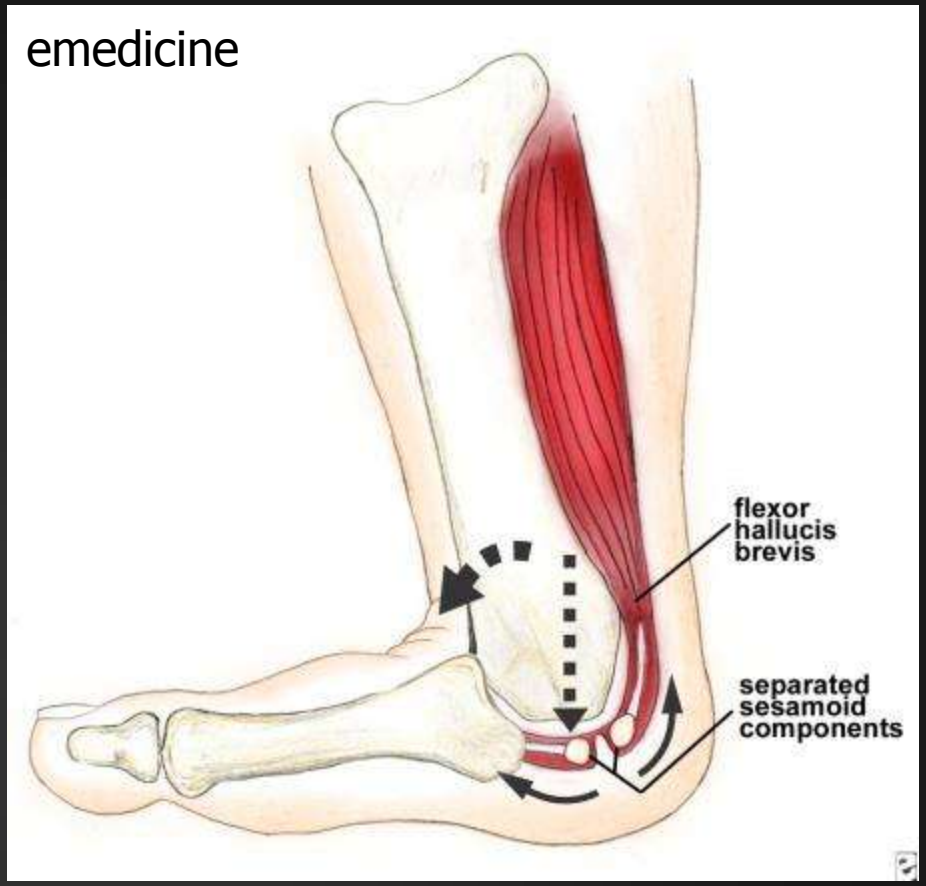
Sesamoid fractures. (a) Medial oblique radiograph reveals a transverse fracture (straight arrows) and a slight comminution (curved arrow) of the lateral sesamoid bone. The fracture cleft is jagged and irregular and lacks a sclerotic edge. (b, c) In another patient, medial oblique (b) and lateral (c) radiographs obtained 2 weeks after fracture of the medial sesamoid demonstrate widening of the fracture cleft from resorption (arrowheads), which normally occurs as an early sign of healing. Widening of the fracture cleft can also persist in cases of delayed union or nonunion.

Taylor et al. RadioGraphics 1993; 13:817-830

Pathology

Capsular-Ligamentous injury

Anteroposterior linear tomogram of a 24-year-old professional football player, following an acute hyperextension injury, shows diastasis of a bipartite medial sesamoid

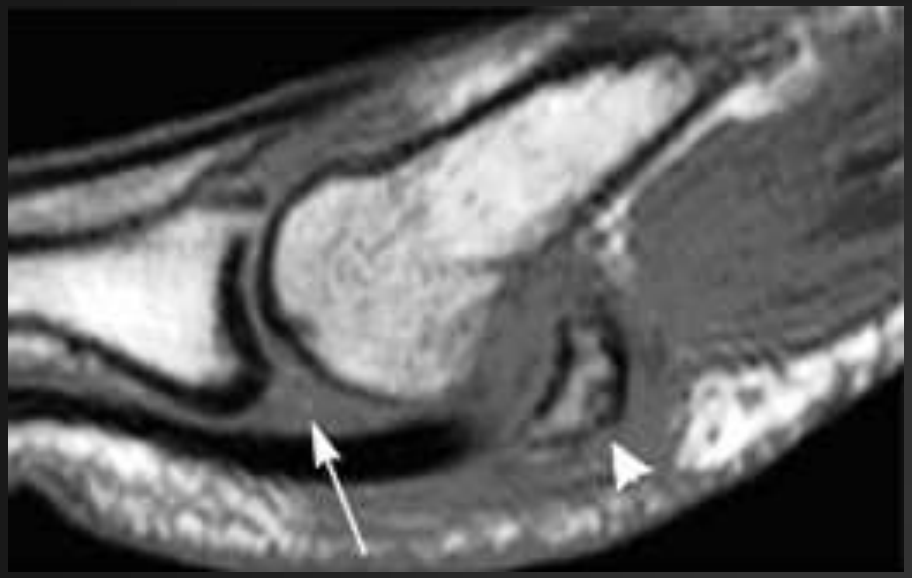


Metatarsophalangeal (MTP) joint hyperextension with tearing of the plantar plate complex. Unrestricted motion of the proximal phalanx results in severe compression of the articular surface of the metatarsal head along with separation of the sesamoid components.

Potter et al. Skeletal Radiol (1992) 21:437-444

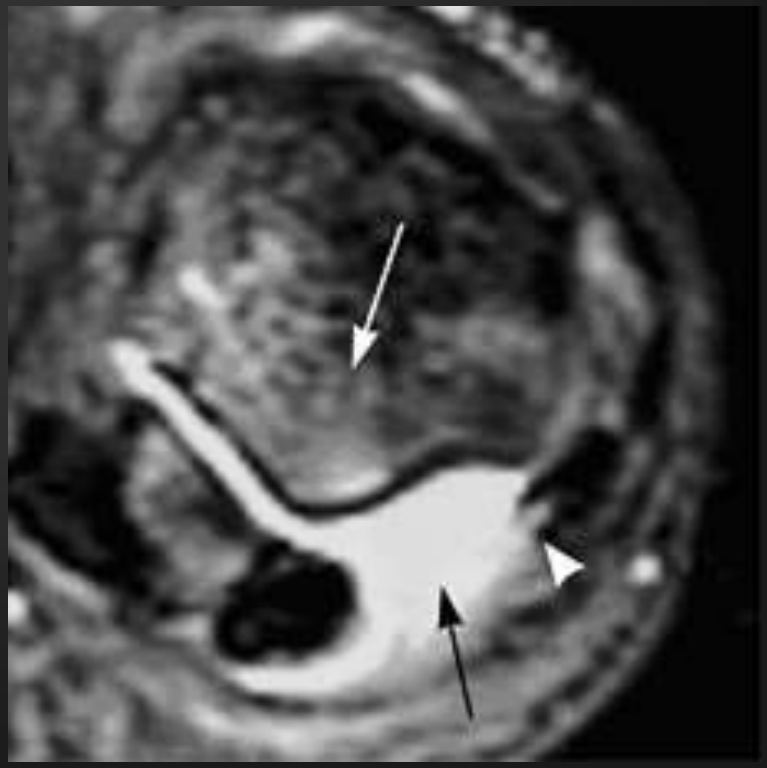
Pathology

Sesamoid Dislocation



A T1-weighted sagittal image of a patient following severe turf toe injury reveals ill-defined soft-tissue thickening and edema (arrow) throughout the region of the plantar plate. The medial sesamoid (arrowhead) is dislocated and displaced proximally.

Fluid fills the expected location of the medial sesamoid (black arrow) on a T2-weighted axial image obtained with fat-suppression. Edema is evident within the plantar aspect of the 1st metatarsal head (white arrow) and partial tearing is seen at the site where the abductor hallucis tendon would normally attach to the medial sesamoid (arrowhead).



http://www.radsource.us/rf/RADS/Internal.aspx?PID=401

Pathology

Rupture of Intersesamoid Ligament

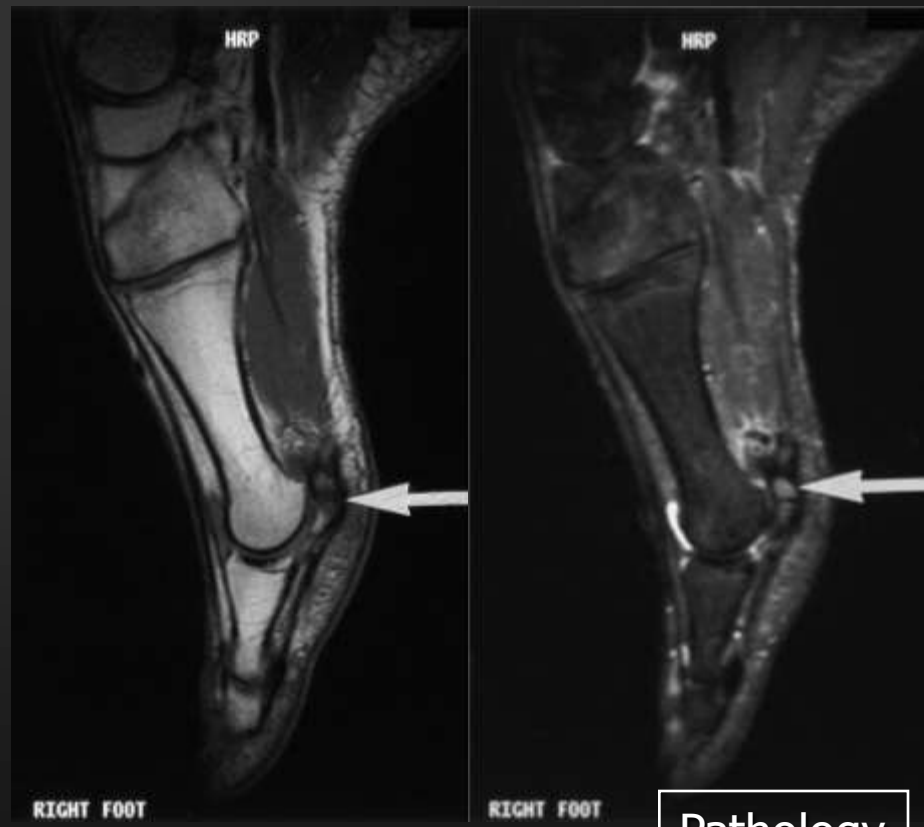
A 23-year-old male athlete with pain in the great toe following a football game. Coronal fast STIR image (TR/TE, 3250, 60 ef) demonstrates a ruptured intersesamoid ligament (asterisks) with increased distance between the sesamoids. Note the associated bone bruise of the first metatarsal head (arrow) with soft tissue swelling medially

Karasick et al. Skeletal Radiol (1998) 27:411–418

Pathology

Chronic Stress: Sesamoiditis

17-year-old female ballet dancer. (a) Sagittal spin echo T1 weighted MR image (TR/TE, 722/20) shows low T1 signal within the medial sesamoid. In addition there is a smooth break in the cortex of the sesamoid (arrow), in keeping with a bipartite sesamoid. (b) Sagittal short tau inversion recovery MR image (TR/TE/TI, 4655/30/130) shows high signal in the medial bipartite sesamoid (arrow) in keeping with sesamoiditis.



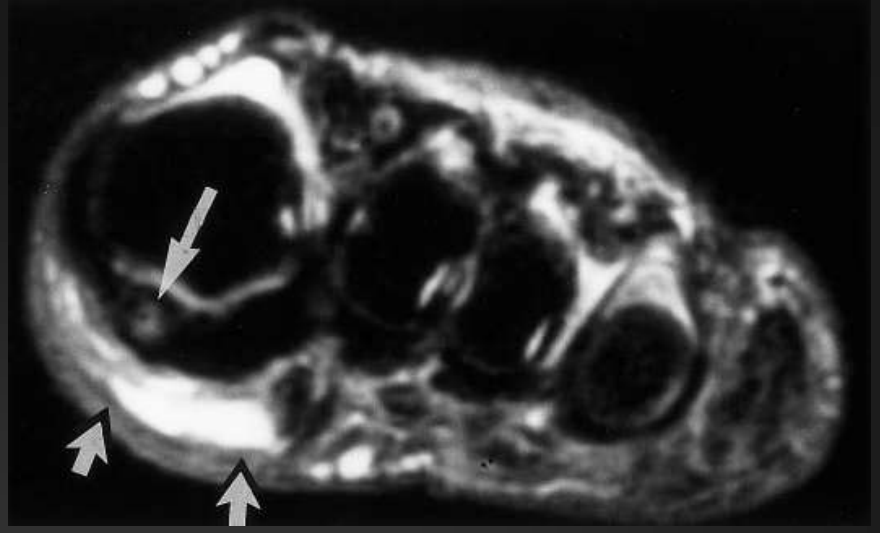
18-year-old female ballet dancer. Coronal spin echo T1 weighted MR image (TR/TE, 722/20) showing low signal in the medial sesamoid (arrow). Coronal short tau inversion recovery MR image (TR/TE/TI, 4655/30/130) showing high signal within the medial sesamoid in keeping with sesamoiditis

Hillier et al. The British Journal of Radiology, 77 (2004), 532–537

Pathology

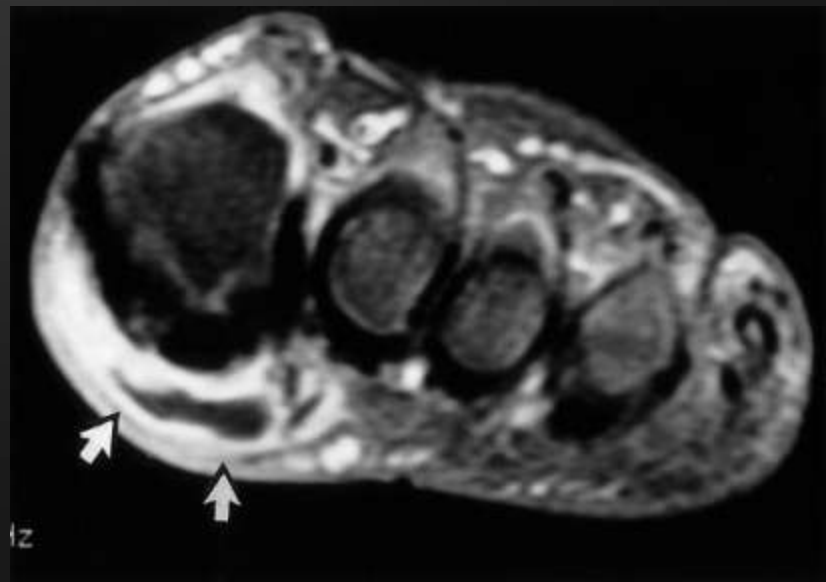
Sesamoiditis

Coronal T1-weighted MR image (TR/TE, 466/14) demonstrates marrow replacement of the tibial sesamoid (black arrow) as well as replacement of the subcutaneous fat (white arrows)



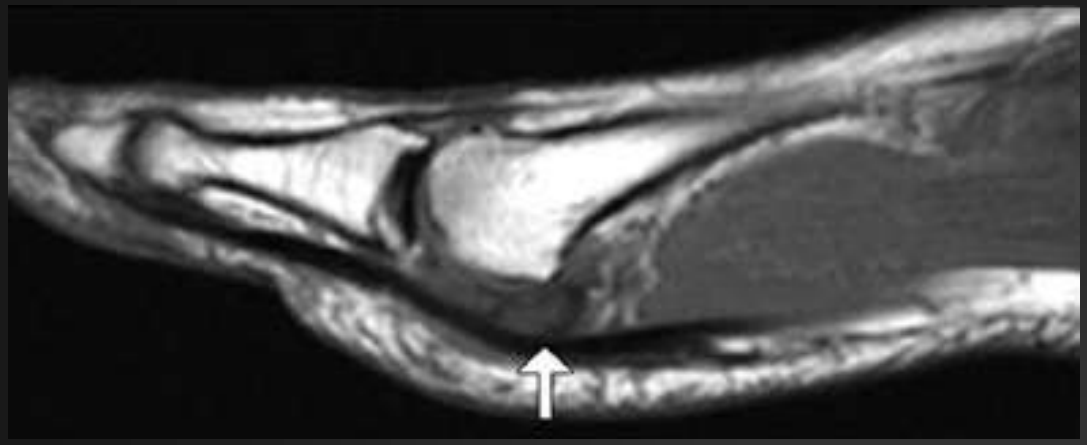
Coronal fast STIR MR image (TR/TE, 3033/48 ef) demonstrates marrow edema in the tibial sesamoid (large white arrow) compatible with sesamoiditis. A bursal fluid collection within the plantar subcutaneous fat (small white arrows) is also seen.

Coronal T1-weighted image (TR/TE, 683/14) following intravenous gadolinium administration shows rim enhancement around this fluid collection consistent with an adventitial bursitis (arrows).

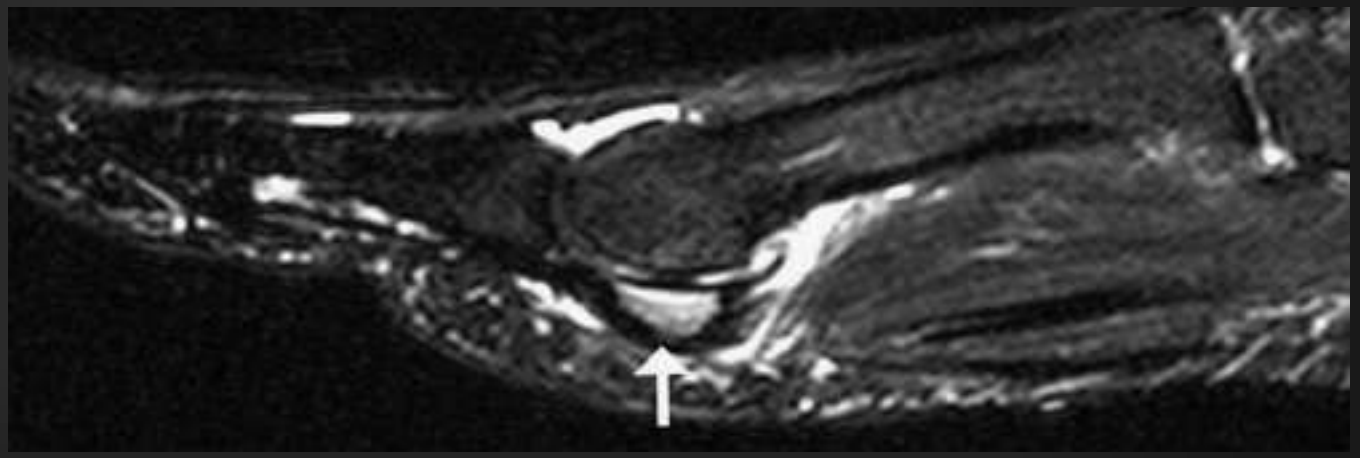


Karasick et al. Skeletal Radiol (1998) 27:411–418

Stress Fracture



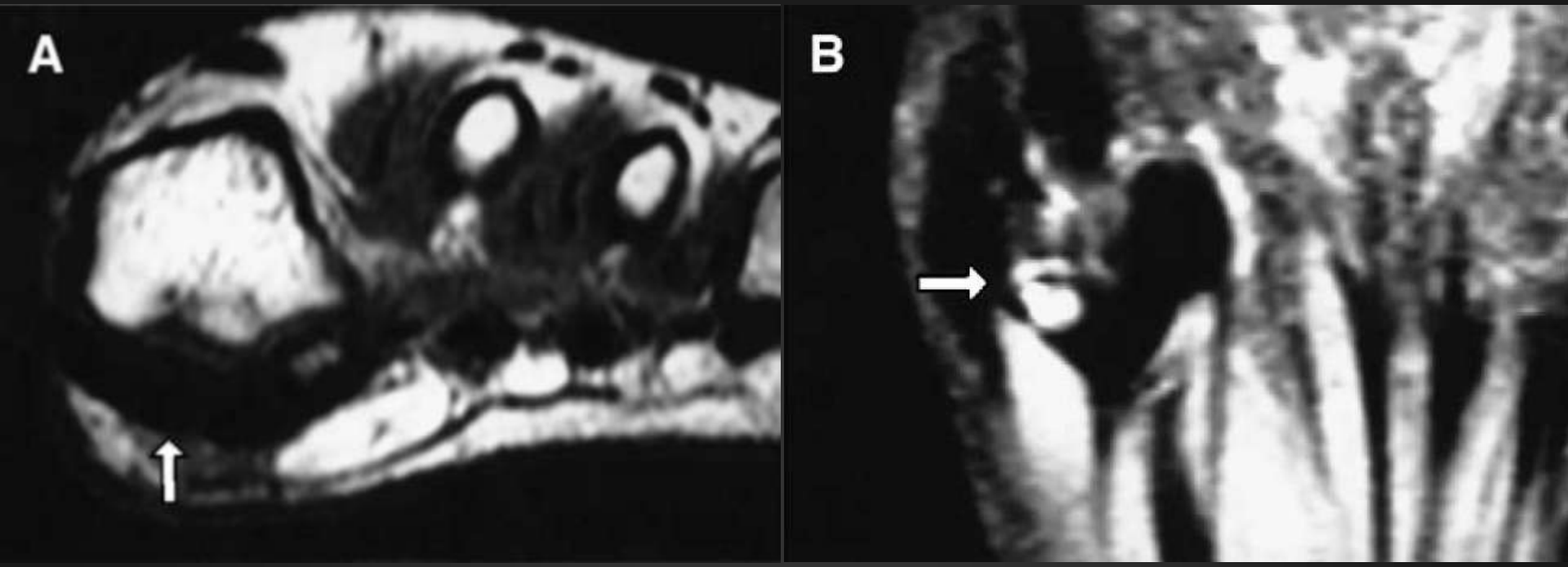
A 29-year old female competitive runner with foot pain. (A) Sagittal T1-weighted and (B) inversion recovery T2-weighted images show marrow edema in the hallux sesamoid bone (arrows), which is consistent with a stress fracture.



Kalantari et al. Appl Radiol. 2007; 36(10):28-37

Pathology

Stress Fracture



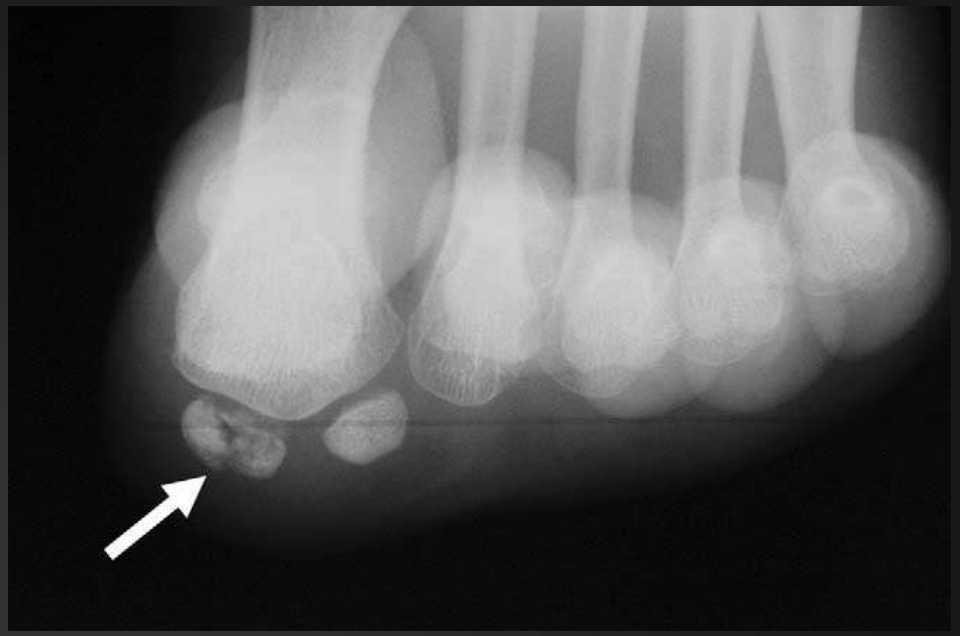
(A) Axial T1 SE. Medial sesamoid stress fracture. Seventeen-year-old runner with replacement of fat marrow signal by edema (arrow) related to the stress fracture. (B) Coronal T2 FSE fat-suppressed (FS), same patient. Medial sesamoid stress fracture. Transverse low signal line consistent with fracture plane (arrow).

Wall et al. Clin Sports Med 25 (2006) 781–802

Pathology

Osteonecrosis

Koulouris et al. Semin Roentgenol. 2005 Oct;40(4):358-79



Sesamoid avascular necrosis. Sesamoid view shows sclerosis and fragmentation of the tibial sesamoid (arrow) consistent with avascular necrosis

Axial radiograph showing post-traumatic osteonecrosis of the medial sesamoid in a 26-year-old woman

Potter et al. Skeletal Radiol (1992) 21:437-444

Pathology

Synchondrotic Degeneration

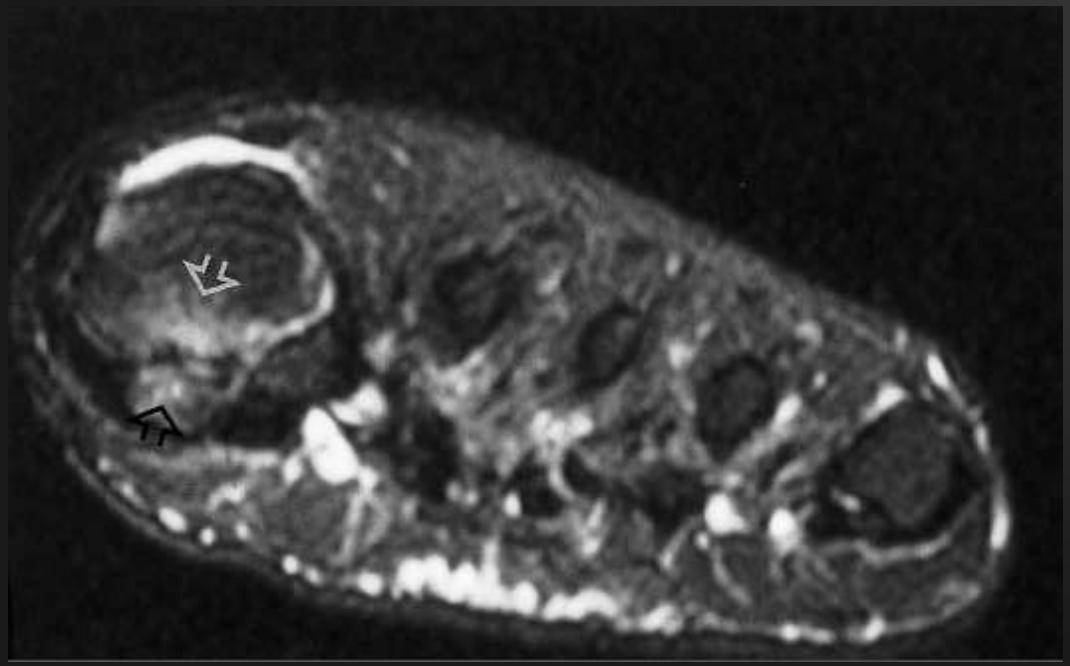
Dorsoplantar radiograph in a 47-year-old woman presenting with long-standing sesamoiditis in her right foot. A bipartite medial sesamoid is present (*arrowhead*). Mild cystic changes are found adjacent to the synchondrosis between the small (*long arrow*) and large (*short arrow*) components, consistent with synchondrotic degeneration.

Mellado et al. Eur Radiol (2003) 13:L164–L177

Pathology

Articular Disorders: Osteoarthritis

A 71-year-old woman with painful hallux valgus. A Coronal T1-weighted MR image (TR/TE, 550/11) demonstrates cystic areas (arrows) in the dorsal aspect of the tibial sesamoid and adjacent first metatarsal head.



Coronal fat-suppressed MR image (TR/TE, 3216/90 ef) shows increased signal in the cystic regions as well as adjacent bony edema (arrows). "Kissing" lesions, particularly when only a portion of the medullary cavity is involved, are consistent with osteoarthritis.

Karasick et al. Skeletal Radiol (1998) 27:411–418

Pathology

Degenerative

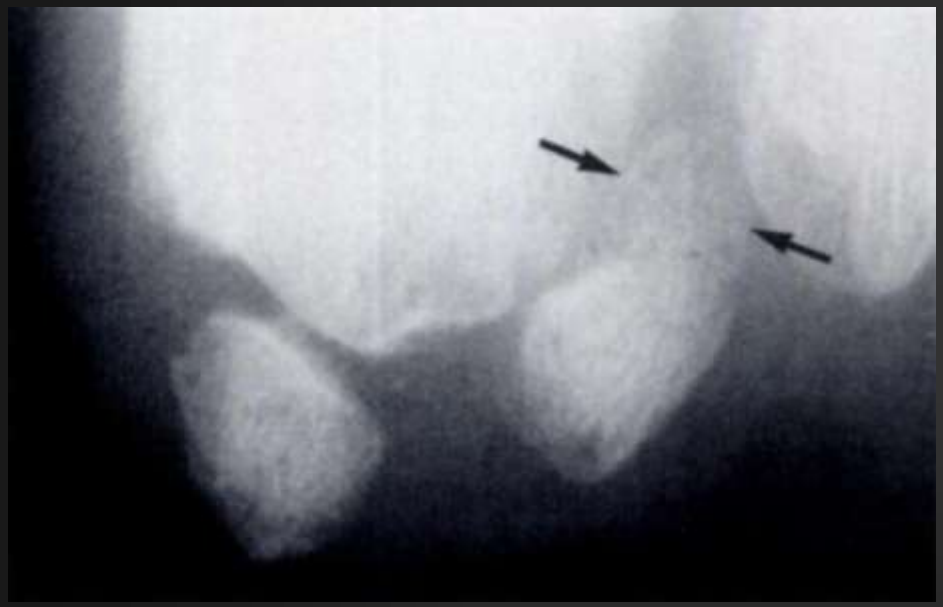
62-year-old woman referred for evaluation of calcaneal spur and Morton's neuroma. Coronal T1-weighted MR image of her left foot shows osteoarthritic changes in the lateral aspect of the hallux sesamoid complex, including joint space narrowing and altered signal intensity of the subchondral bone marrow, consistent with chondromalacia (*arrowheads*). Ill-defined thickening of the flexor tendons of the second toe is also noted (*arrow*), consistent with tendinopathy.

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

Pathology

Reiter Disease

Seronegative spondyloarthropathies. Axial radiograph of a patient with Reiter disease shows-ill defined enthesopathy arising from the lateral sesamoid bone (arrows).



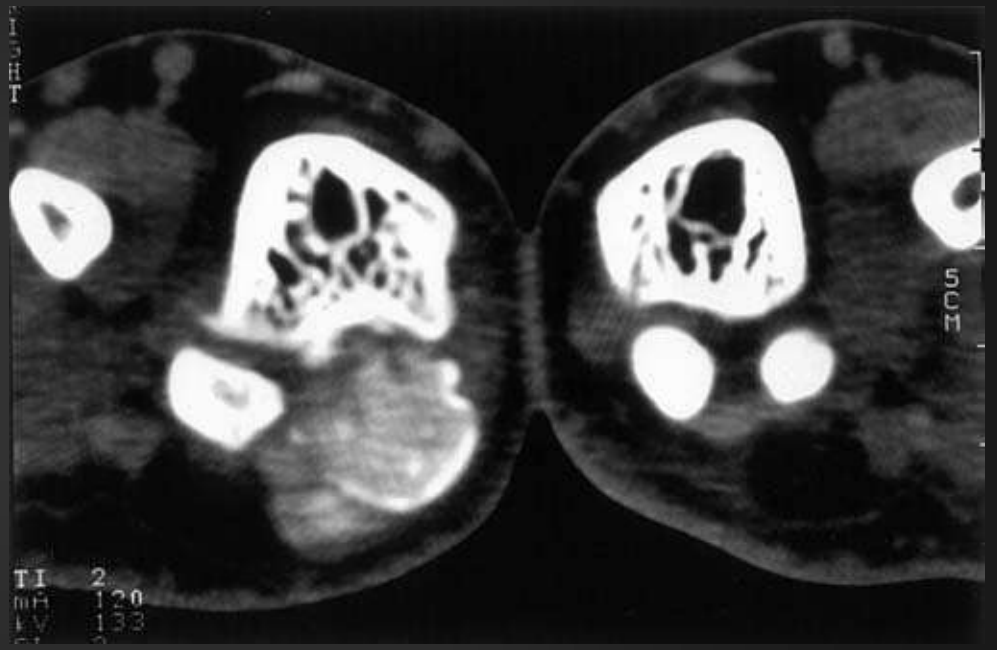
Dorsoplantar radiograph of another patient with psoriatic arthropathy shows extensive enthesopathy or whiskering, evident at the margins of the sesamoid bones (solid arrows) and in a periarticular distribution about the metatarsophalangeal joint (open arrows).

Taylor et al. RadioGraphics 1993; 13:817-830

Pathology

Intraosseous Gout in Sesamoid

Non-contrast CT scan of the lesion demonstrated focal cortical thinning; diffuse milky calcification with extension to plantar soft tissue, and small erosion of articular surface between first metatarsal head and medial hallux sesamoid



Liu et al. Skeletal Radiol (2003) 32:647–650

Idiopathic hyperuricemic teenager (19yo) complicated with a solitary intraosseous gouty tophus in medial hallux sesamoid mimicking a bone tumor. Lateral (A) and axial (B) projections of the hallux sesamoids show an expansive osteolytic lesion of the medial hallux sesamoid with focal cortical erosion of the cortex (*arrows*).

Pathology

Infection

Osteomyelitis and septic arthritis. Frontal radiograph shows severe demineralization and loss of cortical definition of the medial sesamoid (straight arrows). Associated metatarsophalangeal joint-space narrowing (arrowheads) and periarticular erosions (curved arrows) are also evident.

Taylor et al. RadioGraphics 1993; 13:817-830

Osteomyelitis

A 45-year-old man with diabetic foot ulcer. A Coronal T1-weighted MR image (TR/TE, 500/11) demonstrates marrow replacement of the tibial sesamoid (arrow) with incomplete marrow replacement of the fibular sesamoid (arrowhead).

Fat-suppressed coronal T1-weighted MR images (TR/TE, 450/11) following intravenous gadolinium administration show intense enhancement of the fibular sesamoid (arrowhead), as well as enhancement of the tibial sesamoid (arrow). Sesamoid resections confirmed the presence of osteomyelitis.

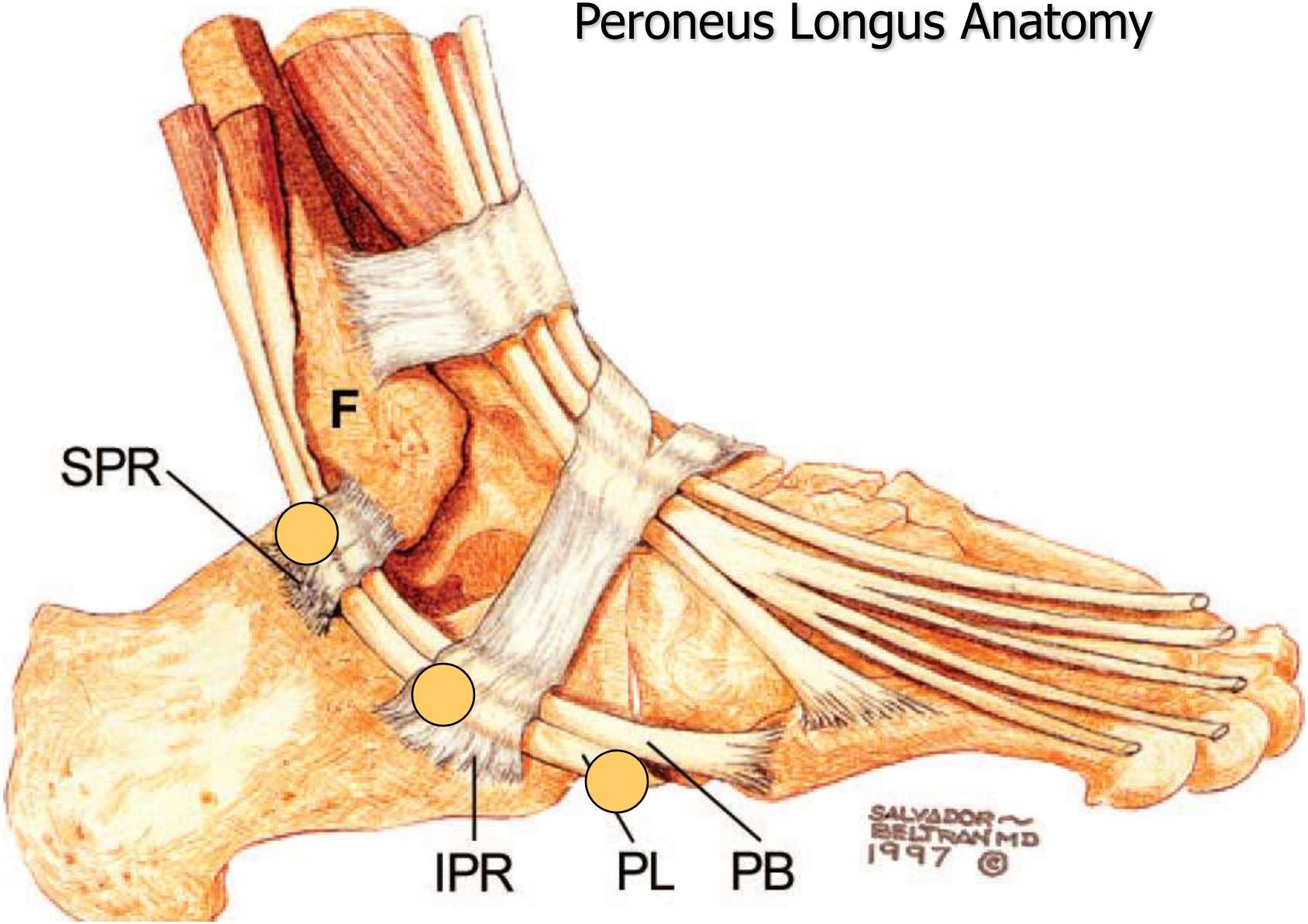
Karasick et al. Skeletal Radiol (1998) 27:411–418

Os Peroneum

Os peroneum

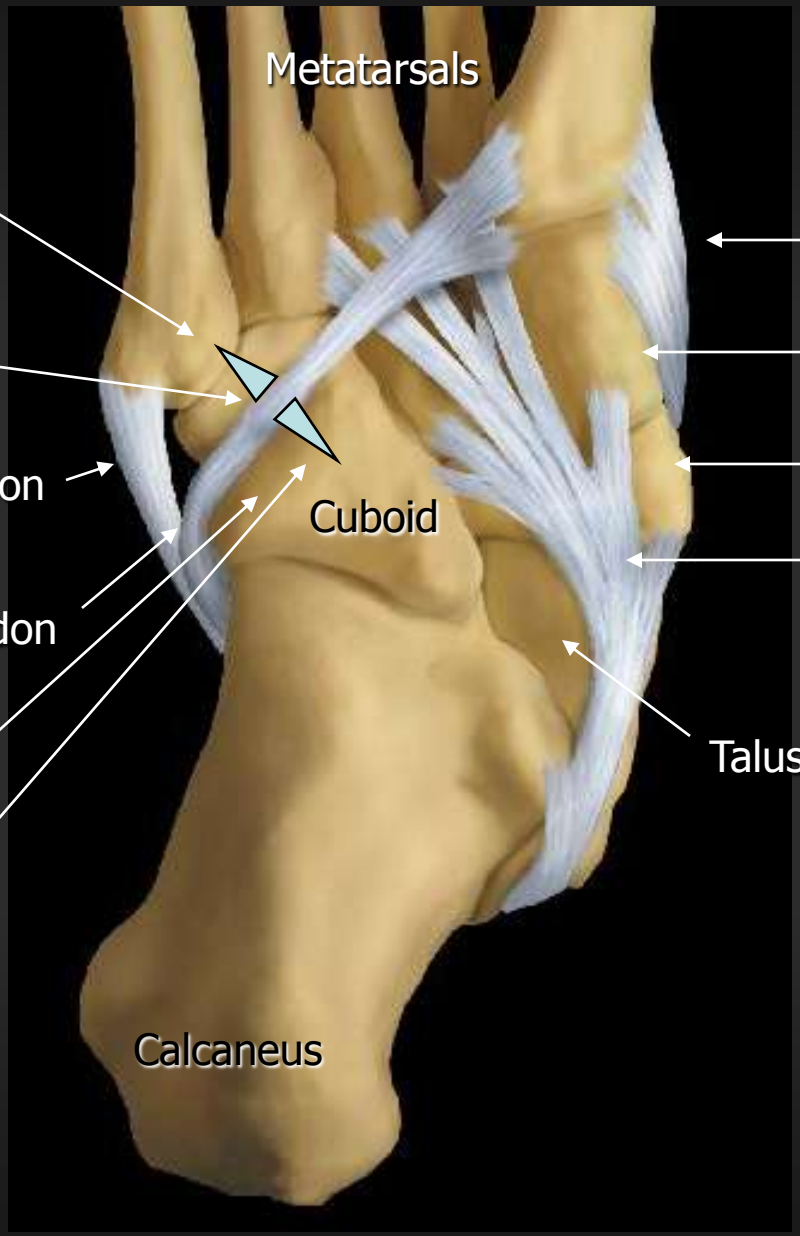
- Sesamoid (bone, cartilage or fibrocartilage) embedded within peroneus longus tendon
- May be bipartite or multipartite
- Location:
  - Lateral edge of cuboid (point where peroneal tendon changes direction)
  - Sesamoid may rarely in retromalleolar or calcaneal portion of peroneus longus
- Frequency: 9% in ankles

Peroneus Longus Anatomy



Wang et al. RadioGraphics 2005; 25:587–602

Anatomy



Adapted from StatDx

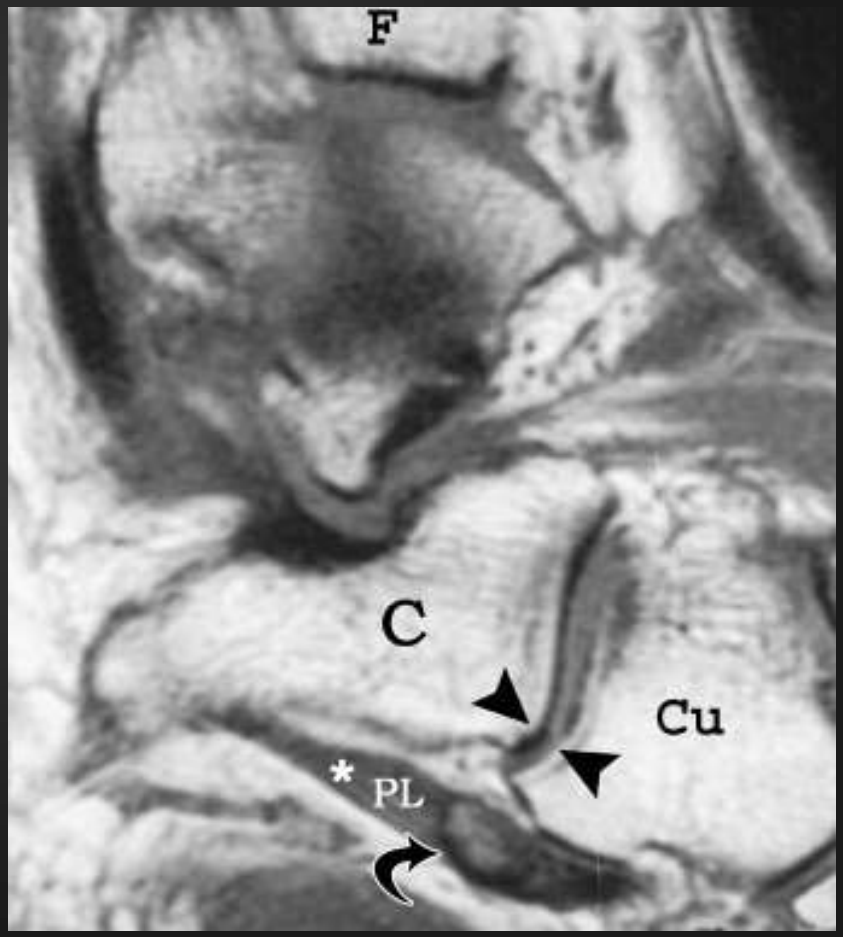
Anatomy

Os Peroneum

Incidental os peroneum in a 32-year-old patient with a history of repetitive ankle sprains. The oblique radiograph reveals a small os peroneum (*arrow*) adjacent to the calcaneocuboid joint

Mellado et al. Eur Radiol (2003) 13:L164–L177

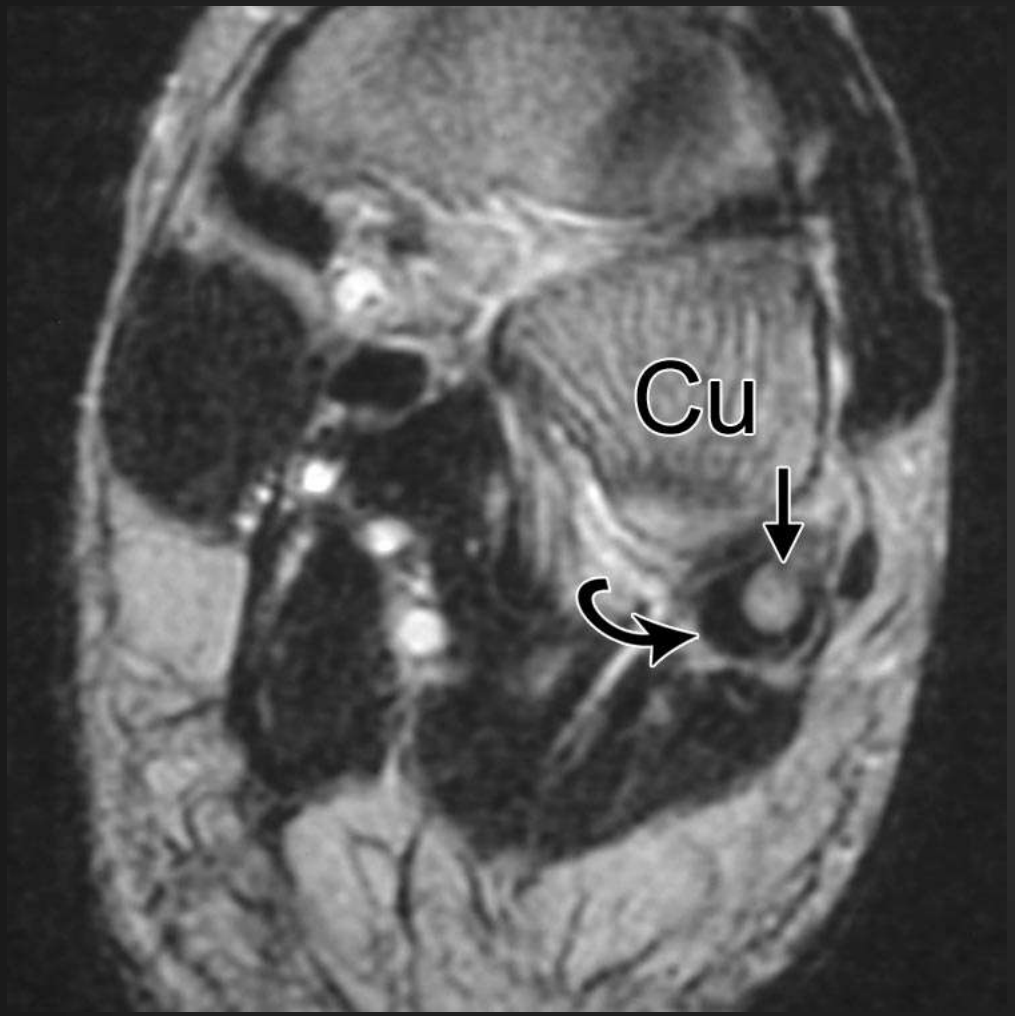
Sagittal T1-weighted MR image (500/14) show the normal os peroneum (curved arrow) at the level of the calcaneocuboid joint (arrowheads) within the substance of the peroneus longus tendon (*).



Brigido et al. Radiology 2005;237:235-241

Anatomy

Os Peroneum



Oblique coronal T2-weighted MR image shows the os peroneum (straight arrow), which should not be mistaken for a peroneus longus tendon tear. The peroneus longus tendon (curved arrow) is normal. *Cu* cuboid bone.

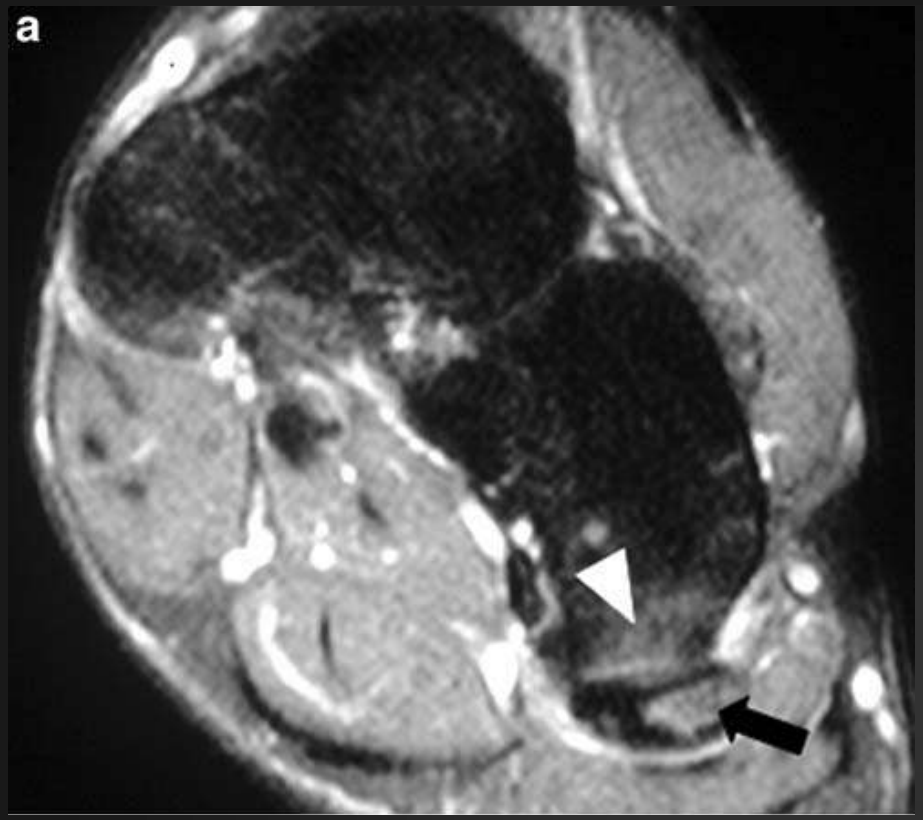
Wang et al. RadioGraphics 2005; 25:587–602

Anatomy

Os Peroneum

- Painful Os Peroneum Syndrome
  - Os peroneum fracture / hypertrophic healing of fractured os peroneum
  - Diastasis of a bipartite os peroneum
  - Attrition or tear of the peroneus longus tendon proximal or distal to the sesamoid bone
  - Enlarged peroneal tubercle

Os Peroneum Friction Syndrome



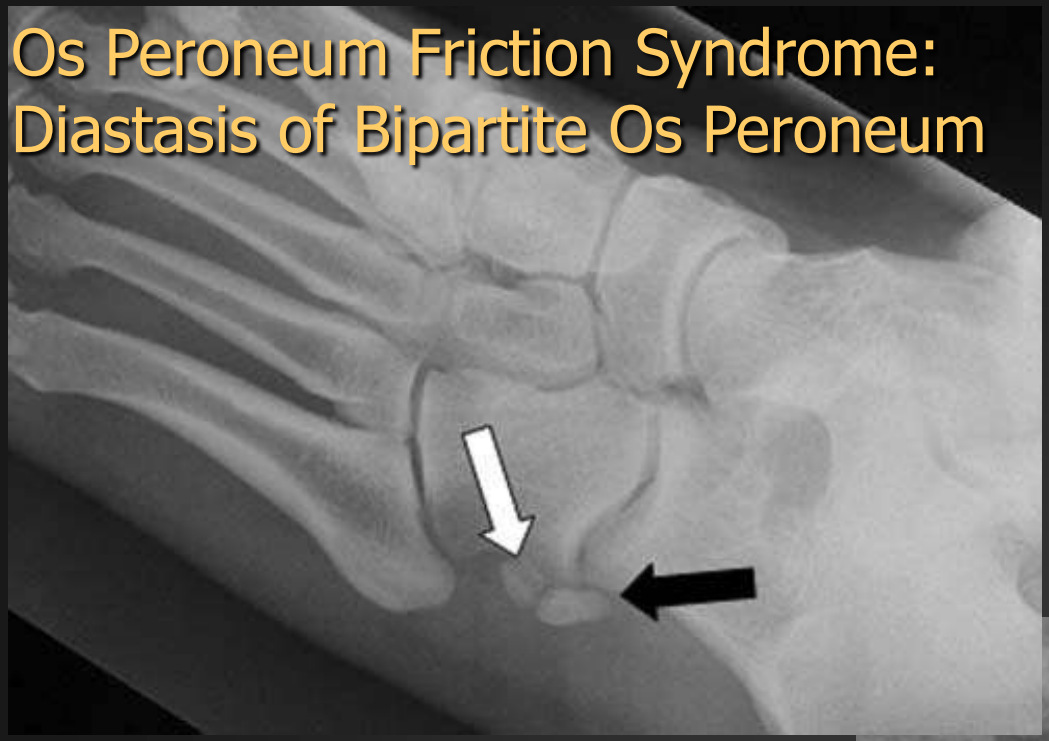
Sagittal STIR image showing bone marrow edema in the bipartite os peroneum (white arrow) and the adjacent cuboid (lower black arrow) and calcaneus.

19-year-old professional footballer complaining of discomfort on the lateral aspect of both his feet, slightly worse on the left side. Axial STIR imaging shows edema of the os peroneum (black arrow) and the adjacent left calcaneus (white arrowhead)

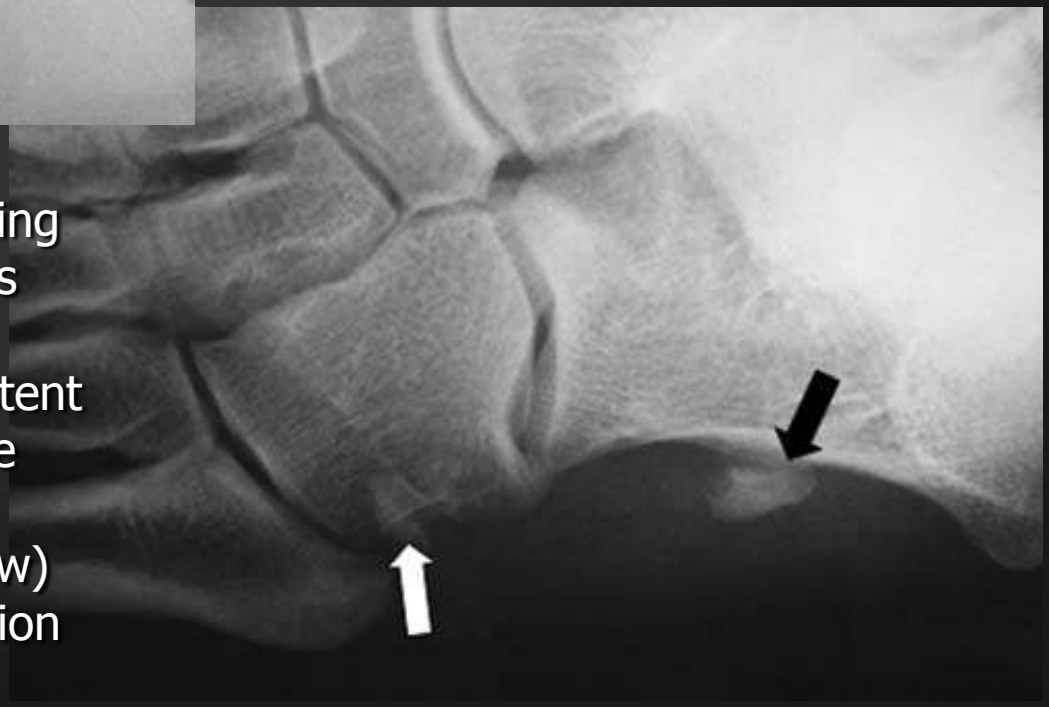
Bashir *Skeletal Radiol* (2009) 38:181–186

Pathology

Os Peroneum Friction Syndrome: Diastasis of Bipartite Os Peroneum



Oblique radiograph of the left foot showing both moieties (black arrow = proximal moiety and white arrow = distal moiety) of the normal bipartite os peroneum with well-defined corticated contours at the level of the calcaneocuboid articulation



Oblique radiograph of the left foot showing the previously well corticated bipartite os peroneum now in two distinct separate fragments with irregular contours consistent with fracture of the sesamoid bone. Note that the proximal moiety is now at the region of the mid calcaneum (black arrow) and the distal moiety remains at the region of the cuboid bone (white arrow)

Bashir *Skeletal Radiol* (2009) 38:181–186

Pathology

Os Peroneum Fracture

Images in 56-year-old woman with fracture of os peroneum and full-thickness tear of peroneus longus tendon.

Oblique radiograph of foot show diastasis of os peroneum fragments (arrows). The fragments were separated by 10 mm, and the distance from the most posterior fragment to the calcaneocuboid joint was 22 mm.

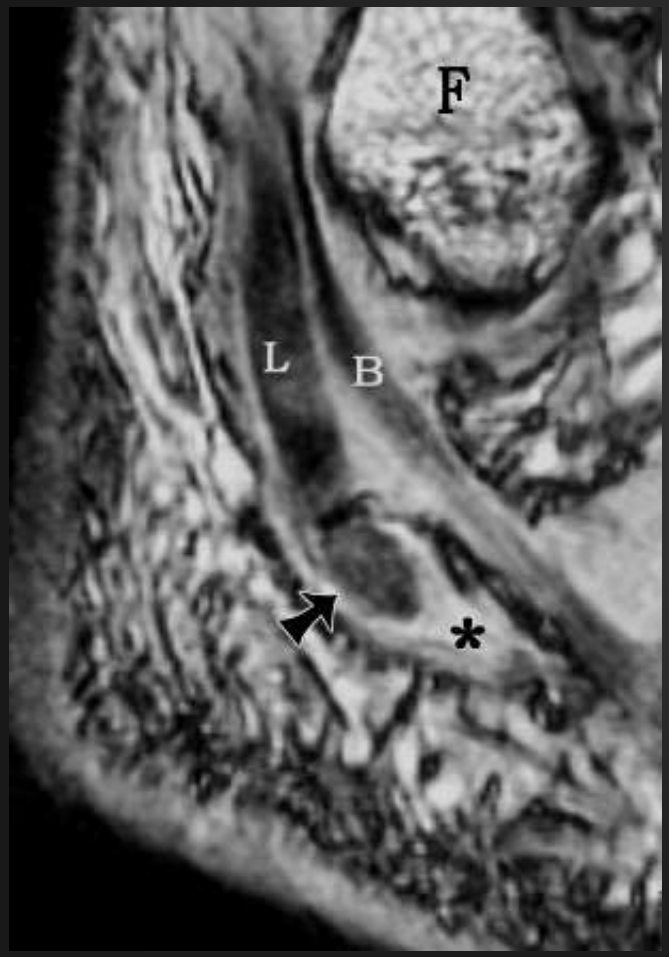
Brigido et al. Radiology 2005;237:235-241

Sagittal T2-weighted fat-saturated MR image (3500/90) shows the two most proximal os peroneum fracture fragments (arrows). The small distal fragment was not well visualized. Note the fluid signal intensity at the site of the tear (*) and in the proximal fracture fragments

Pathology

Os Peroneum Fracture

Images in 35-year-old man with os peroneum fracture and full-thickness peroneus longus tendon tear.



Oblique radiograph of foot show diastasis of os peroneum fragments (arrows). The greatest degree of fragment separation was 25 mm, and the distance from the most posterior fragment to the calcaneocuboid joint was 45 mm.

Oblique sagittal T1-weighted gradient-echo MR image (500/14) shows the most proximal os peroneum fracture fragment (arrow). The small distal fragments were not well visualized. Note fluid signal intensity at the site of the tear (*) and the marrow replacement of the proximal fracture fragment.

Brigido et al. Radiology 2005;237:235-241

Pathology

Os Peroneum Fracture

Images in 42-year-old man with fracture of os peroneum and full-thickness peroneus longus tendon tear. Lateral radiograph of foot shows diastasis of os peroneum fragments (arrows). The fragment separation was 80 mm, and the distance from the most posterior fragment to the calcaneocuboid joint was 75 mm.

Brigido et al. Radiology 2005;237:235-241

Sagittal T1-weighted MR image (500/14) and sagittal T2-weighted MR image (3500/90) show the most proximal fracture fragment (arrow) and the site of the tendon tear (*). Note fluid signal intensity at the site of the tear and the marrow replacement of the proximal fracture fragment, which has retracted to the level of the tibiotalar joint

Pathology

Ossicles

Ossicles

- Commonly derive from unfused accessory ossification centers
- May appear to be normal subdivisions of ordinary bones or nearby additional free elements
- Most common accessory ossicles of the ankle and foot
  - Os trigonum
  - Accessory navicular
  - Os intermetatarseum

Os Trigonum

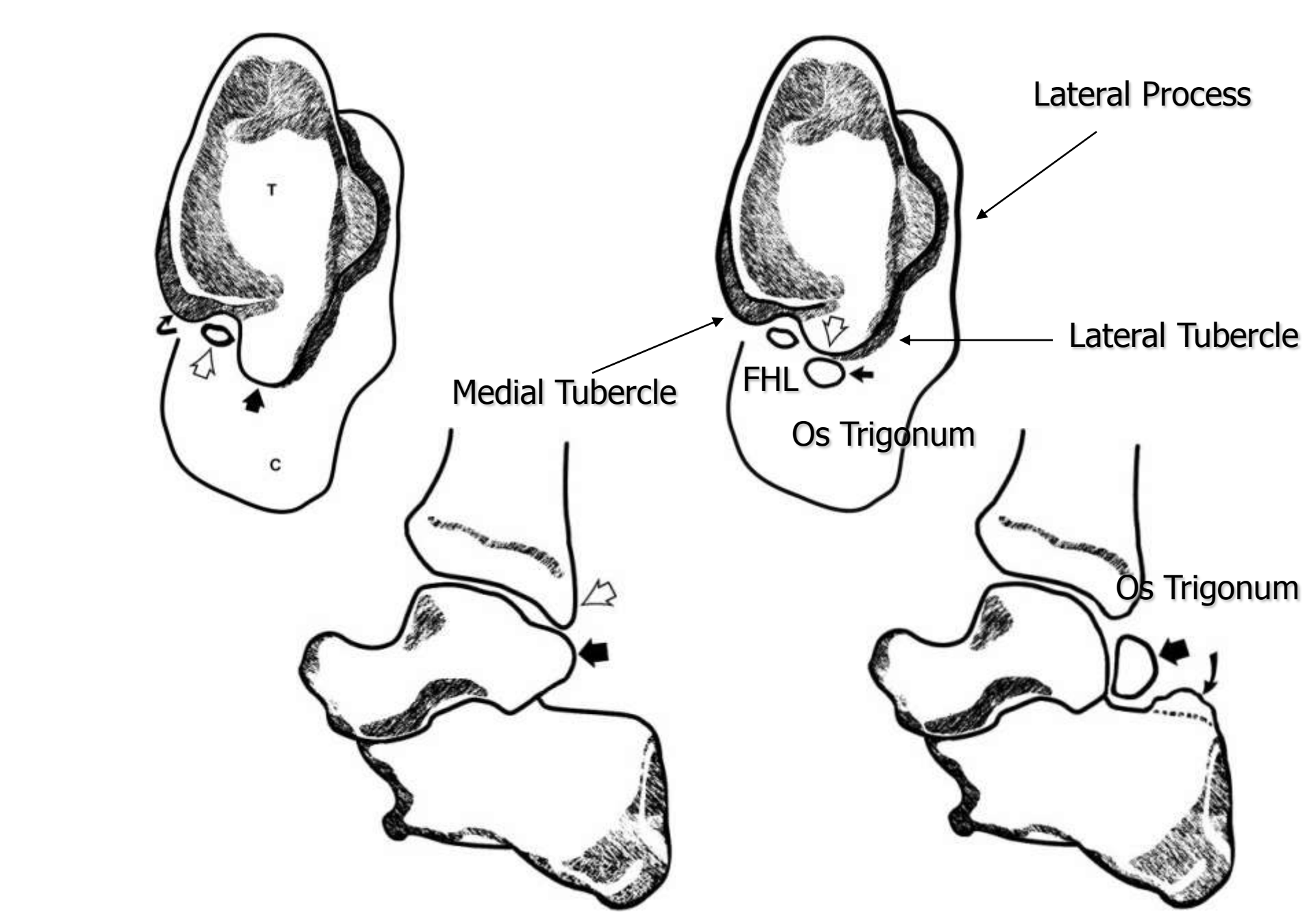
Os Trigonum

- Location: secondary ossification formed within cartilaginous extension in posterior portion of the talus
  - Appears between 7 and 13 years; usually fuses with the talus within 1 year, forming trigonal (Stieda) process
  - Os trigonum likely derives from failure of secondary ossification center to fuse
- Frequency: 1-25%

Anatomy

Os Trigonum

- 3 surfaces: anterior, inferior and posterior
  - Anterior surface connects with the lateral tubercle by cartilaginous synchondrosis
  - Inferior surface may articulate with the calcaneus at the posterior subtalar joint
  - Posterior surface is nonarticular but serves as a point of attachment for capsuloligamentous structures, in particular the posterior talofibular and posterior talocalcaneal ligaments



Bureau et al. *Radiology* May 2000

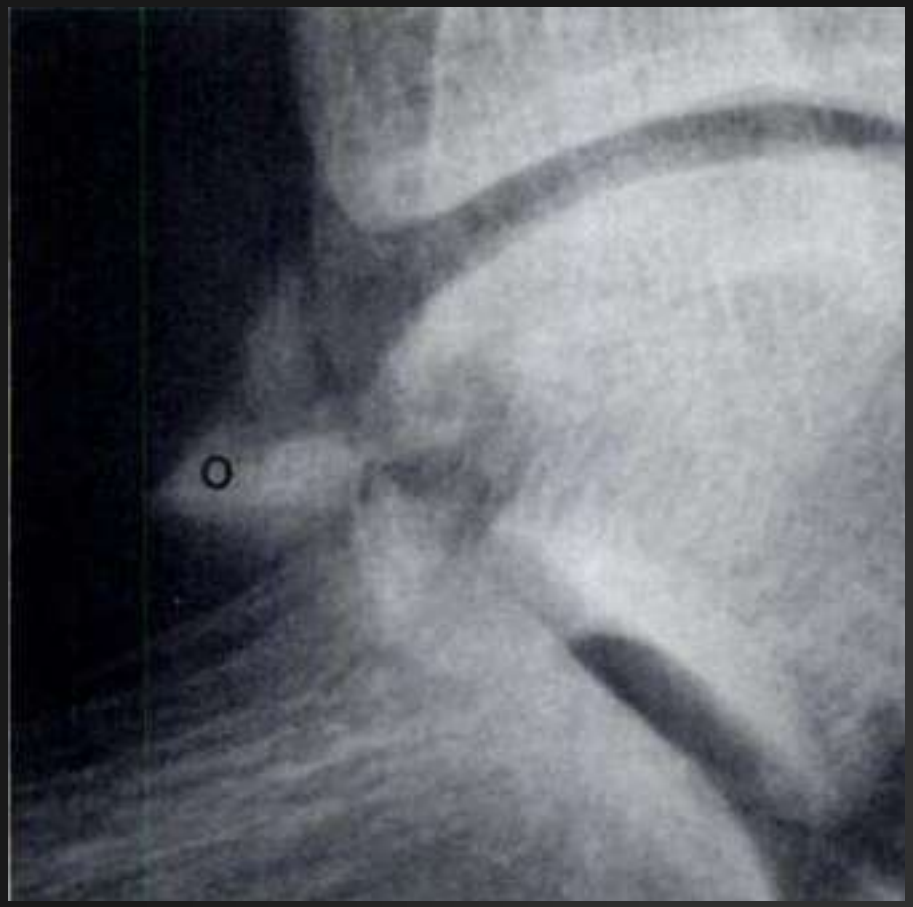
Anatomy

Os Trigonum

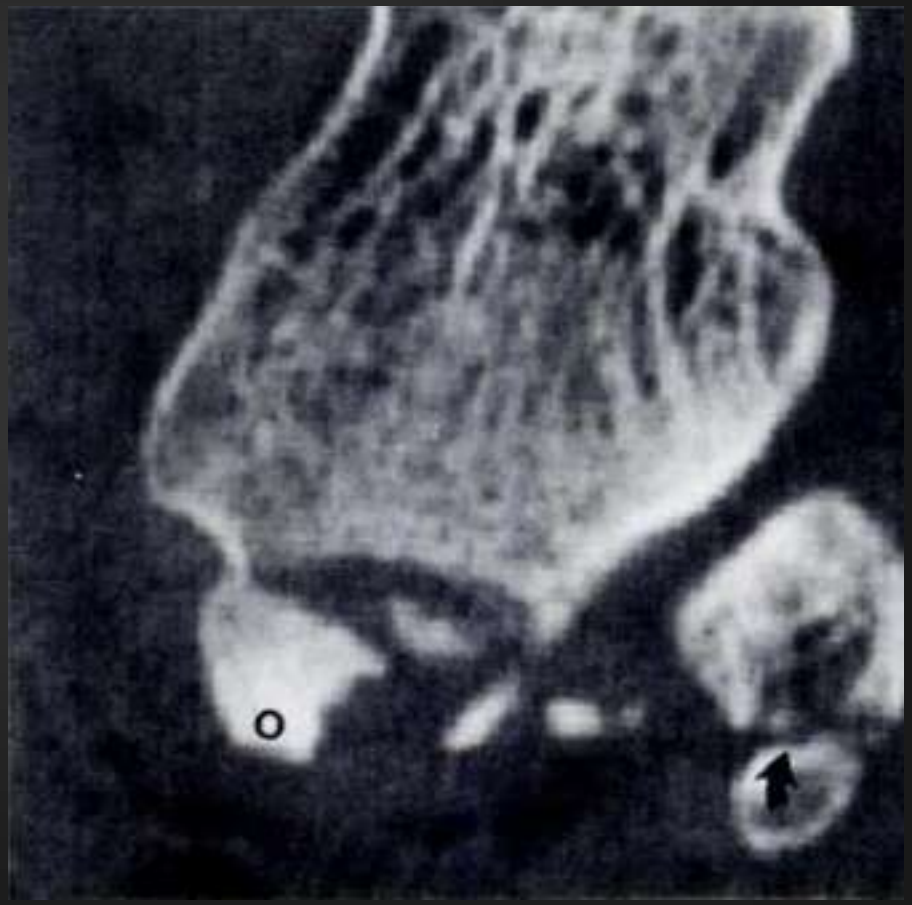
- Trauma – fracture or separation of cartilaginous synchondrosis from forced plantar flexion of foot
  - Shepard's (fracture of lateral tubercle)
  - Cedell's (fracture of medial tubercle)
- Os trigonum syndrome
  - Disruption of cartilaginous synchondrosis between os and talus secondary to repetitive microtrauma and inflammation
  - Activities involving extreme plantarflexion (e.g. ballet)
- Posterior tibiotalar impingement
- Mechanical entrapment of FHL tendon

Pathology

Fracture of Trigonal Process



28 year-old man with inversion and plantar flexion ankle injury. Lateral ankle radiograph shows comminuted trigonal process fracture of talus. 0 = os trigonum

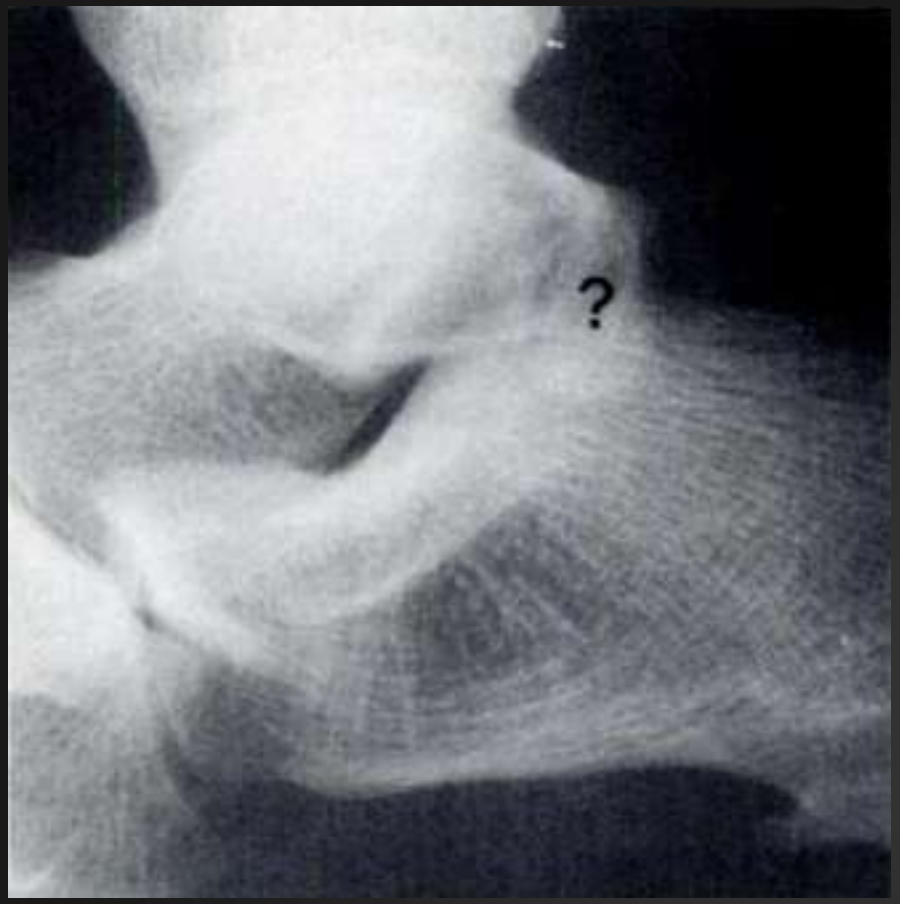


Axial CT scan shows fractured trigonal process, which represents os trigonum (0) fused to lateral talus tubercle. Also note distal fibular fracture (arrow).

Karasick et al. AJR:166, January 1996

Pathology

Shepard's and Cedell's Fractures

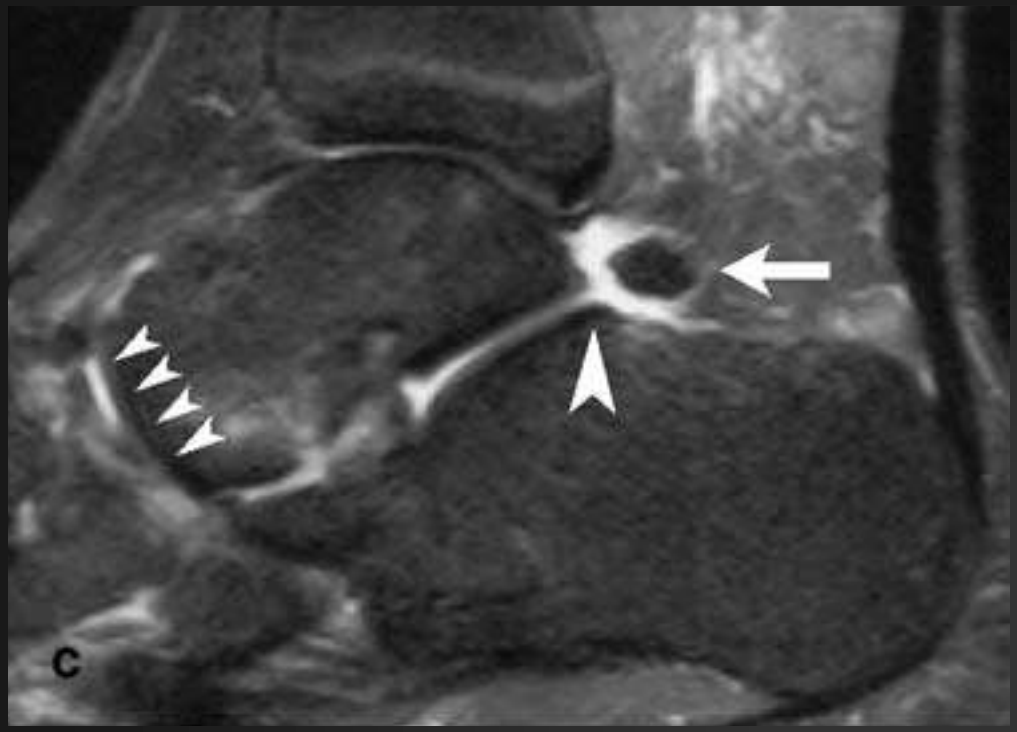


41 year-old woman with forced plantar flexion injury. Lateral ankle radiography shows structure resembling large os trigonum (?)

Axial CT scan shows this structure to be comminuted fractures of both medial (m) and lateral (L) tubercles of posterior talar process. CT is useful in diagnosing posterior talar fractures in presence of questionable or unusual findings on conventional radiography

Karasick et al. *AJR*:166, January 1996

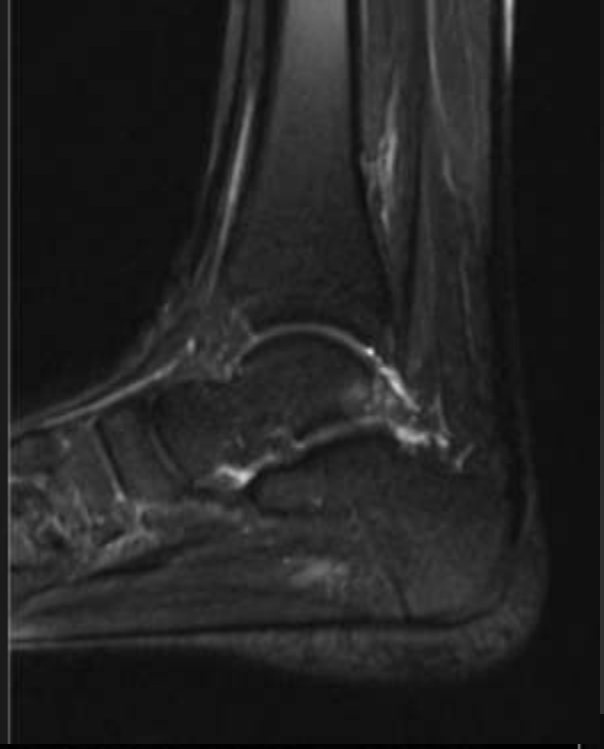
Abnormalities of Synchondrosis



Mellado et al. Eur Radiol (2003) 13:L164–L177

A 21-year-old man presenting with right flat-foot deformity and avascular necrosis on the tarsal navicular. Sagittal short tau inversion recovery (STIR) image shows a fluid-filled interface (*large arrowhead*) between the os trigonum (*arrow*) and the talus, reflecting disruption of the fibrocartilaginous synchondrosis. Collapse of the necrotic tarsal navicular (*small arrowheads*) is also noted.

A 45-year-old man suffering from chronic tenderness and pain on his left ankle joint. The CT section shows a large os trigonum (*arrow*). Subchondral cysts adjacent to the synchondrosis (*arrowheads*) are seen, reflecting chondro-osseous degenerative changes.

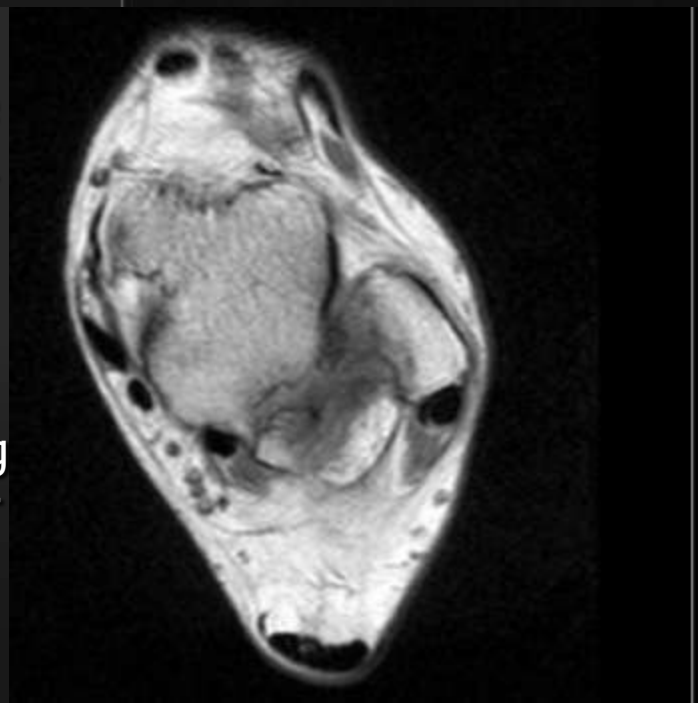


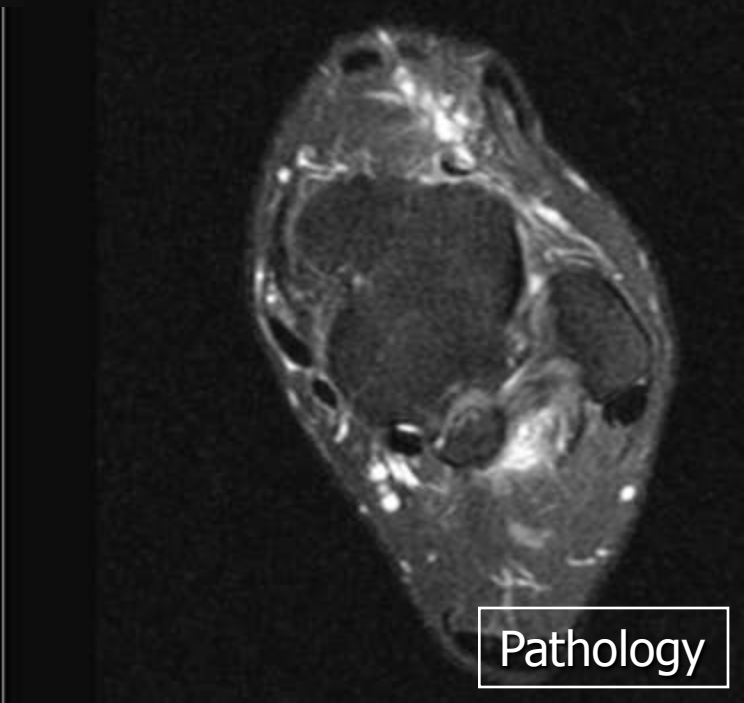
Os Trigonum Syndrome

27 yo female with ankle pain. Sagittal T1 and T2 FS MRI show edema in os trigonum and parent bone and in junctional tissue indicative of abnormal motion across synchodrosis.

31 yo male with ankle pain x 1 year. Axial T1 and T2 FS MRI show edema in synchondrosis and surrounding soft tissues with thickening of posterior talofibular ligament.

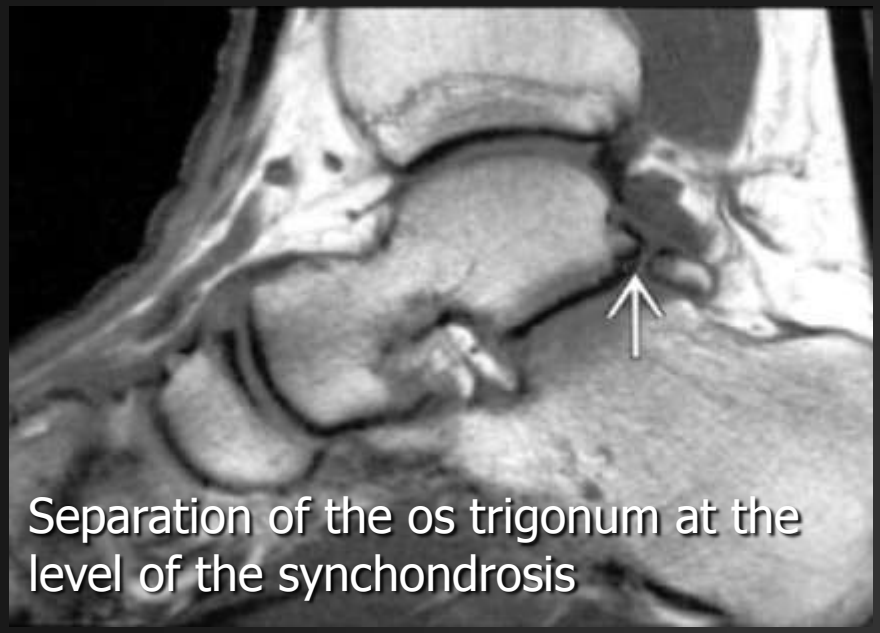
Tele Cases



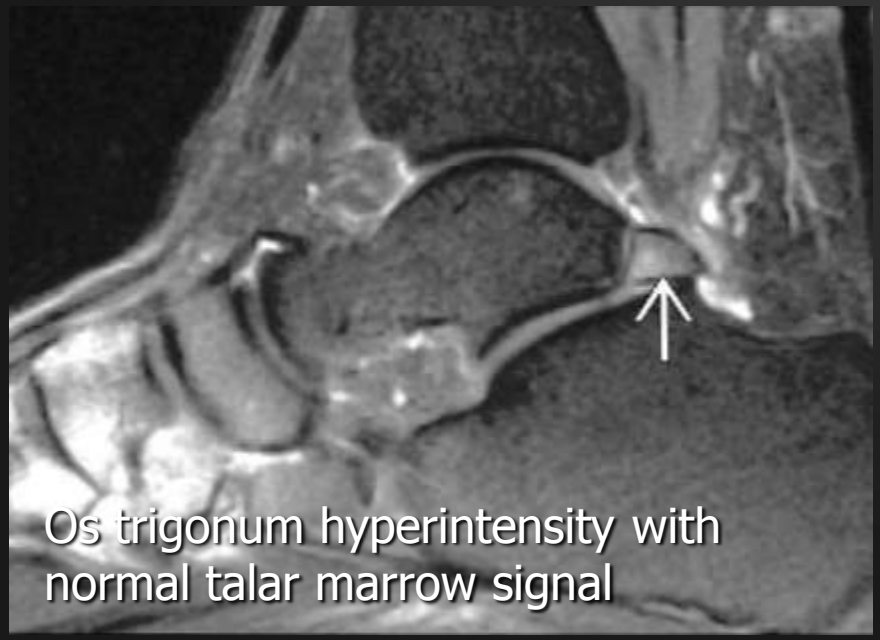


Pathology

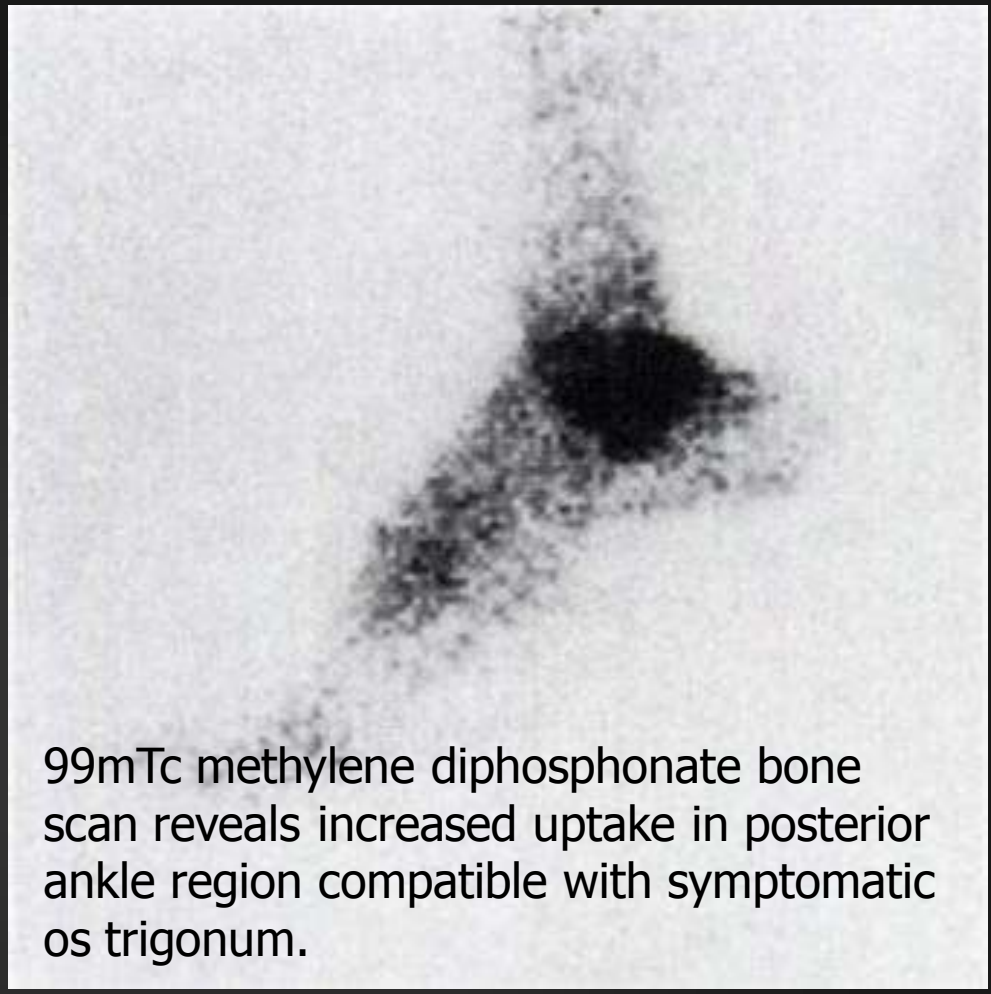
Os Trigonum Syndrome



Separation of the os trigonum at the level of the synchondrosis



Os trigonum hyperintensity with normal talar marrow signal



99mTc methylene diphosphonate bone scan reveals increased uptake in posterior ankle region compatible with symptomatic os trigonum.

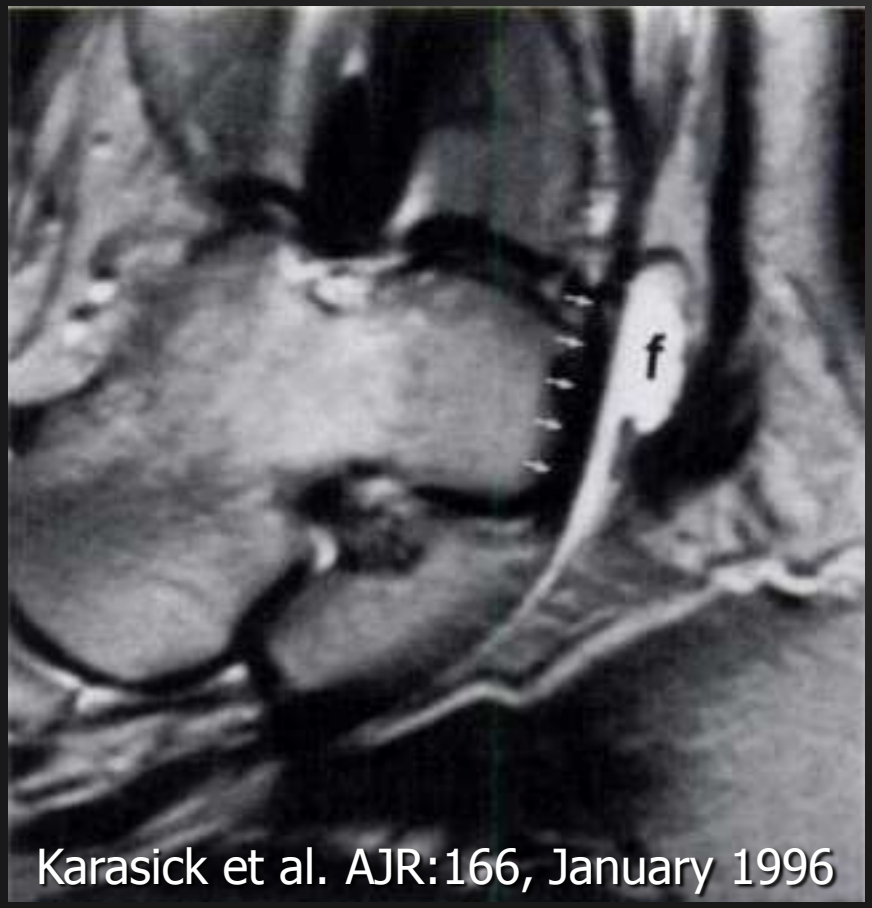
Karasick et al. AJR:166, January 1996

StatDx

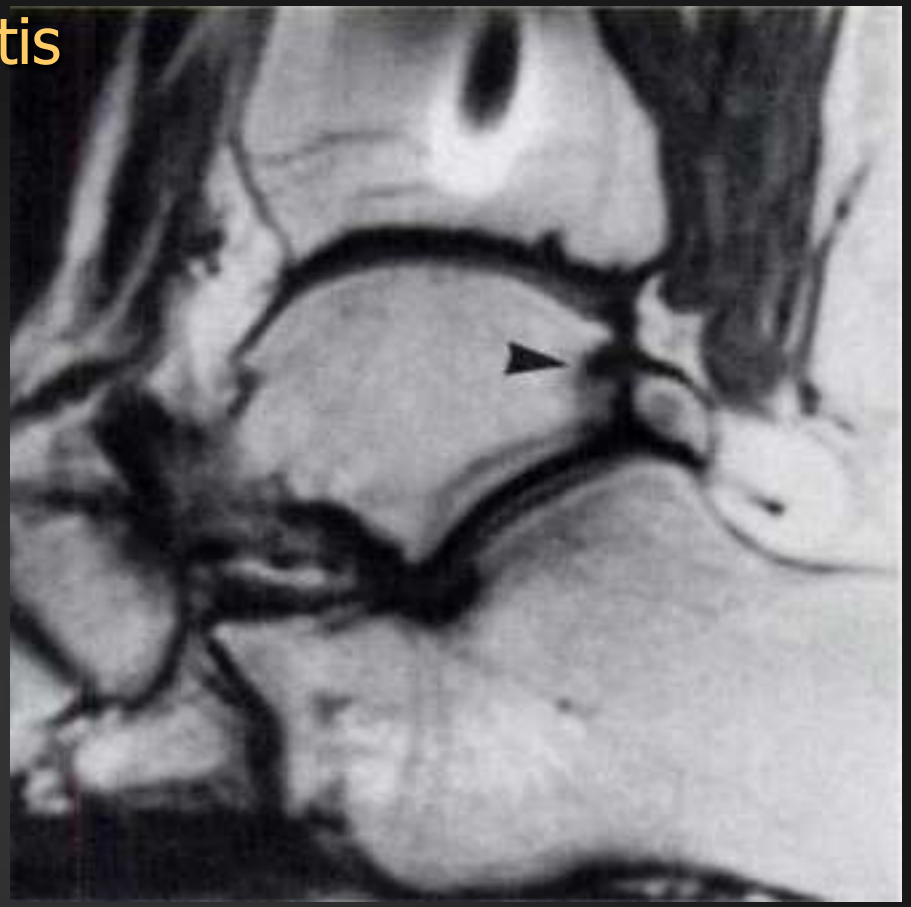
Pathology

Flexor Hallucis Longus Tenosynovitis

34 year-old man with activity-limiting pain in posterior ankle. SagIttal Ti-weighted MR image (500/16 [TRiTE]) shows degenerative cystic change (arrowhead) adjacent to cartilaginous synchondrosis between lateral talar tubercle and os trigonum



Karasick et al. AJR:166, January 1996

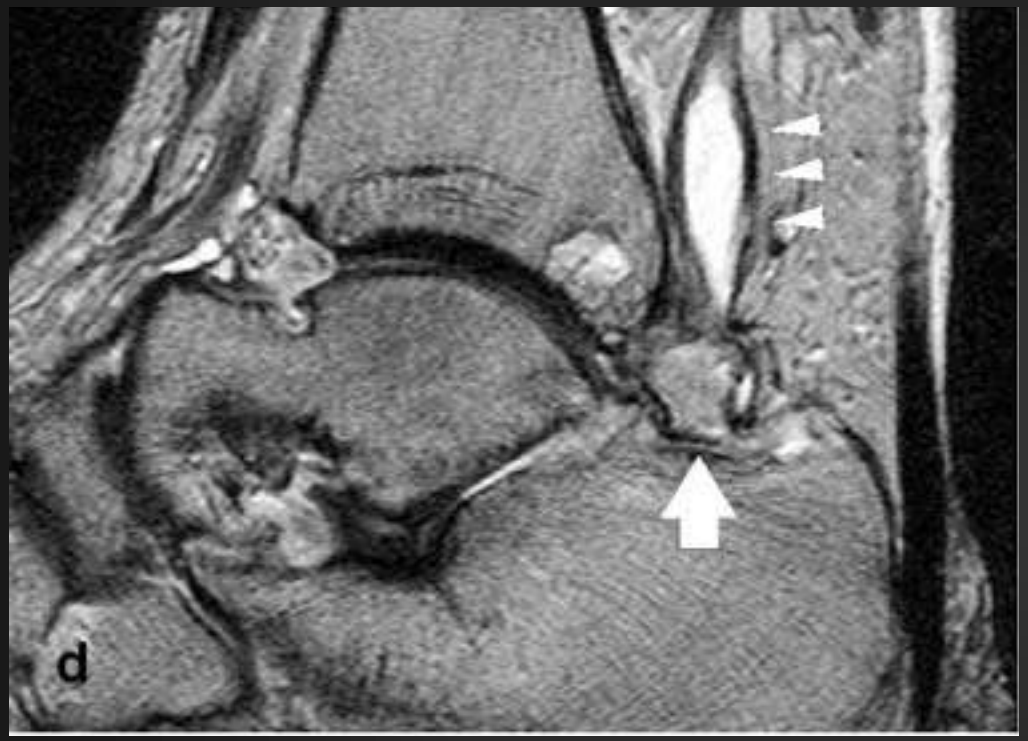


Sagittal T2-weighted MR image (6000/72) shows flexor hallucis longus tendon (arrows) with fluid in sheath proximally. In addition, portion of fluid (f) appears loculated consistent with stenosing synovitis secondary to mechanical obstruction.

Pathology

A 66-year-old man suffering chronic inflammatory arthritis in his left ankle joint. d. Sagittal T2-weighted MR image shows a large os trigonum (arrow). Significant distention of the flexor hallucis longus tendon sheath is also noted (arrowheads).

FHL Tenosynovitis



e. Axial T2-weighted MR image in the same patient shows a fluid-filled flexor hallucis longus tendon sheath (arrowheads) and an extremely thin tendon (arrow), consistent with chronic FHL tenosynovitis.

Mellado et al. Eur Radiol (2003) 13:L164–L177

Accessory Navicular

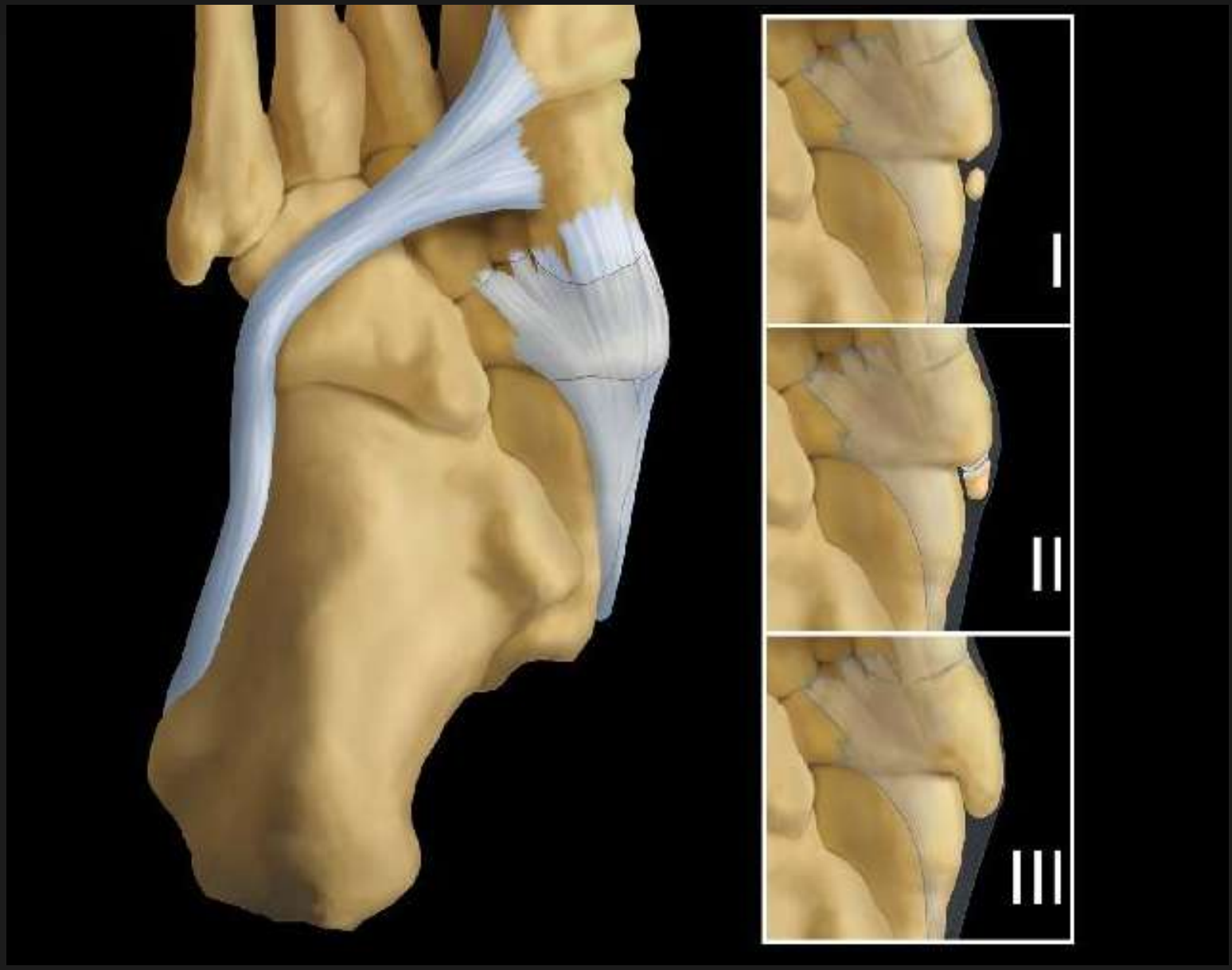
Accessory Navicular

- AKA os tibiale and naviculare secundarium
- Location: adjacent to posteromedial tuberosity of navicular
- Frequency: 4-21% in feet
- 3 types
  - Type I – ossification within PTT, 2-3mm
  - Type II – most often sxs, 9-12mm, residual synchondrosis with tubercle of navicular
  - Type III – prominent navicular tuberosity, essentially type II with bony bridge

Anatomy

Accessory Navicular

- Fracture – DDx from fx navicular tuberosity
- Type I
  - Proposed association with pes planus (unproven)
- Type II
  - Disruption of synchondrosis
  - Osteonecrosis accessory naviculare
- Type II / III
  - Abnormal posterior tibialis tendon mechanics
  - Accessory navicular acts as if it were a native navicular with the bulk of the posterior tibialis tendon inserting onto the accessory navicular
  - Presence of either an accessory navicular or a cornuate navicular increases risk for posterior tibialis tendon tears



Type I Accessory Navicular

- Located in distal segment of posterior tibialis
- Implicated in development of pes planus deformity

Twenty two-year-old female with pain over the lateral aspect of the left hind foot following a fall. An AP roentgenogram of the foot demonstrates a fracture of the antero-lateral margin of caleaneus *(arrowheads).* A well-defined oval ossicle (Type 1 accessory navicular) is noted adjacent to the posteromedial margin of the navicular *(arrows)*

Lawson et al. Skeletal Radiol (1984) 12:250-262

Type I Accessory Navicular

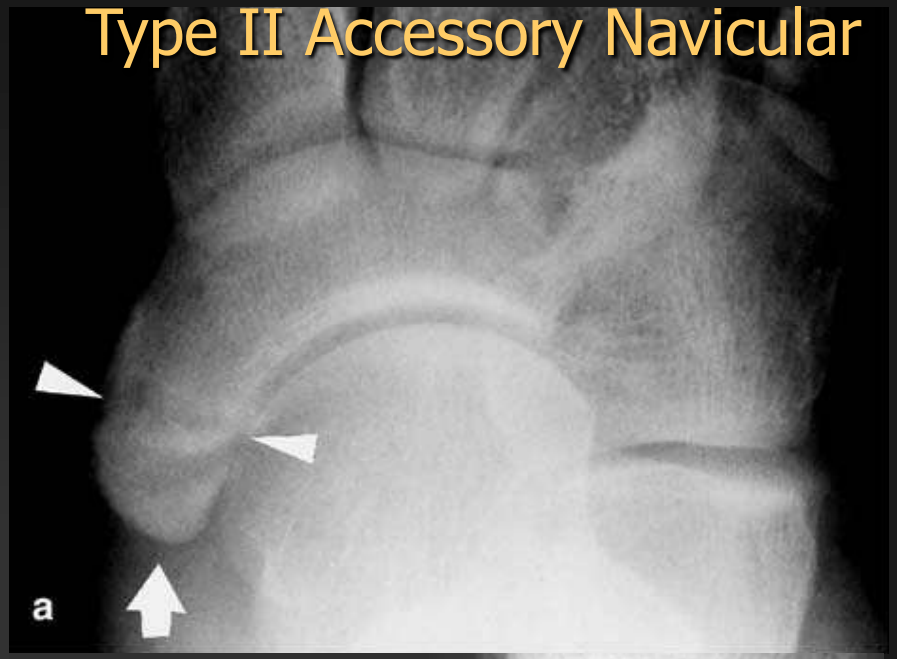
Incidental type-I accessory navicular bones (*arrows*) in two different patients presenting with a history of ankle sprain

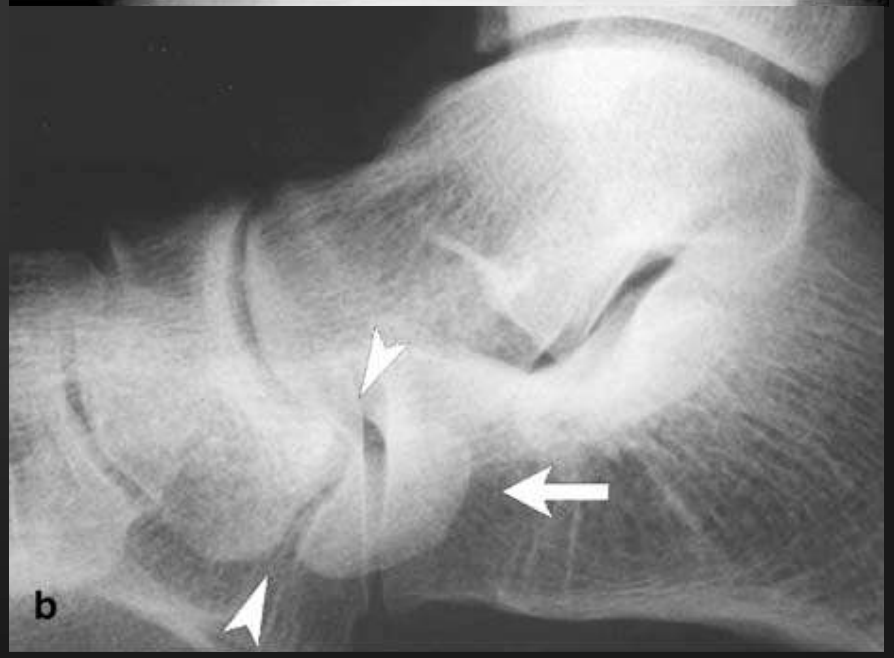
MR image the sesamoid bone is seen within the distal portion of the posterior tibial tendon (*small arrowheads*). The distal portion of the spring ligament (*large arrowhead*) is also seen

Mellado et al. Eur Radiol (2003) 13:L164–L177

Pathology

Type II Accessory Navicular





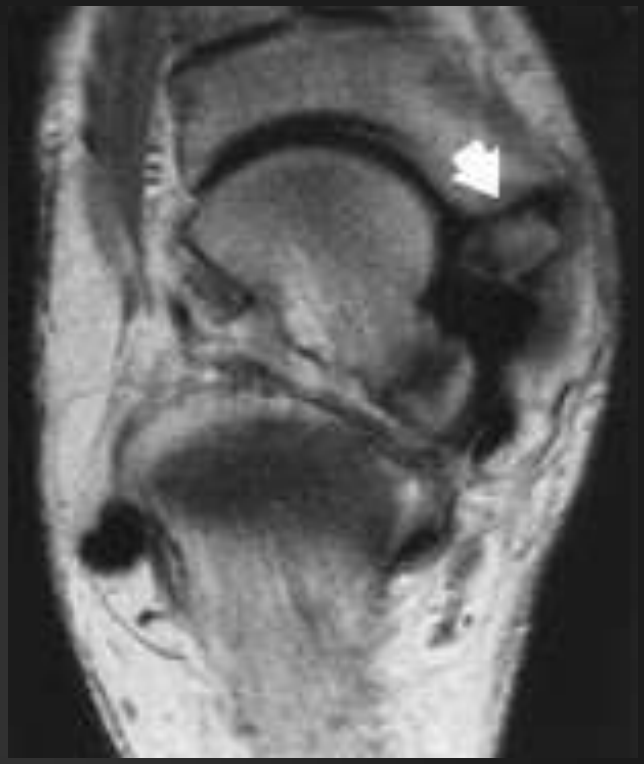
A 43-year-old-woman presenting with acquired flat-foot deformity. (a) Dorsoplantar and (b) lateral radiographs show a type-II accessory navicular (*arrow*) bridged to the posteromedial aspect of the navicular by a fibrocartilaginous synchondrosis, represented by a narrow radiolucent interface (*arrowheads*)

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

Anatomy

Type II Accessory Navicular

Sagittal T2-weighted MR image (TR/TE, 6000/70) reveals accessory navicula (a). Note normal low signal intensity between accessory navicular and native navicular (curved arrow). Also note straight line (instead of normal smooth curve) that posterior tibialis tendon makes as it extends from medial malleolus. This abnormality causes focal point of friction at medial malleolus (straight arrow).



Axial intermediate-weighted MR image (6000/40) shows accessory navicular with low-signal-intensity synchondrosis (arrow).

Schweitzer et al. AJR:175, September 2000

Pathology

Symptomatic Accessory Navicular Type II

Axial T1- (B) and T2- (C) weighted MR images demonstrate cortical irregularity at the synchondrosis and "kissing" marrow edema on either side of the pseudarthrosis. Repetitive contractions of the PTT as it inserts onto the accessory ossicle can produce shearing stress forces at the synchondrosis, and generate pain and tenderness along the medial aspectof the midfoot. Bernaerts et. al. JBR–BTR, 2004, 87 (5)

Symptomatic Accessory Navicular Type II

Symptomatic accessory navicular with bone marrow edema of accessory navicular and tuberosity

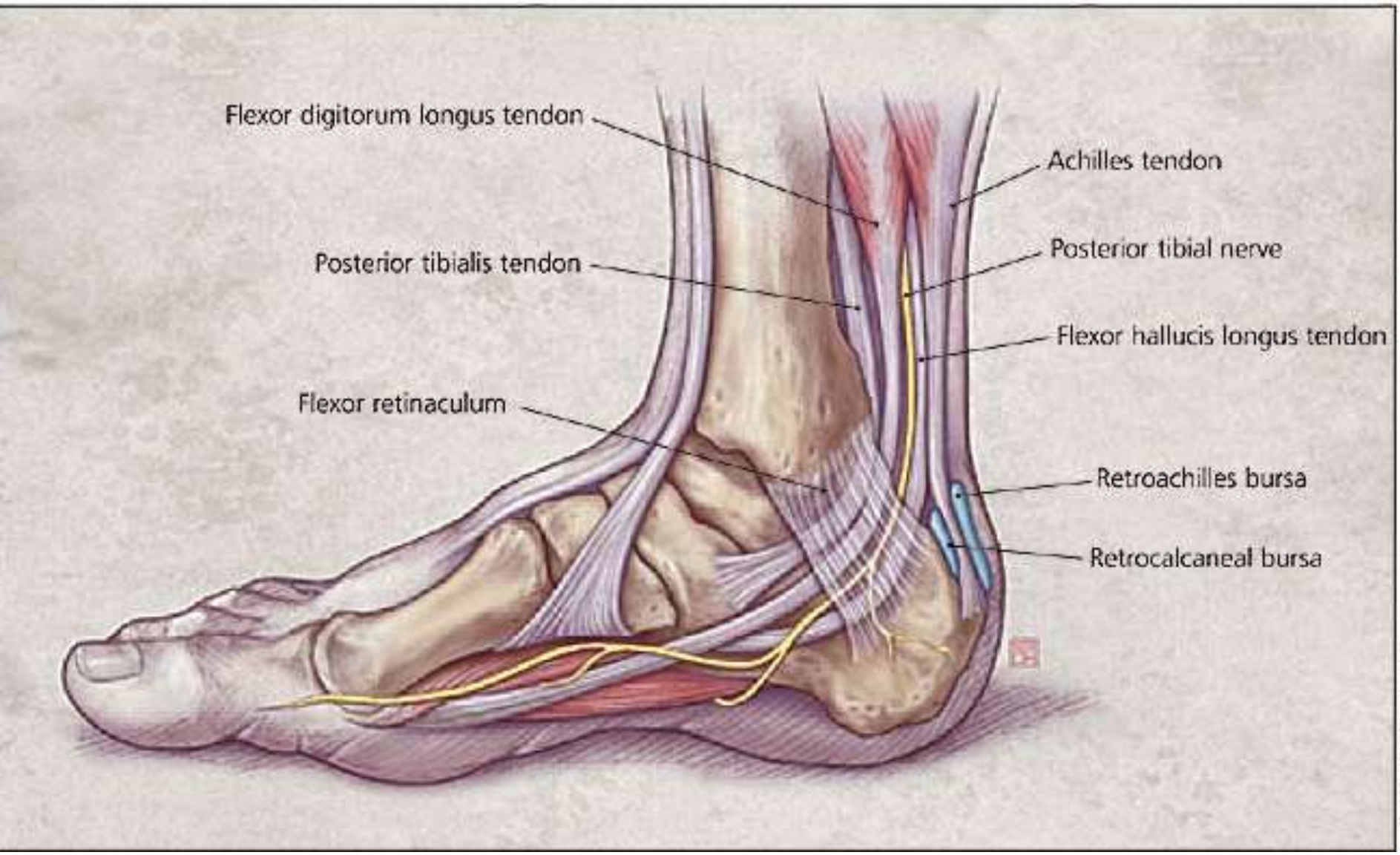
StatDx

Axial FS PD FSE shows marrow edema of type II accessory navicular and navicular

Axial FS PD FSE shows hyperintense marrow edema on both sides of non-ossified synchondrosis of type II accessory navicular and navicular bone

Pathology

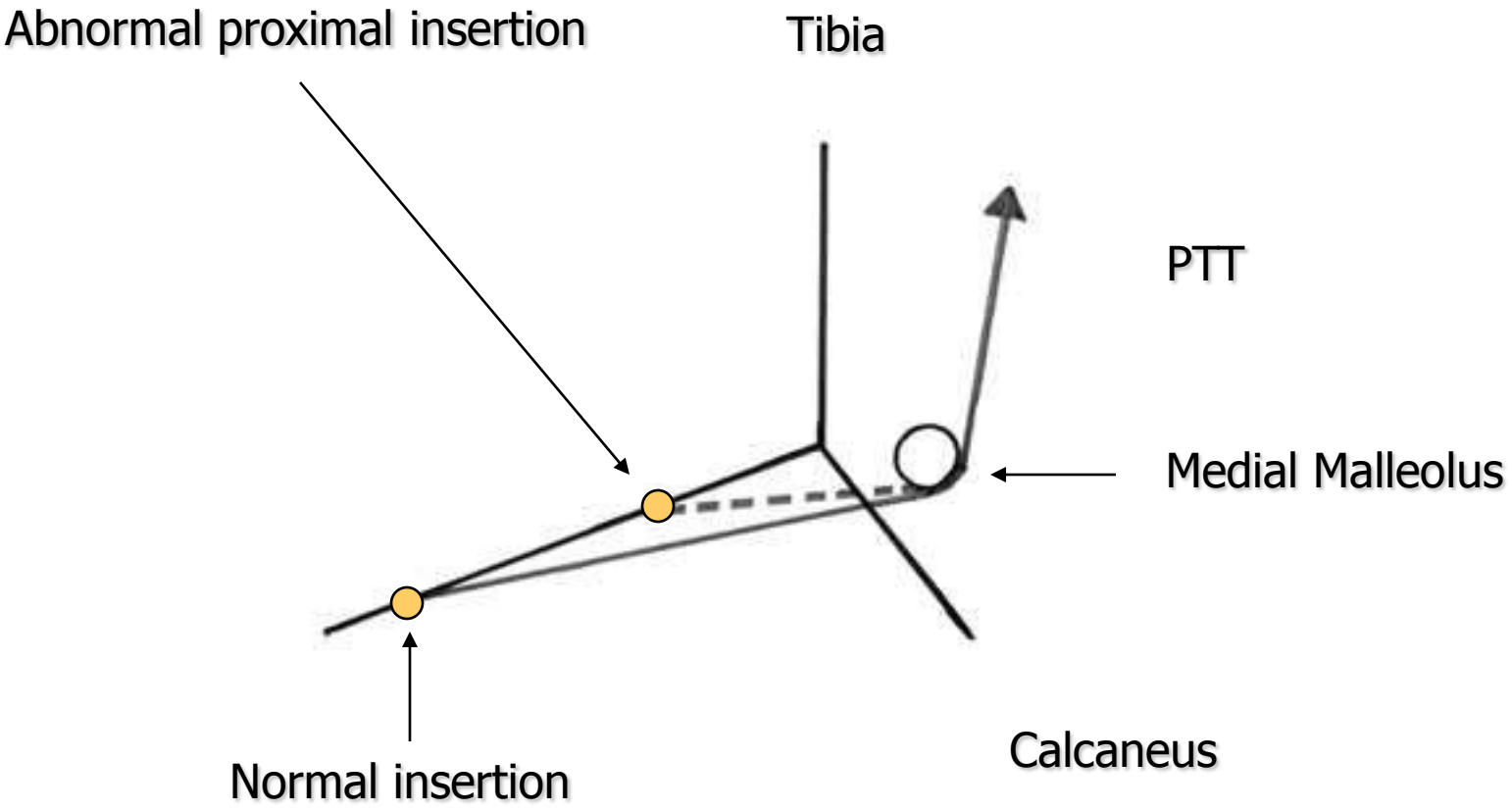
Accessory Navicular and Posterior Tibialis Tendinopathy



http://www.aafp.org/afp//AFPprinter/20040715/332.html

Accessory Navicular and Posterior Tibialis Tendinopathy

Altered PTT biomechanics due to presence of type 2/3 accessory navicular



Bernaerts et. al. JBR–BTR, 2004, 87 (5)

Type II Accessory Navicular and Posterior Tibialis Pathology

A 62-year old woman presenting with painful acquired flat-foot deformity and type-II accessory navicular. The MR images show a (c) type-II accessory navicular (arrow) and a (d) interstitial tear of the posterior tibial tendon (arrow). A bony spur sharpening the medial aspect of the tendon groove (arrowhead) is also seen.

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

Pathology

Type II Accessory Navicular

Surgically proven partial tear of the posterior tibial tendon with painful accessory navicular bone in a 51-year old woman.
A. Axial T1-weighted spin-echo image (TR/TE, 500/12) shows low signal intensity in the accessory navicular bone (solid arrow) with distraction of the synchondrosis. The posterior tibial tendon is thickened with increased signal intensity in the tendon (open arrow).
B. Fat-suppressed T2-weighted fast spin-echo image (TR/TE, 4000/108) shows high signal intensity in the accessory navicular bone (long solid arrow) and fluid signal intensity in the synchondrosis (short solid arrow). The posterior tibial tendon displays increased signal intensity (open arrow), indicative of partial thickness tear.

Choi et al. Korean J Radiol 5(4), December 2004

Pathology

Type III accessory navicular

Axial T1-weighted MR image shows a prominent navicular tuberosity (*arrow*), consistent with type-III accessory navicular, also known as cornuate navicular

StatDx

AP radiograph shows a type 3 accessory navicular

Bernaerts et al. JBR-BTR. 2004 Sep-Oct;87(5):250-2

Anatomy

Type III Accessory Navicular

Axial T1- and T2- weighted MR images reveal an enlarged PTT with multifocal speckled internal signal intensity (white arrow). Also note edema in the adjacent cornuate navicular (black arrow).

Bernaerts et al. JBR-BTR. 2004 Sep-Oct;87(5):250-2

Pathology

Os Sustentaculi

Os Sustentaculi

- Location: posterior aspect of sustentaculum tali
  - Almost invariably attached to sustentaculum by fibrous or fibrocartilagenous tissue
- Frequency: 1-10%
- Symptomatology: abnormal motion across synchondrosis

Anatomy

Os Sustentaculi

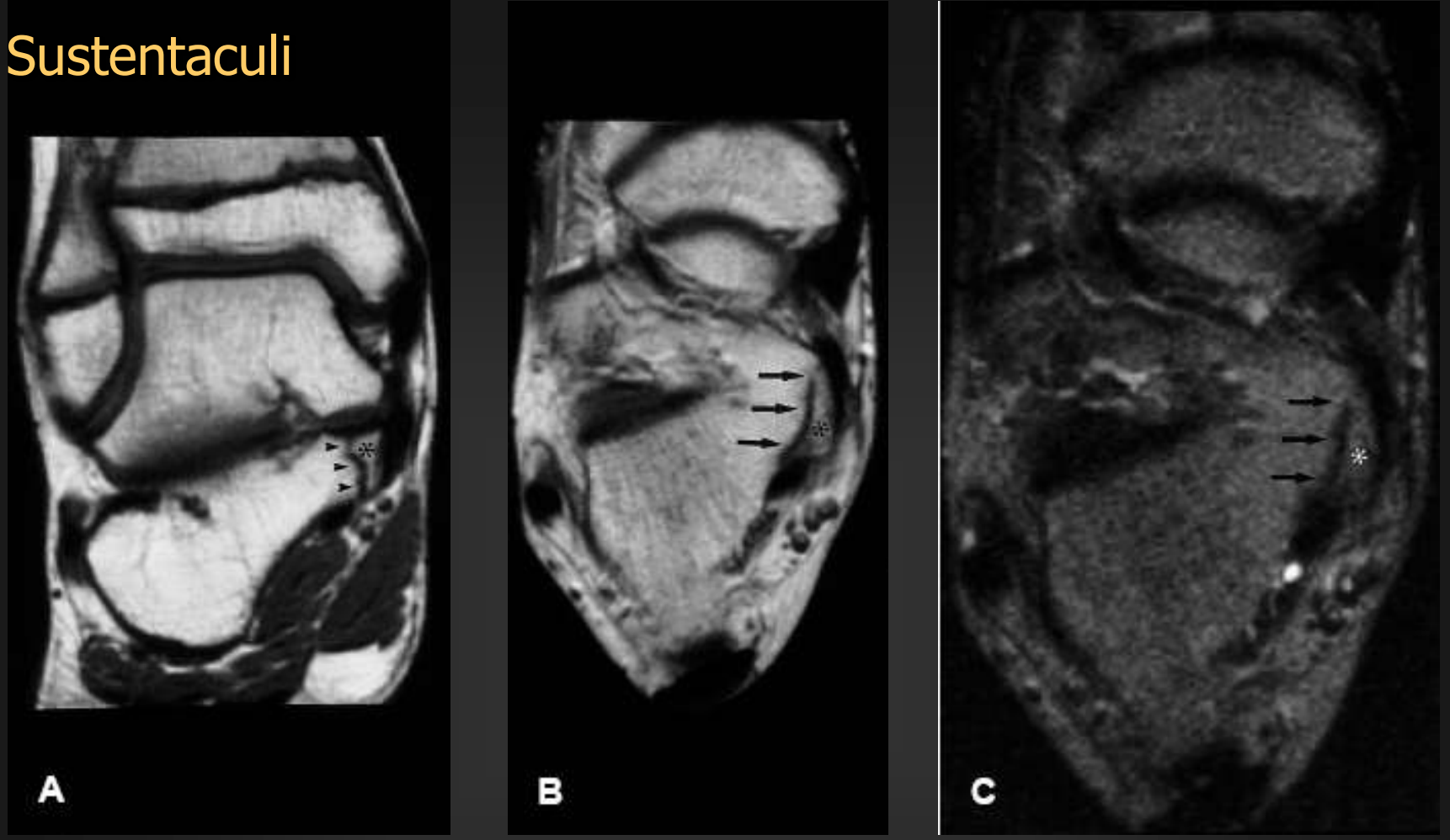
Painful os sustentaculi in a 49-year-old man (above) Lateral radiograph shows an os sustentaculi (arrow) located posterior to the sustentaculum tali (asterisk). A faint radiolucent interface is seen in-between (arrowheads), reflecting the existence of a fibrocartilaginous synchondrosis.

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

Oblique coronal CT scan shows an os sustentaculi (arrow) united to the sustentaculum tali (star) and articulating with an elongated medial tubercle of the talus (asterisk). A narrow and irregular interface in-between the three bones is seen, along with subchondral cyst formation and hypertrophic margins.

Anatomy

Os Sustentaculi



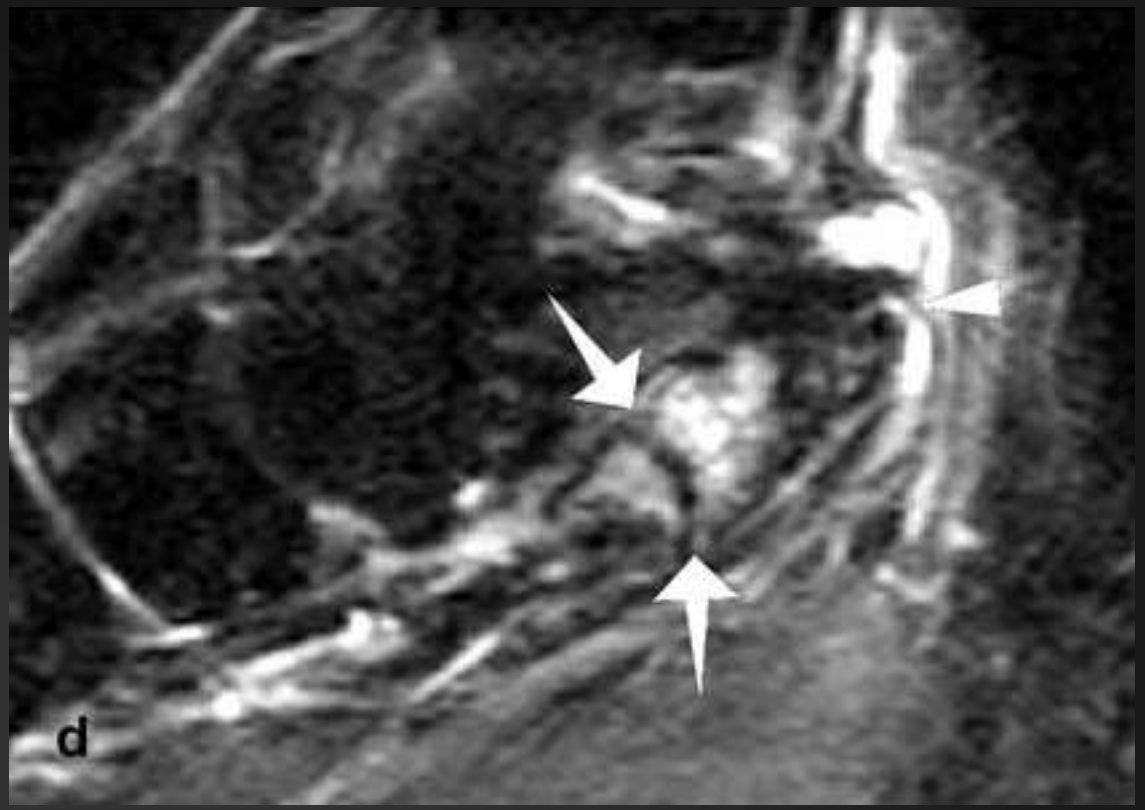
MR appearance of the os sustentaculi (OS). (A) Coronal T1-weighted (650/15, TR/TE) image of the hindfoot shows an irregular line (*arrowheads*) separating the sustentaculum tali from the OS (*asterisk*). (B) Axial proton density and (C) T2-weighted images (2400/20,90, TR/TE) through the sustentaculum tali. The OS (*asterisk*) is distinguished from the calcaneus by a low-signal line (*straight arrows*). No bone marrow edema is evident on the T2-weighted images

Bencardino et al. Skeletal Radiol (1997) 26:505–506

Anatomy

Painful Os Sustentaculi

c. Axial T2-weighted MR image shows mild bone marrow edema in the os sustentaculi (arrow)



d. Sagittal STIR image shows subchondral bone marrow edema adjacent to the synchondrosis between the os sustentaculi and the sustentaculum tali (arrows). The articulation between the os sustentaculi and the talar body (arrowhead) is also seen

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

Pathology

Os Intermetatarseum

Os Intermetatarseum

- Location: between medial cuneiform and bases of 1st and 2nd metatarsal
- Frequency: 2-8% of feet
- Fused or separate ossicle
- Some reports associate with hallux valgus
- Symptomatology
  - Fracture
  - Compression of superficial or deep peroneal nerves

Anatomy

Os Intermetatarseum

A 27-year-old with a history of multiple ankle injuries and chronic foot pain. An anteroposterior radiograph shows an os intermetatarseum situated between the first and second metatarsal bases (arrow). Kalantari et al. Appl Radiol. 2007; 36(10):28-37

Large os intermetatarseum arising from second metatarsal base region. Reichmister Clin Orthop Relat Res. 1980 Nov-Dec; (153):201-3

Pathology

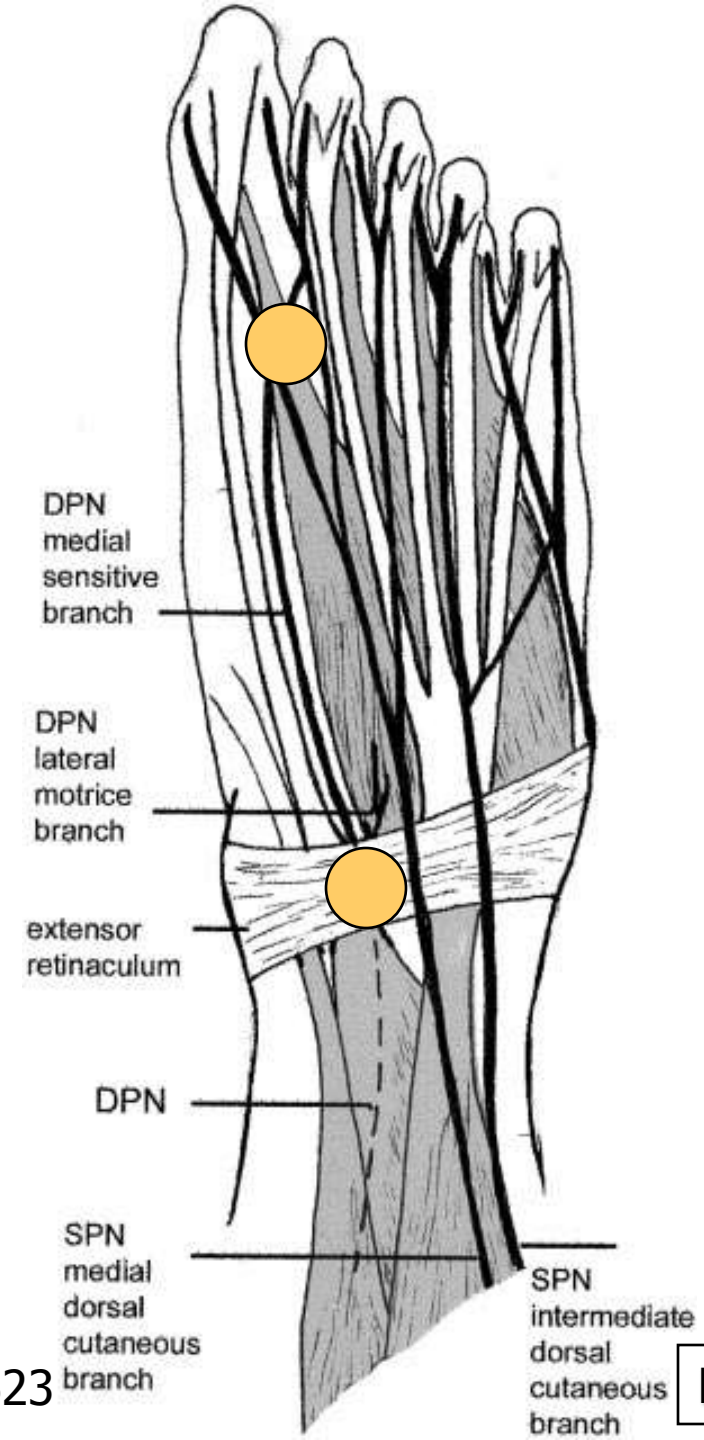
Os Intermetatarseum

Os intermetatarseum in a 59-year-old woman presenting with hallux valgus deformity and forefoot pain. Dorsoplantar radiograph shows a small os intermetatarseum (*arrowhead*). Associated hallux valgus deformity is also noted (*thick arrow*). The real involvement of the os intermetatarseum in the painful syndrome remained undetermined. Incidental bipartite tibial hallux sesamoid bone is seen (*thin arrow*).

Mellado et al. Eur Radiol (2003) 13:L164–L177

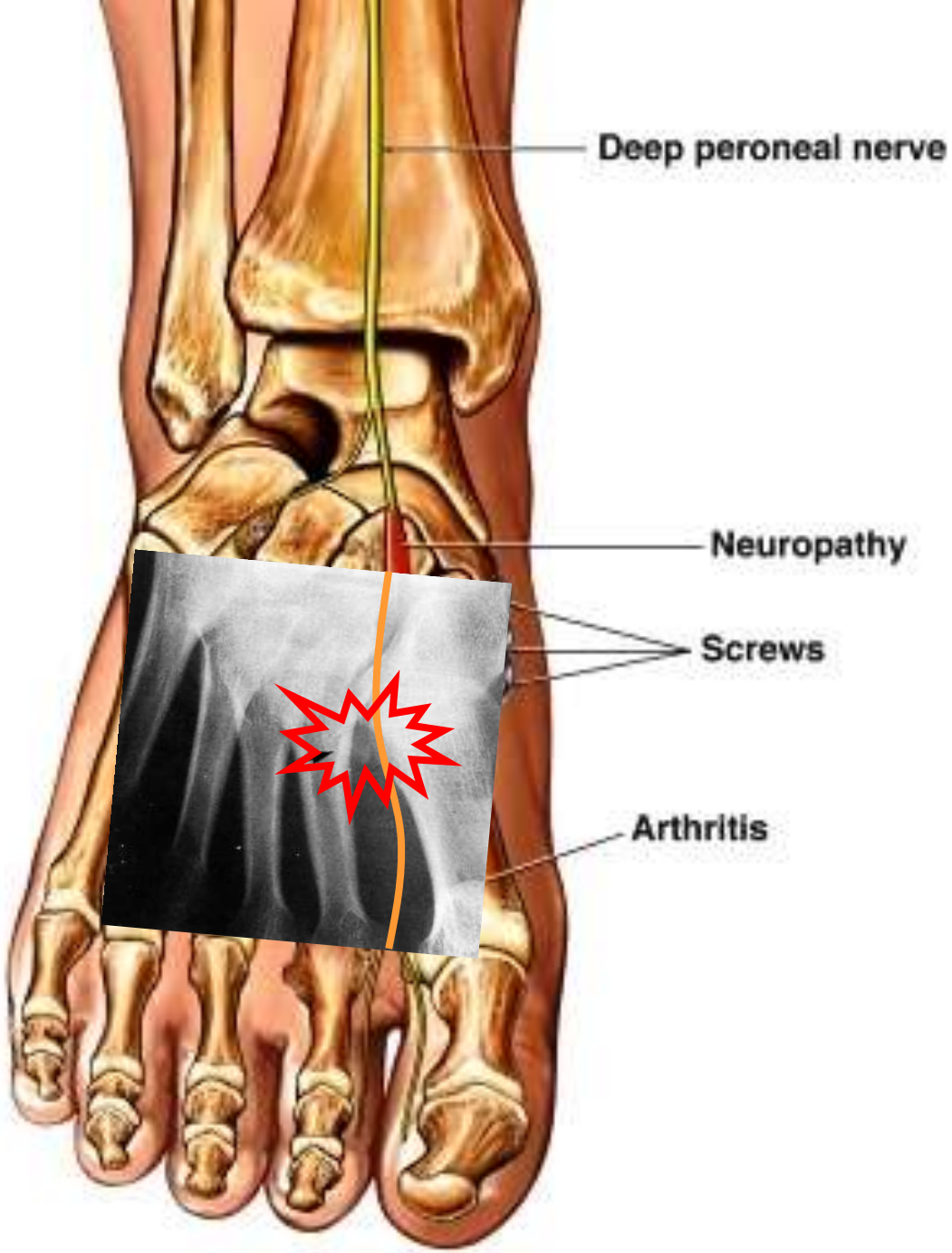
Painful Os Intermetatarseum

Deep Peroneal Nerve – branch of common peroneal nerve. Supplies sensory innervation to 1st metatarsal interspace and motor innervation for extensor digitorum brevis muscle. Two main compression sites: anterior tarsal tunnel and dorsum of foot at level of 1st and 2nd tarsometatarsal joints.



Delfault et al. RadioGraphics 2003; 23:613–623

Pathology



https://healthlibrary.epnet.com/GetContent.aspx?token=af362d97-4f80-4453-a175-02cc6220a387&chunkiid=432318

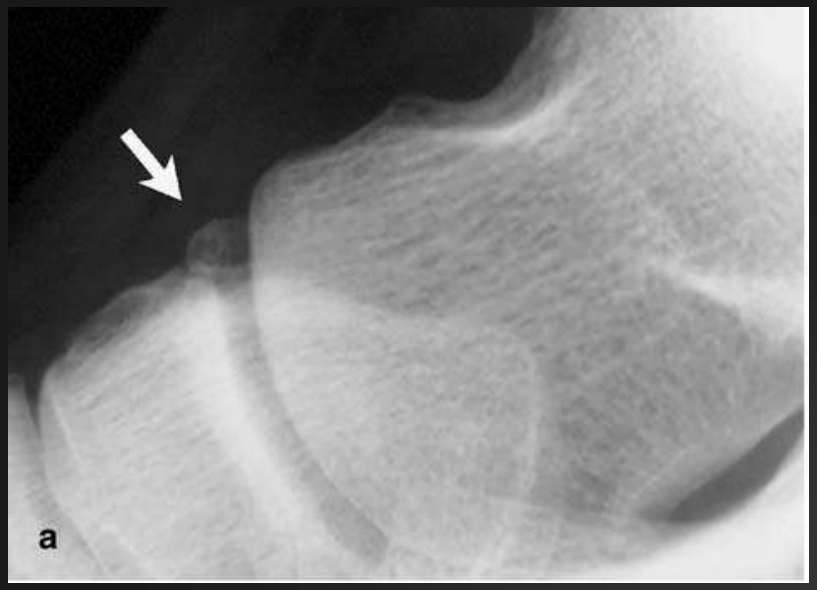
Os Supranaviculare

Os Supranaviculare

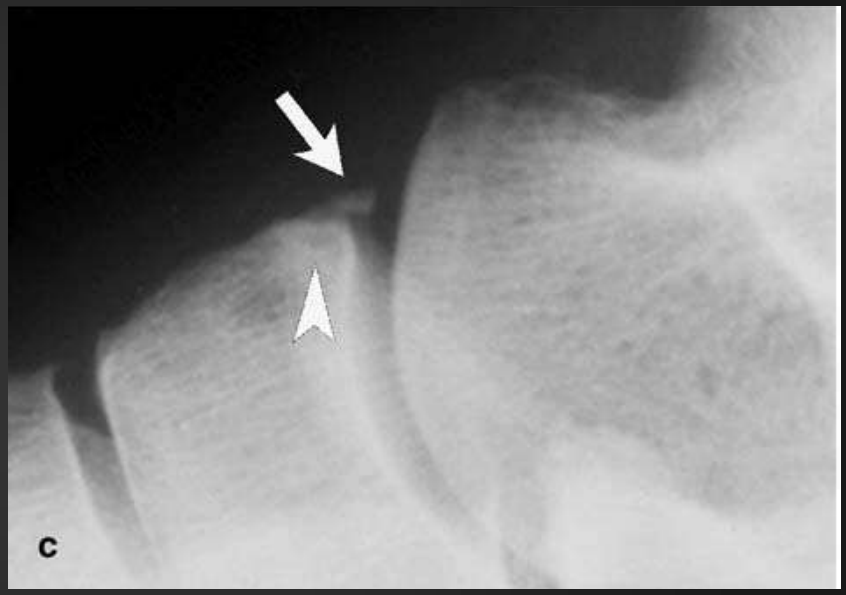
- AKA os talonaviculare dorsale, talonavicular ossicle or Pirie's bone
- Location: dorsal to anterior talonavicular joint (talonavicular portion)
- Frequency: 1% of feet
- Most ossicles in this region likely post-trauamatic
  - Dorsiflexion with avulsion injury to dorsal capsule and nearby ligamentous structures

Anatomy

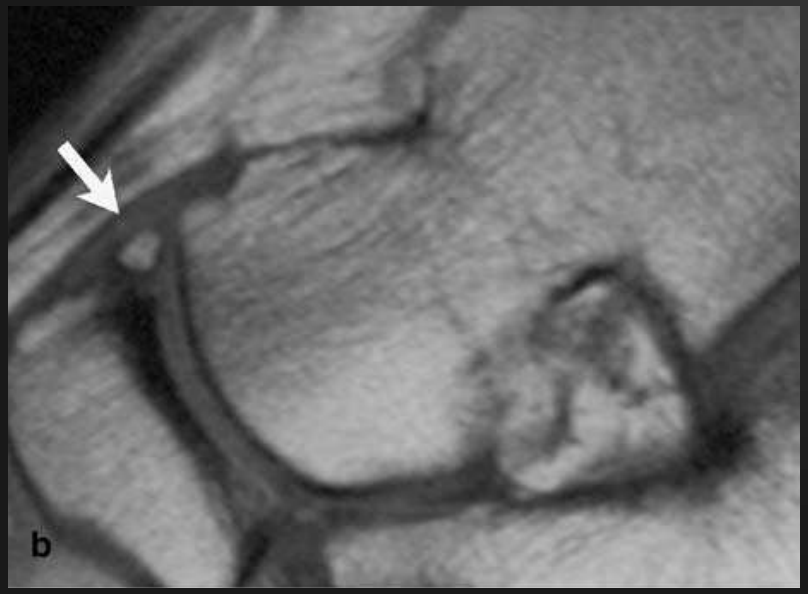
Os supranaviculare



A. Lateral radiograph in a 27-year-old man shows an incidental supranavicular bone (*arrow*) located in the dorsal aspect of the talonavicular joint.



B. Sagittal T1-weighted MR image demonstrates the round and well-corticated appearance of the accessory ossicle (*arrow*)



C. Lateral ankle radiograph in a 50-year-old man reveals a small pointed os supranaviculare (arrow) fused to the navicular. A small adjacent radiolucency in the dorsal aspect of the navicular bone (arrowhead) simulates an avulsion site

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

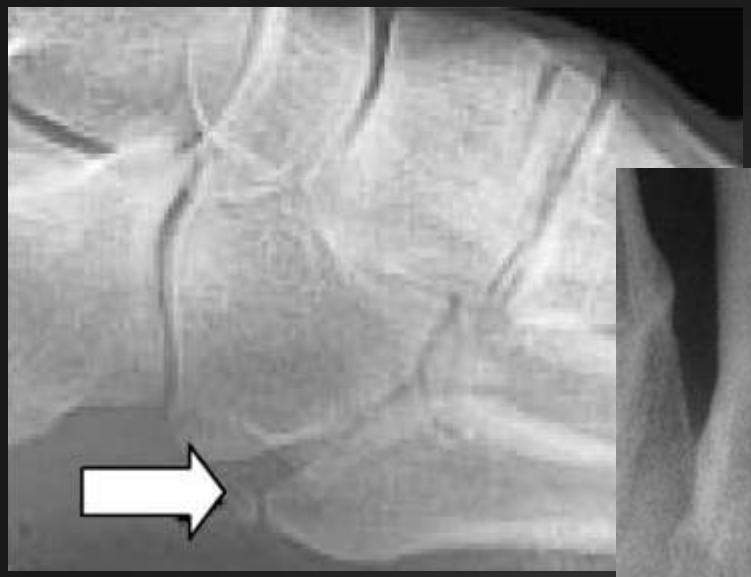
Os Vesalianum

Os Vesalianum

- Location: adjacent to the tip of a well-developed tuberosity of the fifth metatarsal
- Frequency: less than 1% of feet
- Rarely associated with symptomatology
- DDx:
  - Ossifying apophysis of 5th MT
  - Avulsion fracture apophysis / base 5th MT
  - Os peroneum

Anatomy

Os Vesalianum



Northover et al. The Foot 16 (2006) 172–174

AP radiograph of the foot demonstrates a large ossicle posterior to the base of the fifth metatarsal bone.

medcyclopedia

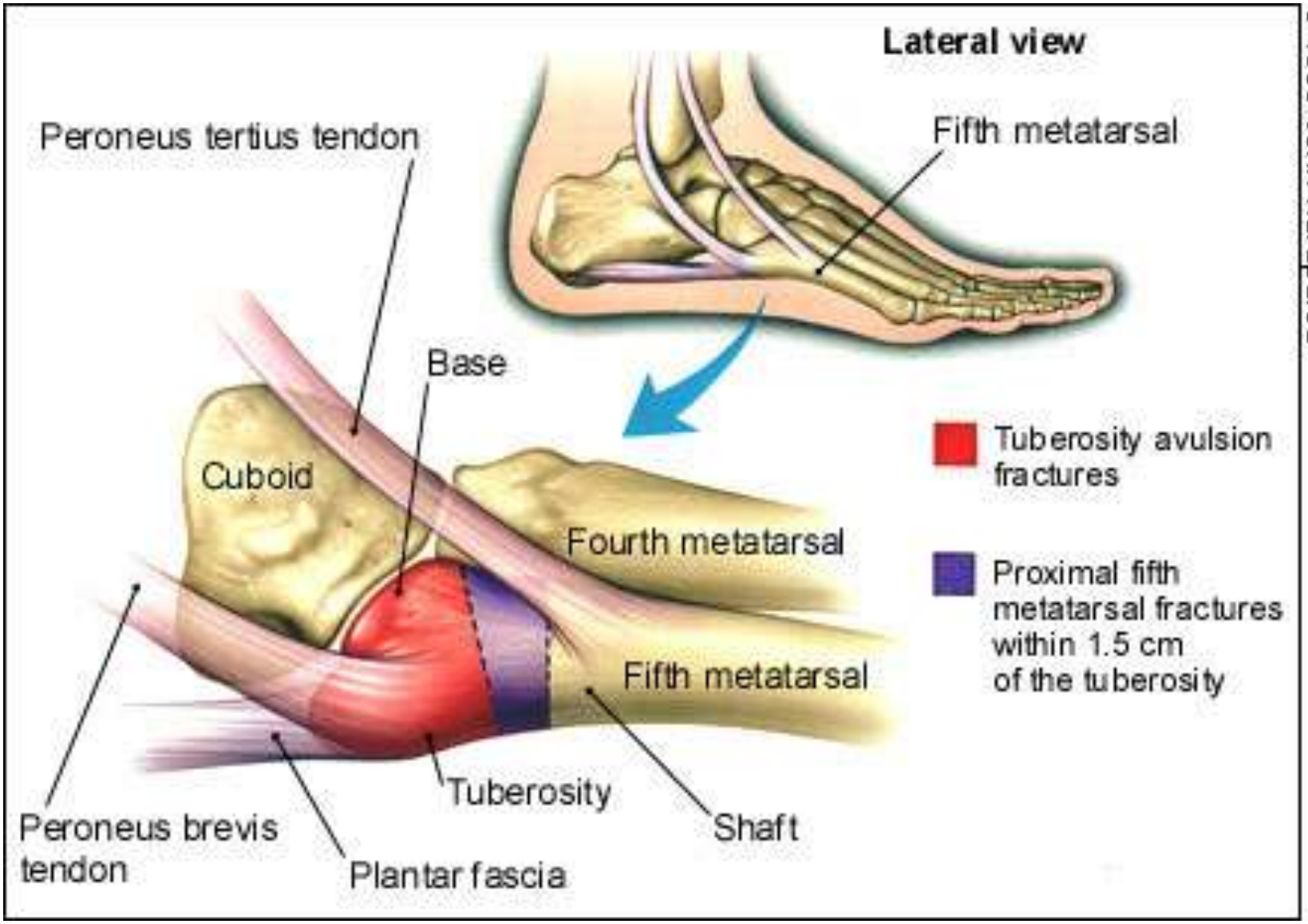
Anatomy

5th Metatarsal Apophysis

http://imageinterpretation.co.uk/foot.html

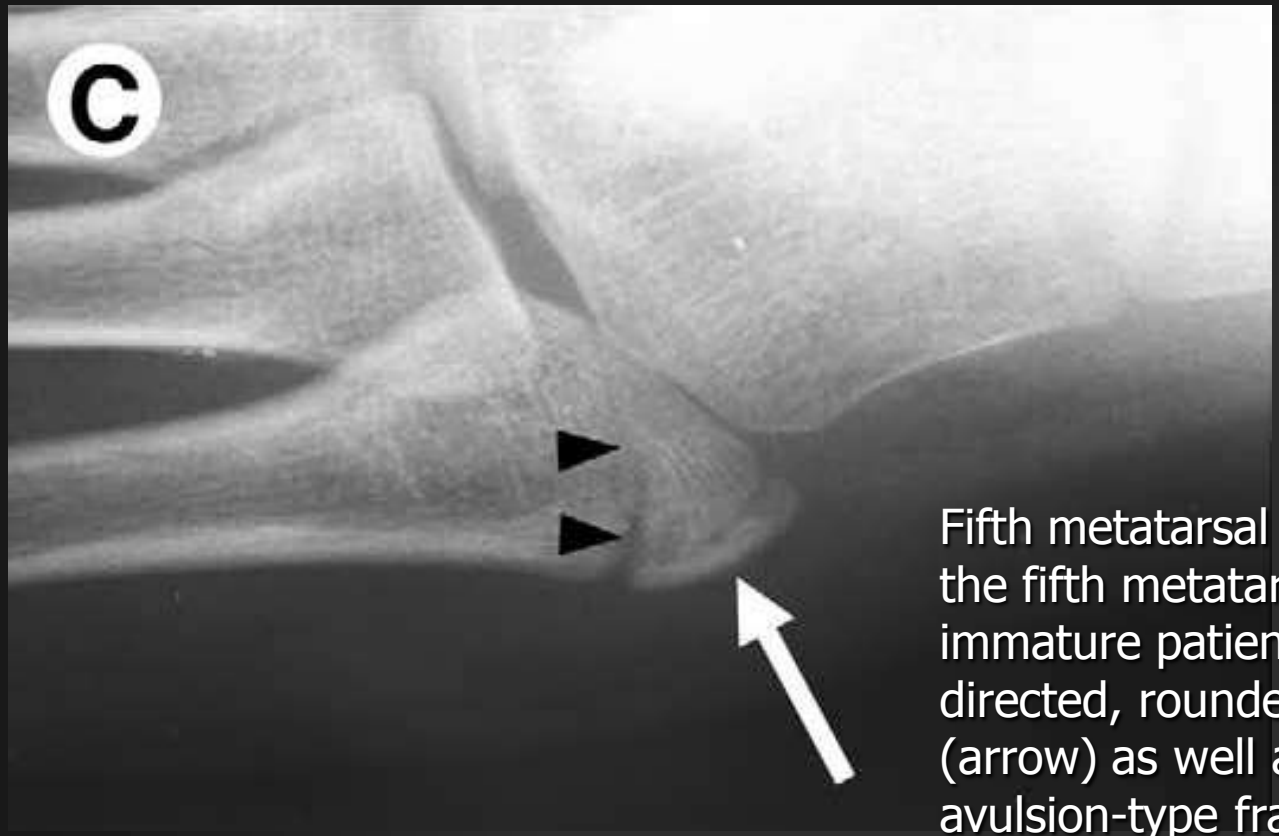
Anatomy

Fracture 5th metatarsal base



http://www.aafp.org/afp//AFPprinter/990501ap/2516.html

Avulsion Fracture Base 5th Metatarsal



Fifth metatarsal base fracture. AP view of the fifth metatarsal base in a skeletally immature patient shows a longitudinally directed, rounded ossification center (arrow) as well as a transversely directed avulsion-type fracture (arrowheads). Avulsion-type fractures in this location typically extend to the tarsometatarsal articular surface, whereas Jones-type fractures are more distal, occurring at the proximal shaft.

Koulouris et al. Semin Roentgenol. 2005 Oct;40(4):358-79

Pathology

Avulsion Fracture Base 5th Metatarsal

AP views of the foot demonstrate a horizontal lucency at the base of the fifth metatarsal (arrow), representing an avulsion injury at the insertion site of the peroneus brevis tendon

Grainger & Allison's Diagnostic Radiology, 5th ed

Pathology

Avulsion Fracture Base 5th Metatarsal

A 34-year-old woman with foot pain status-post trauma. (A) Anteroposterior and (B) lateral radiographs show fragmentation/fracture of an os peroneum (arrows) and a transverse fracture of the fifth metatarsal base (arrowheads).

Kalantari et al. Appl Radiol. 2007; 36(10):28-37

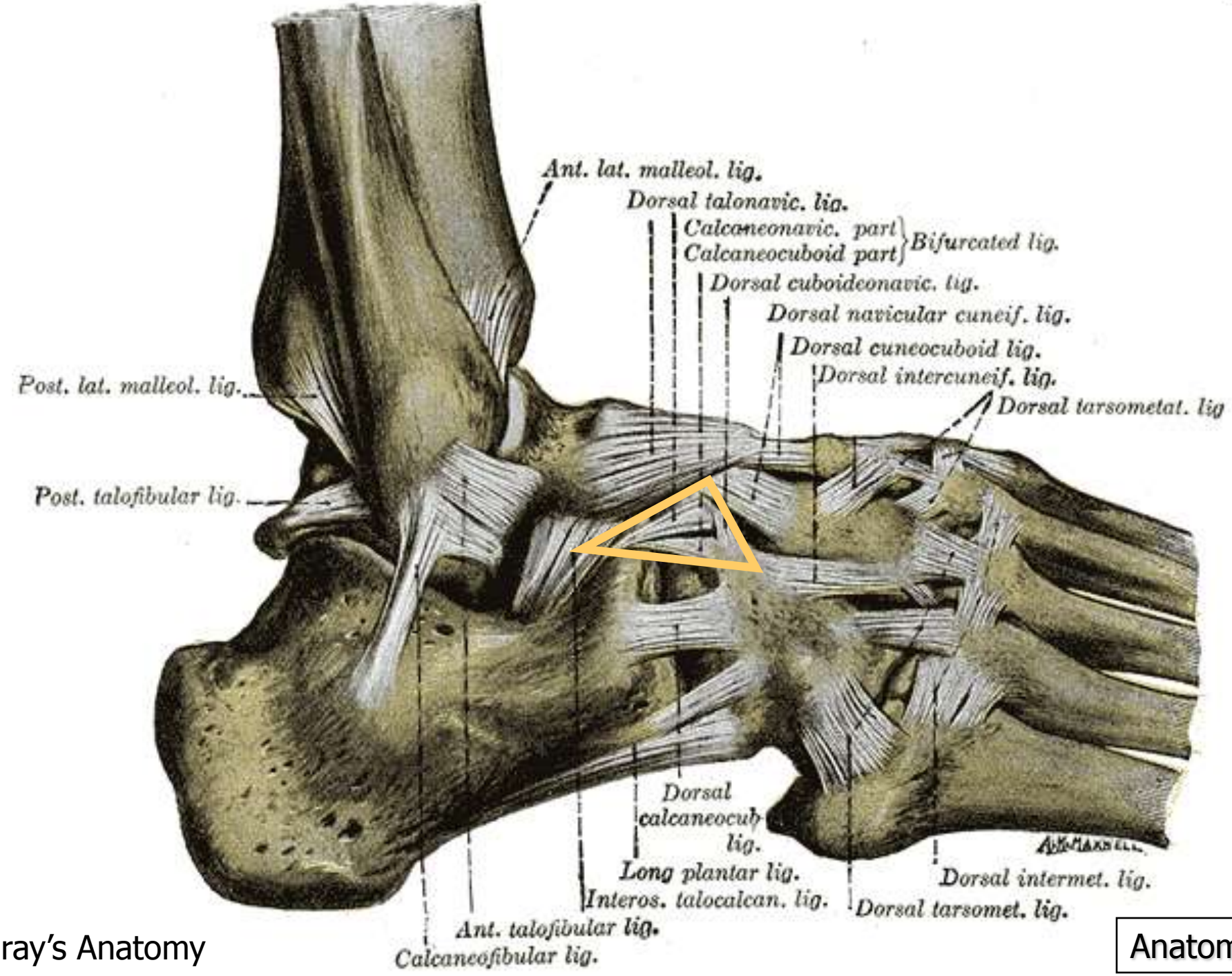
Pathology

Os Calcaneus Secondarius

Os Calcaneus Secundarius

- Location: interval between anteromedial aspect of the calcaneus, cuboid, talar head and tarsal navicular
- Frequency: 0.6 – 7% of feet
- Postulated to have post traumatic etiology
  - Avulsion of bifurcate ligament secondary to inversion and forced plantar flexion
  - Eversion of dorsiflexed foot
- Rarely symptomatic, may limit range of motion, clinically resembling a calcaneonavicular coalition

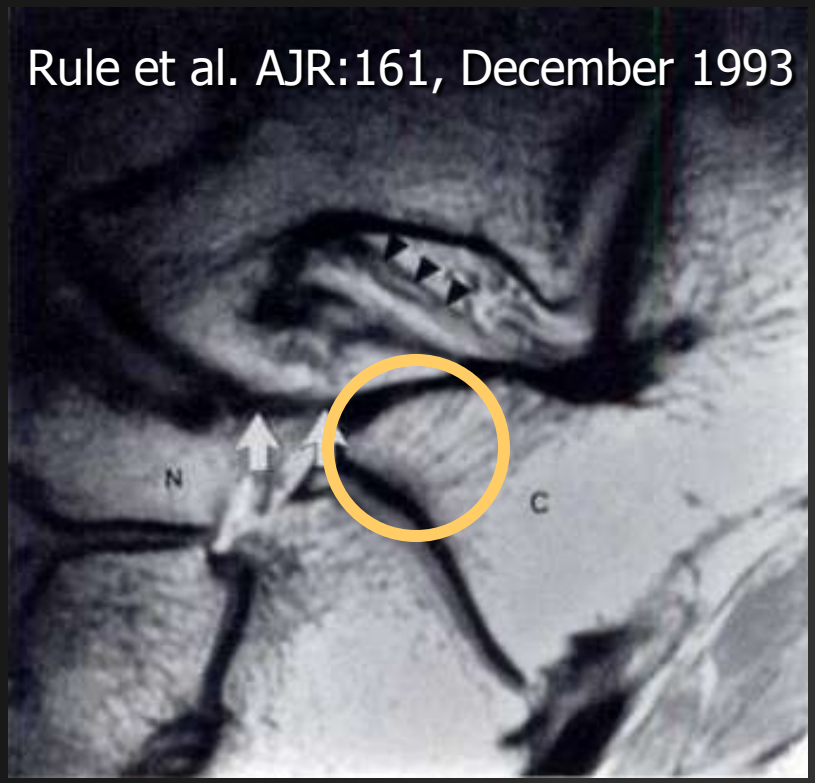
Anatomy



Gray's Anatomy

Anatomy

Bifurcate ligament and relationship to os calcaneus secondarius



Rule et al. AJR:161, December 1993

Bifurcate ligament is seen spanning anterosuperior part of calcaneus and navicular bone (arrows). Arrowheads = Interosseous talocalcaneal ligament, N = navicular bone, C = calcaneus.

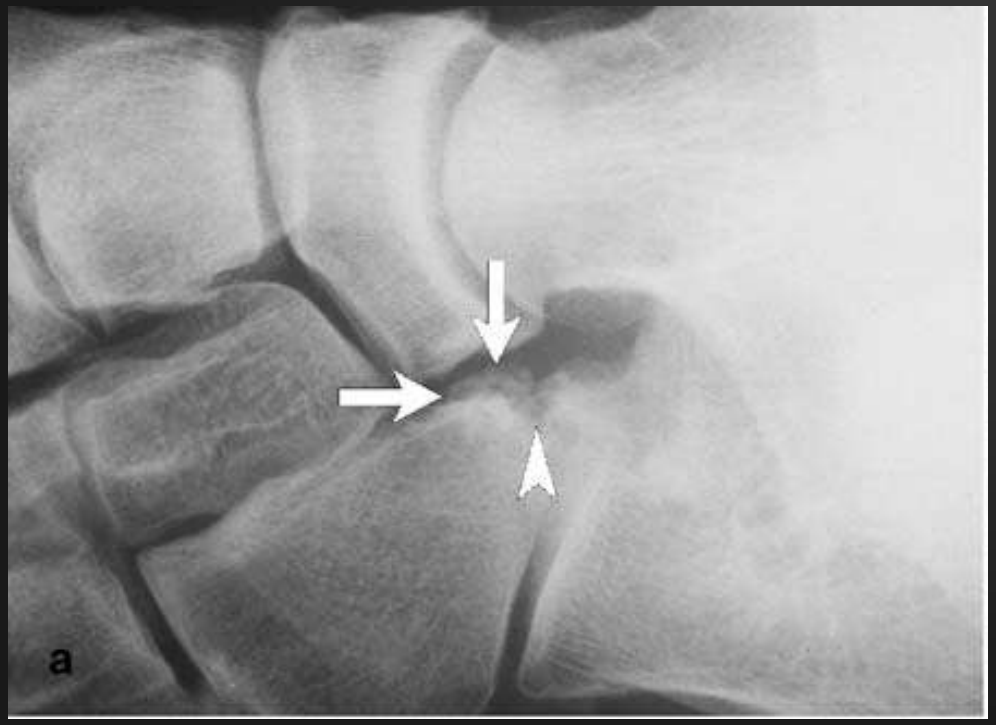
A 32-year-old man with midfoot pain. A medial oblique radiograph shows a large os calcaneus secundarius projected between the anterior calcaneus and the navicular (arrow). Spurs are seen along the adjacent articular surface of the talus, which implies abnormal motion at this area.

Kalantari et al. Appl Radiol. 2007; 36(10):28-37

Anatomy

Os Calcaneus Secondarius

Os calcaneus secundarius in a 40-year-old woman with a painful right forefoot. a. Oblique radiograph incompletely reveals an os calcaneus secundarius (*arrows*). A slightly irregular radiolucent cleft (*arrowhead*) is seen between the accessory bone and the adjacent anterosuperior calcaneal process.



Mellado et al. *Eur Radiol* (2003) 13:L164–L177

b. Axial T2-weighted MR image demonstrates the round and well-corticated appearance of the os calcaneus secundarius (arrows). The incidental accessory bone was considered unrelated to the patient's complaint

Os Calcaneus Secondarius vs. Acute Fracture Anterosuperior Process of Calcaneus

Os calcaneus secondarius – generally ovoid, small and well corticated

vs.

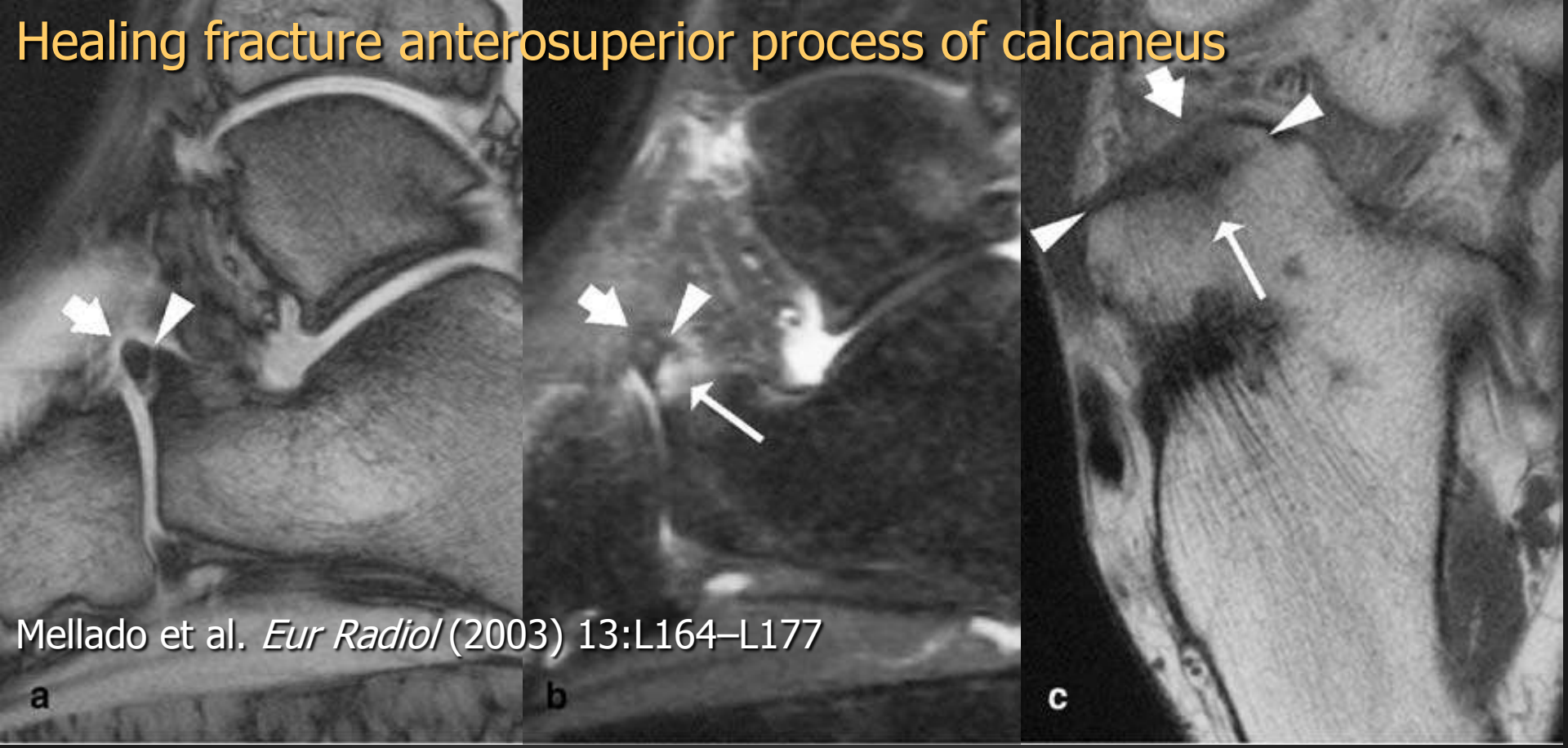
Koulouris et al. Semin Roentgenol. 2005 Oct;40(4):358-79

Acute fracture anterosuperior calcaneal process - wider proximal base (and altered signal on the adjacent bone marrow on MR images)

www.latrobe.edu.au/podiatry/radiologyresources

Pathology

Healing fracture anterosuperior process of calcaneus



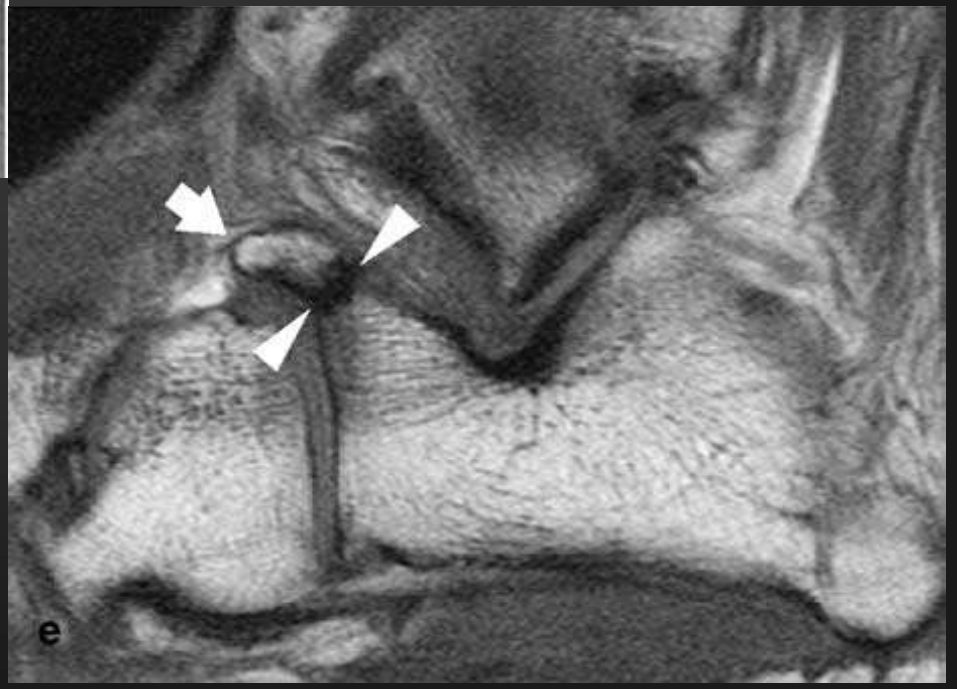
Mellado et al. *Eur Radiol* (2003) 13:L164–L177

54 year-old man with history of inversion and plantar flexion injury. (a) Sagittal T2-weighted and (b) STIR image reveal a slightly irregular interface (*arrowhead*) traversing the base of the anterosuperior calcaneal process (*short arrow*). A pattern of bone marrow edema (*long arrow*) is seen on the STIR image, supporting the diagnosis of healing fracture. (c) Axial T1-weighted MR image in the same patient better reveals the broad-based triangular configuration of the fractured fragment (*short arrow*) outlined by a hypointense line consistent with progressing union (*arrowheads*), with mild hypointensity on adjacent bone marrow (*long arrow*) which reflects bone marrow edema.

Pathology

Healed Fracture of Anterior Process of Calcaneus

28-year-old professional soccer player presenting with non-specific ankle pain. (d) The lateral radiograph reveals a faint radiolucency (*arrowhead*) at the base of an otherwise normal-shaped anterosuperior calcaneal process (*arrow*).



The corresponding sagittal T1-weighted MR image reveals a broad band of hypointensity (*arrowheads*) traversing the base of the anterosuperior calcaneal process (*arrow*). The findings were thought to represent completed healed fracture, unrelated to patient's complaint.

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

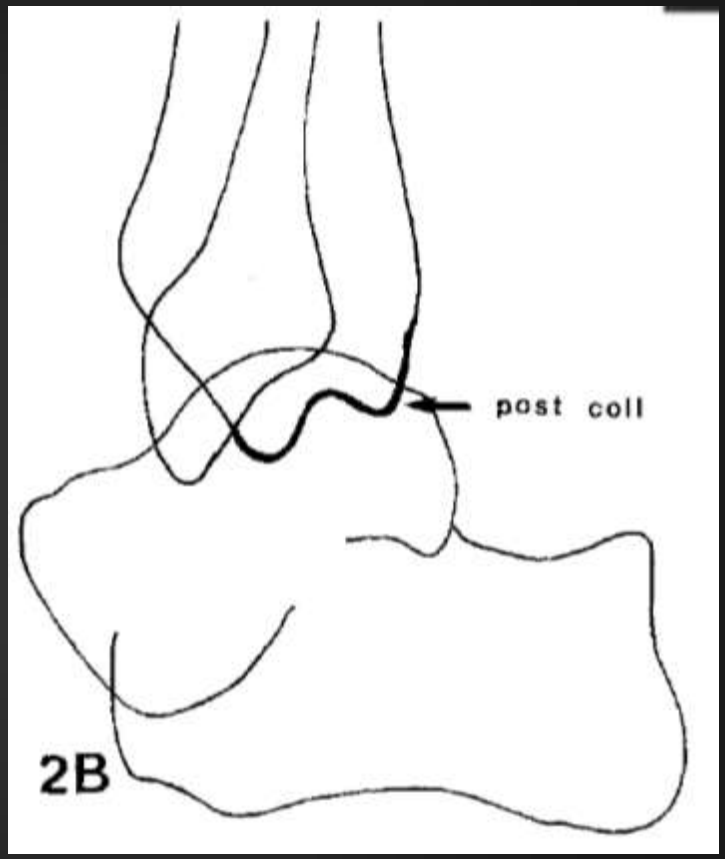
Pathology

Os Subtibiale

Os Subtibiale

- Location: accessory bone and normal variant related to the posterior colliculus of the medial malleolus
- Frequency: 4.6% of feet
- Ossicles related to the anterior colliculus, which forms the tip of the malleolus, are smaller (2.1%) and may represent unfused secondary ossification centers
- No clinical significance, but need to differentiate from acute avulsion fracture of medial malleolus

Os Subtibiale



An example of an os subtibiale. The accessory bone is related to the posterior colliculus which shows some irregularity in its outline, presumably because the large subtibial bone has interfered with its development

Coral. Skeletal Radiol. (1987) 16:298 303

Anatomy

Medial Malleolus Avulsion

An example of an avulsion fracture. The avulsed fragment completes the normal form of the medial malleolus. Coral. Skeletal Radiol. (1987) 16:298 303

29-year-old man presenting with vague heel pain after eversion injury. AP radiograph reveals a small ossicle (*arrow*) adjacent to the medial malleollus. The irregular contour of the radiolucent interface in-between (*arrowhead*) and the clinical setting supports the diagnosis of avulsion fracture of the medial malleollus.

Mellado et al. Eur Radiol (2003) 13:L164–L177

59-year-old man with history of repetitive ankle sprains. Coronal PD -weighted MR image reveals mild amputation of the medial malleollus (*black arrowhead*). A small irregular ossicle is found in its vicinity (*thick arrow*), consistent with chronic displaced avulsion fracture. The deep fascicle of the deltoid ligament (*white arrowhead*) appears mildly heterogeneous.

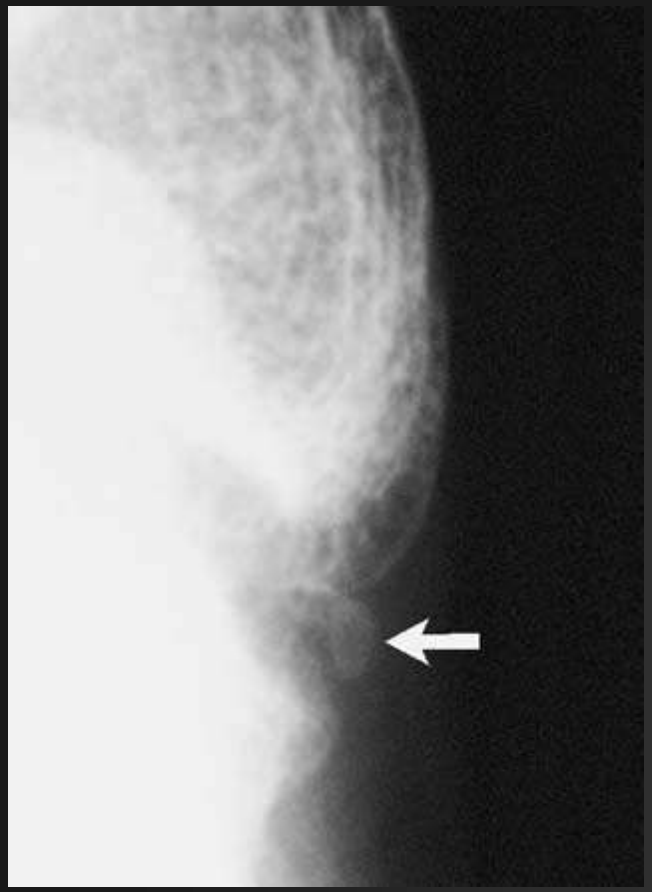
Os Subfibulare

Os Subfibulare

- Location: accessory bone located under the tip of the lateral malleollus
  - Ossicle may be round or comma shaped
- Frequency: 2.1% of feet
  - Given the relative rarity of the os subfibulare, most ossicles adjacent to the lateral malleollus are old non-united avulsion fractures
- Painful os subfibulare syndrome
  - Laxity of anterior talofibular ligament associated with avulsion fracture of lateral malleolus
  - Not true os subfibulare

Os Subfibulare

Rady's Childrens



Os subfibulare in a 34-year-old man who was referred so that osteochondritis dissecans of the talar dome could be ruled out. Anteroposterior radiograph reveals a small, round and well-marginated ossicle (*arrow*), adjacent to the lateral malleollus, consistent with os subfibulare.

Os Subfibulare

Avulsion fracture of the lateral malleollus in a 20-year-old man with a history of ankle sprain and instability. Sagittal T1-weighted MR image reveals an anteriorly displaced avulsed bony fragment (*white arrow*) at the tip of the lateral malleollus. Cortical irregularity is noted at the avulsion site (*black arrow*). An adjacent soft tissue lesion is also noted (*arrowheads*), consistent with reparative granulation tissue.

Mellado et al. *Eur Radiol* (2003) 13:L164–L177

Summary

- Most accessory ossicles and sesamoid bones of the ankle and foot represent fortuitous imaging findings
- Knowledge of the locations, imaging characterisitics and associated clinical entities is important for proper image interpretation

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- Potter HG, Pavlov H, Abrahams TG. The hallux sesamoids revisited. *Skeletal Radiol*. (1992) 21:437-444
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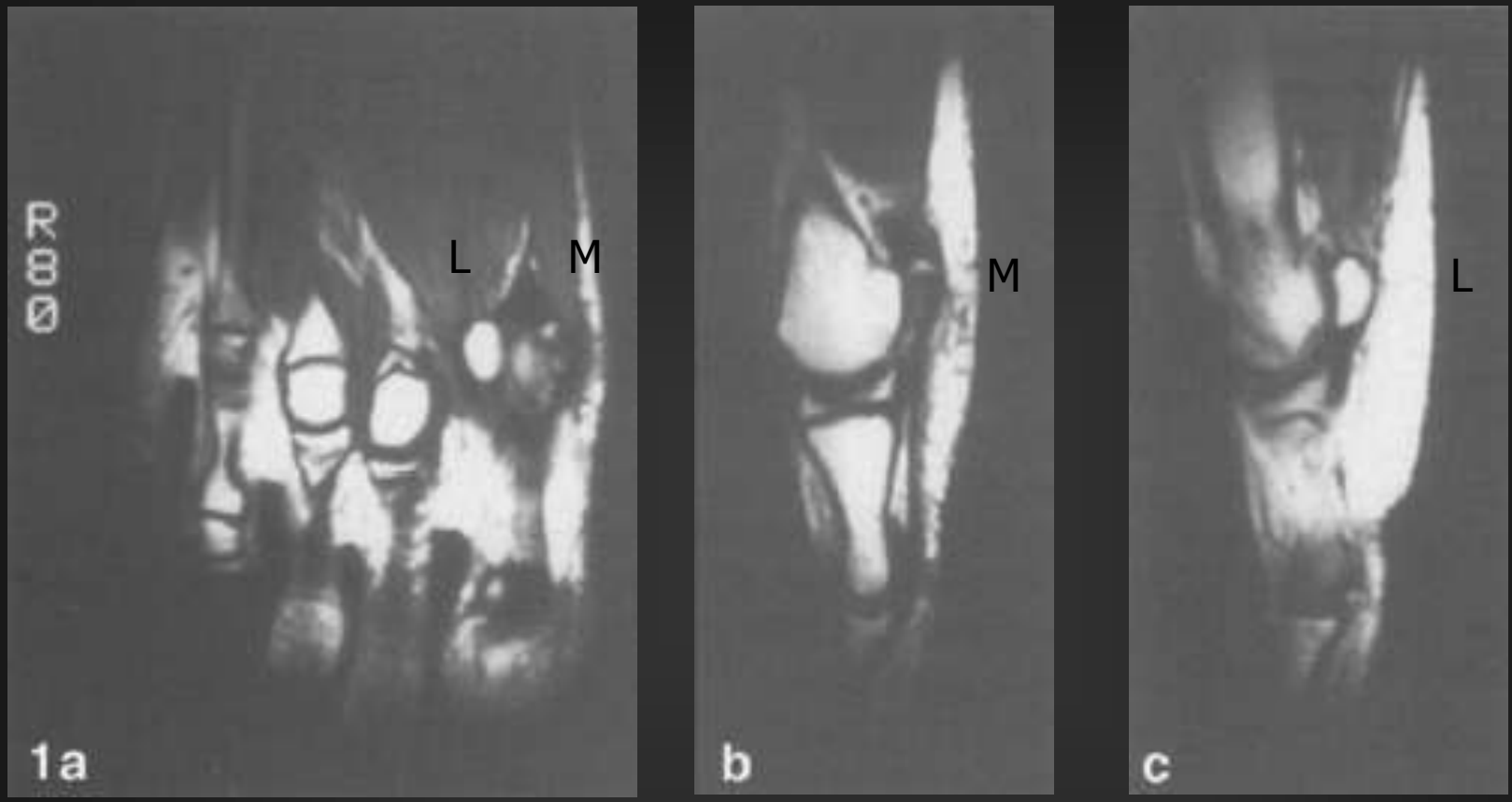
Stress Fracture



Coronal (a) and sagittal (b) T1- weighted images depict a flattened, fragmented, and hypointense medial sesamoid bone. It is compared with images of the normal lateral sesamoid in the coronal (a) and sagittal (c) planes

Burton et al. Pediatr Radiol (1994) 24:37-38

Pathology

Sesamoidectomy

- FHB – no significant effect on moment arm if resect tibial sesamoid or distal portion of both sesamoids; if resect both, reduce dorsiflexion by 1/3
- FHL – moment arm reduced by complete resection of either bone
- Hallux valgus may follow tibial sesamoid resection

Os Subtibiale Mimics

6. An ossicle related to the anterior colliculus. This is compatible with an unfused ossification centre for the tip of the medial malleolus

7. Curvilinear calcification in the line of the deltoid ligament

Coral. Skeletal Radiol. (1987) 16:298 303

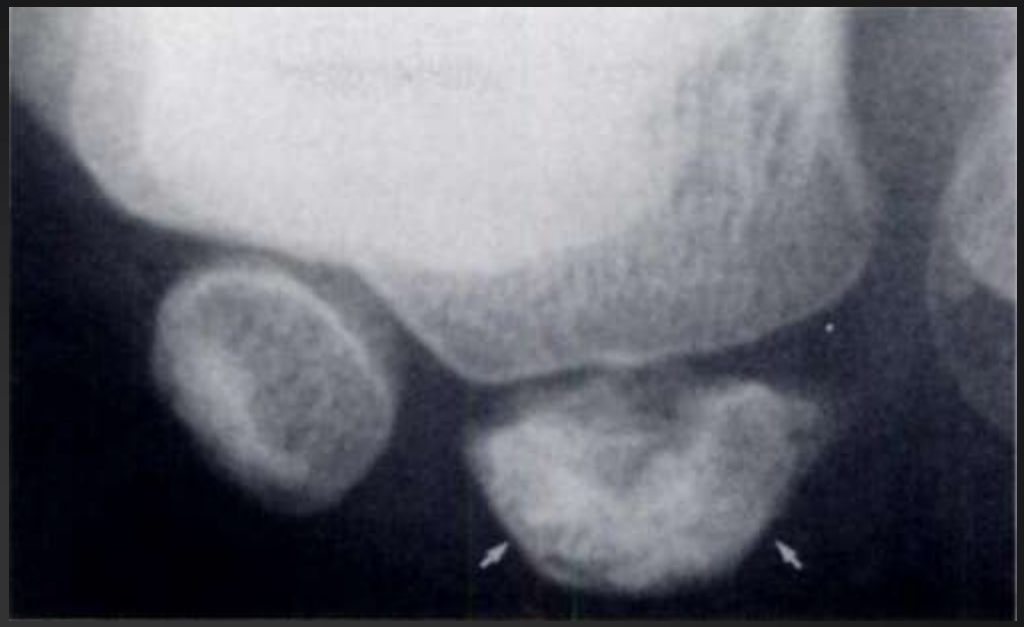
Os Subfibulare

Sag T1

Sag STIR

http://www.mskcases.com/index.php?module=article&view=165

Chronic Stress: Sesamoiditis



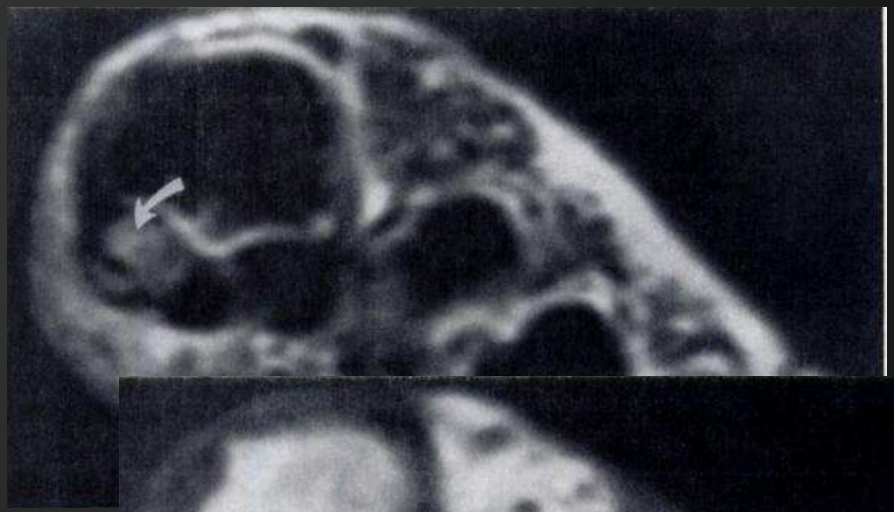
Sesamoiditis of the lateral sesamoid in a 33 year-old man with pain and swelling beneath the great toe and no history of recent trauma to this area. Axial radiograph reveals flattening and sclerosis of the lateral sesamoid bone (arrows). Tc-99m MDP bone scan shows increased uptake (open arrows) in this region. Note the increased uptake at the base of the fifth metatarsal, indicating delayed union of a remote fracture (solid arrow).

Taylor et al. RadioGraphics 1993; 13:817-830

Pathology

Infection

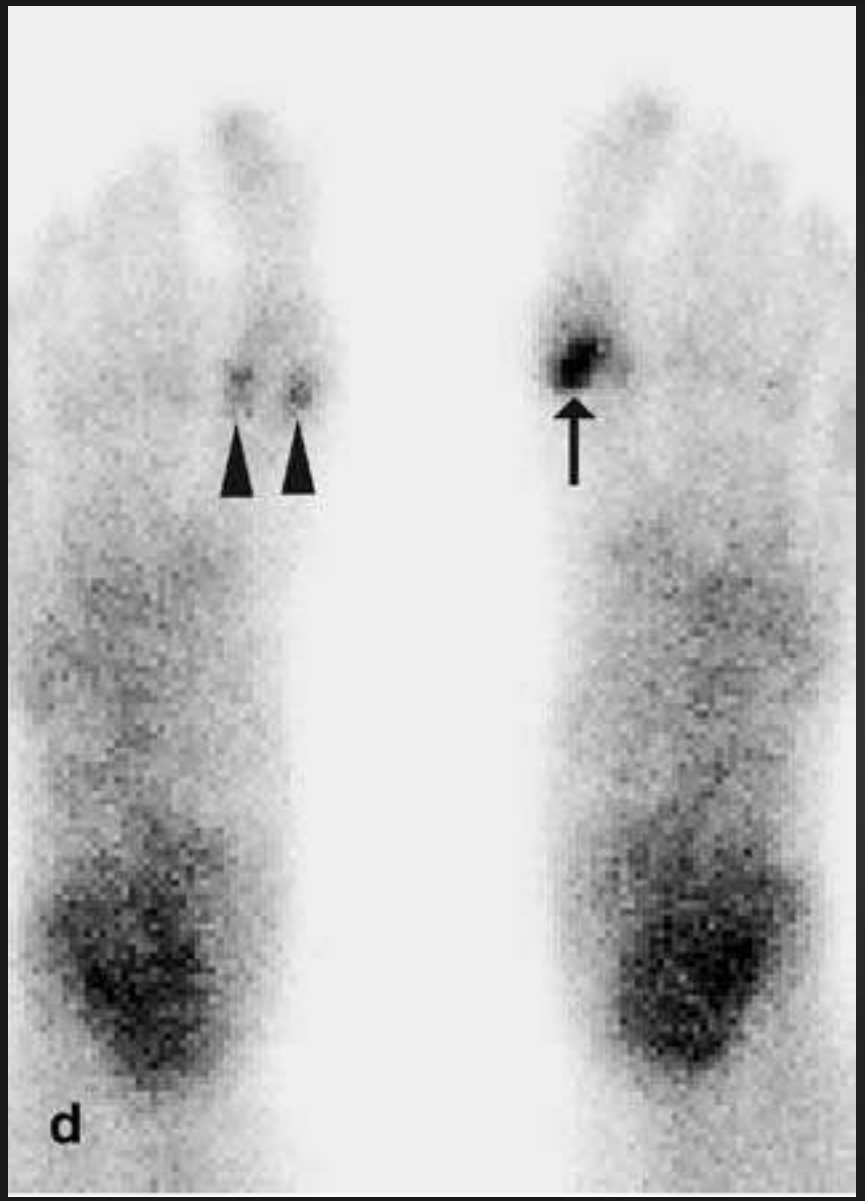
Osteomyelitis. Axial spin-echo Ti-weighted (550/20) (a), and inversion recovery (1,800/20/ 160) (b) MR images demonstrate characteristic signal intensity changes in the medial sesamoid of a diabetic patient's foot. A focal region of low signal intensity (arrow) is seen on the Ti-weighted image (a), and increased signal intensity (arrow) is seen in the marrow on the inversion recovery image (b). MR imaging is a sensitive modality to use to identify early changes in osteomyelitis.



Osteomyelitis and septic arthritis. Frontal radiograph shows severe demineralization and loss of cortical definition of the medial sesamoid (straight arrows). Associated metatarsophalangeal joint-space narrowing (arrowheads) and periarticular erosions (curved arrows) are also evident.

Taylor et al. RadioGraphics 1993; 13:817-830

Sesamoiditis



A 50-year-old man presenting with clinically suspected sesamoiditis in his right foot. The plantar projection of 99mTc-HDP bone scan reveals abnormally increased uptake on the right hallux sesamoids (*arrowheads*), consistent with sesamoiditis. Abnormal increased uptake is also present on the base of the proximal phalanx of the left hallux (*arrow*), most likely reflecting hallux valgus deformity

Mellado et al. Eur Radiol (2003) 13:L164–L177

Pathology