Starting Off On the Right Foot: Differential Diagnosis of Metatarsalgia

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Disclosure of Commercial Interest

Neither I nor my immediate family members have a financial relationship with a commercial organization that may have a direct or indirect interest in the content

Objectives

By the end of this exhibit, sports medicine clinicians and radiologists should be able to:

1. Describe the common causes of metatarsalgia
2. Recognize the imaging characteristics of the most common etiologies of metatarsalgia utilizing multiple imaging modalities
3. Understand how MR imaging allows a specific diagnosis based on the location, signal intensity characteristics, and morphologic features of the abnormality
4. Briefly discuss appropriate management decisions for some of the common conditions resulting in metatarsalgia

Metatarsalgia

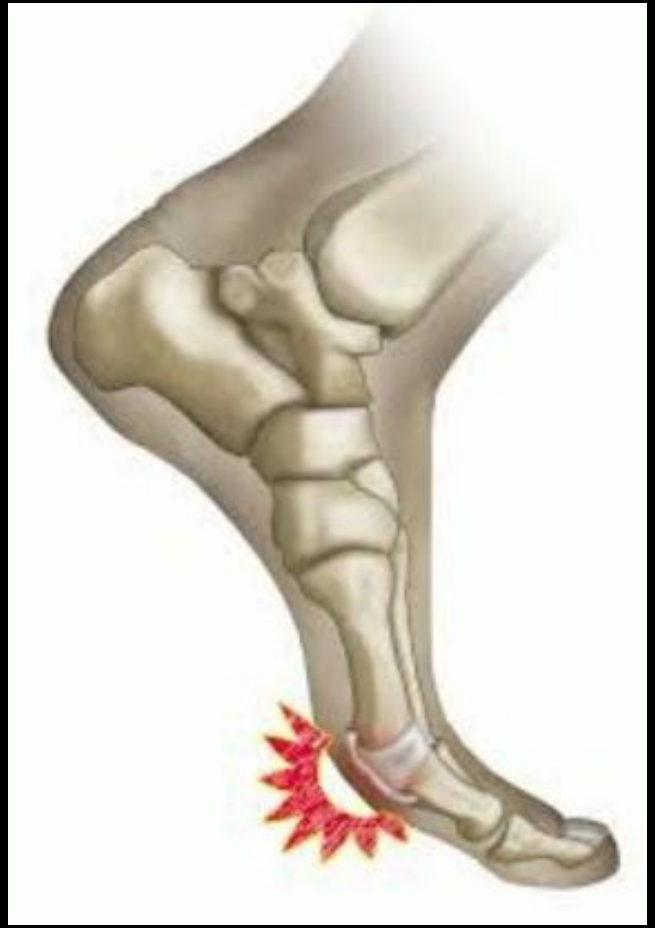
- Metatarsalgia is a common clinical condition, often difficult to diagnose by clinical findings alone
- Wide array of etiologies:
  - Trauma
  - Infection
  - Arthritis
  - Tendon and muscle disorders
  - Soft tissue masses
- MRI is usually the imaging modality of choice for evaluation and diagnosis of metatarsalgia due to its ability to depict soft tissue and osseous pathology
- Most of these conditions are managed non-surgically

Outline

- Trauma - *turf toe, sesamoiditis, lesser plantar plate injuries, stress and insufficiency fractures*
- Infection – *osteomyelitis, septic arthr*itis
- *Arthritis – osteoarthritis, rheumatoid arthritis, gout*
- Tendon disorders – *calcific tendinosis and traumatic injuries*
- Soft tissue masses - *intermetatarsal bursitis, adventitial bursa, ganglion, Morton's neuroma, plantar fibroma, miscellaneous eg. fibrolipomatous hamartoma*

Turf toe

- Sprain of plantar capsuloligamentous complex at 1st MTP joint
- Acute axial load on hyperextended forefoot
  - Capsular injury 1st MTP joint
  - +/- osteochondral injury
  - +/- sesamoid diastasis or fracture
- Acute pain, swelling, bruising, limited ROM
- Can also develop as a result of chronic repetitive overuse



Anatomy of the 1st MTPJ capsuloligamentous complex

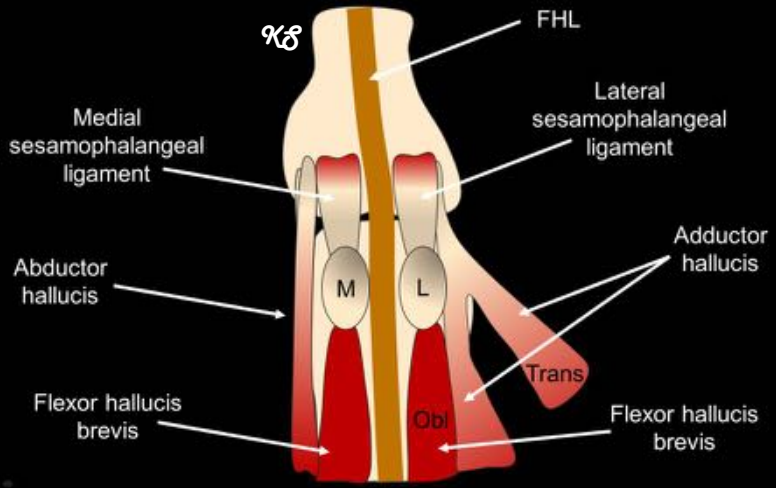


Diagram of the plantar aspect of the 1st MTP joint

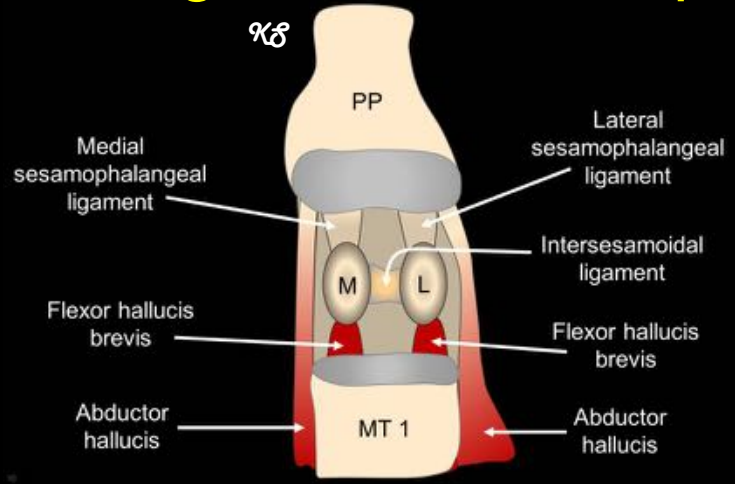
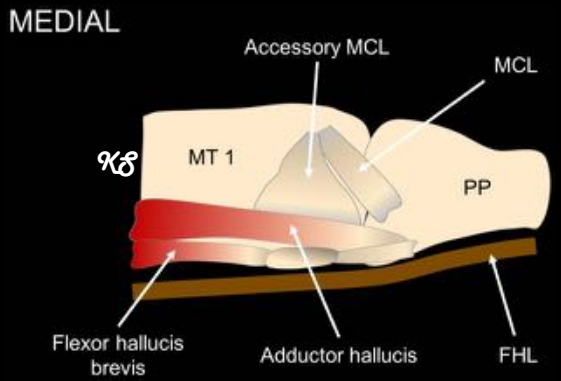
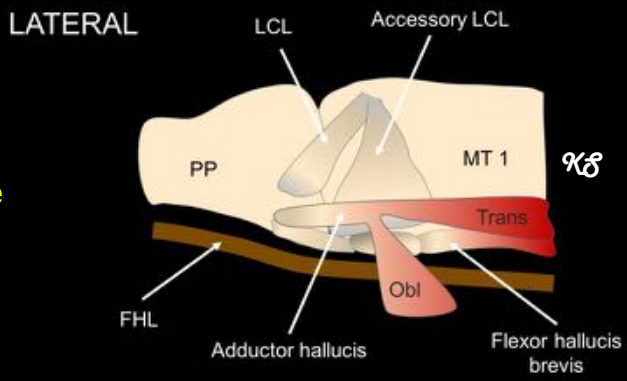


Diagram of the superior aspect of the plantar plate complex with the first metatarsal head removed



Diagrams of the medial and lateral aspects of the 1st MTP joint



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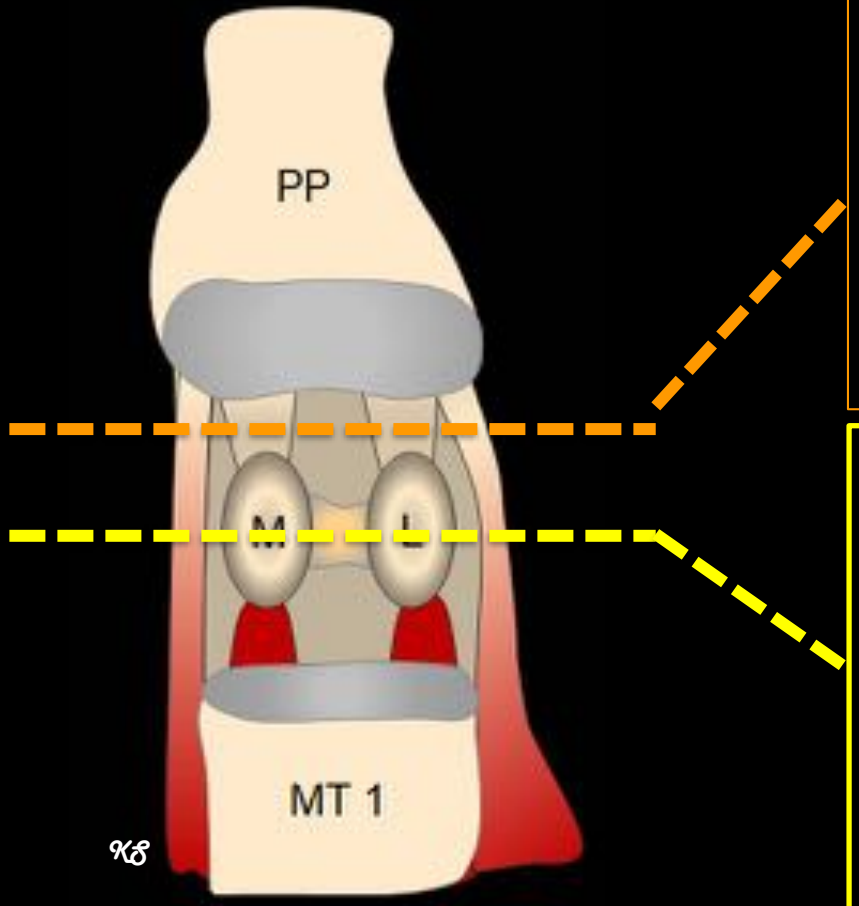

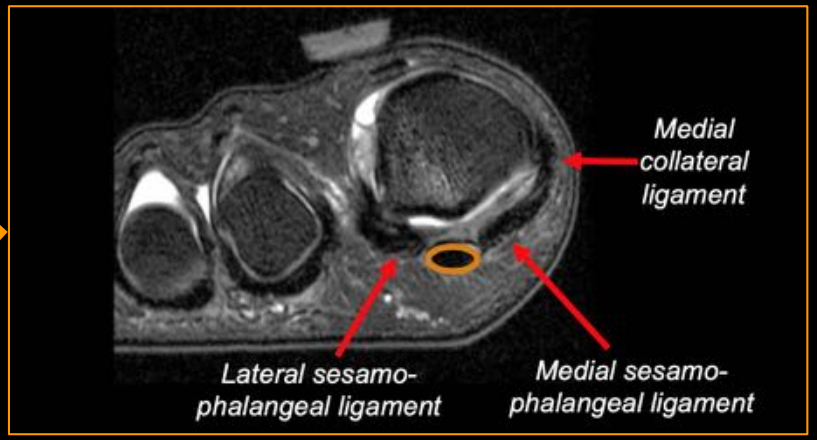

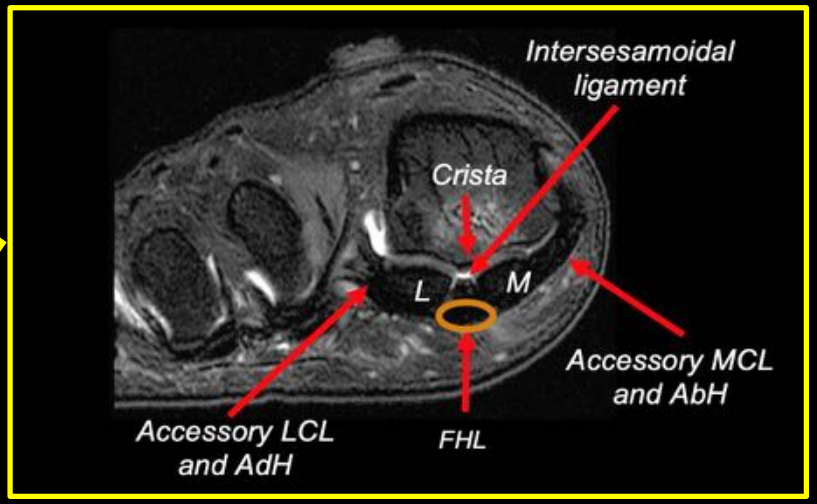

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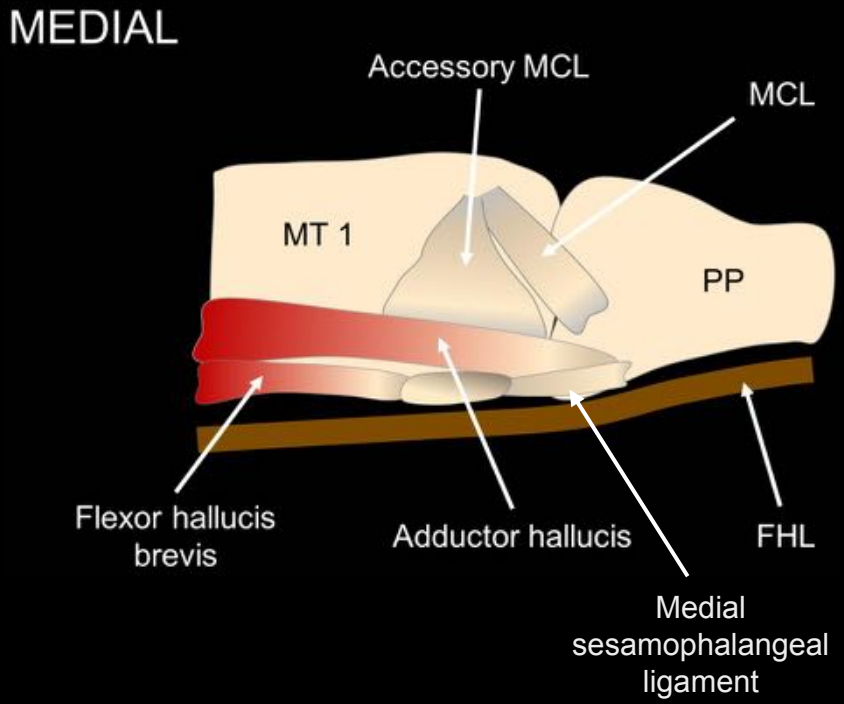
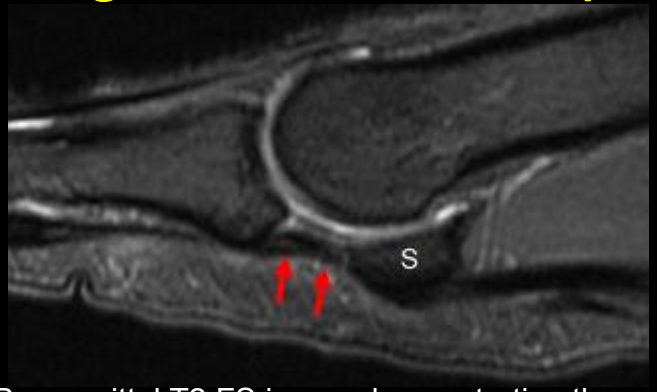
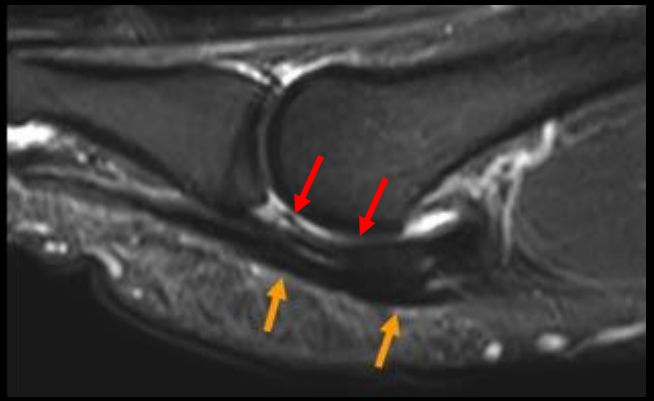


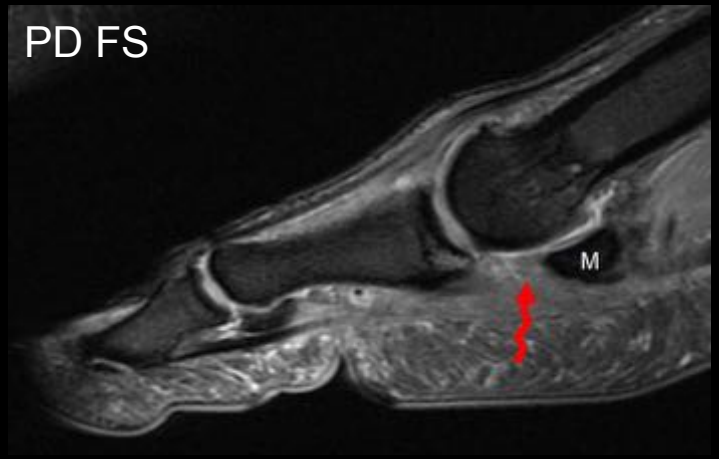


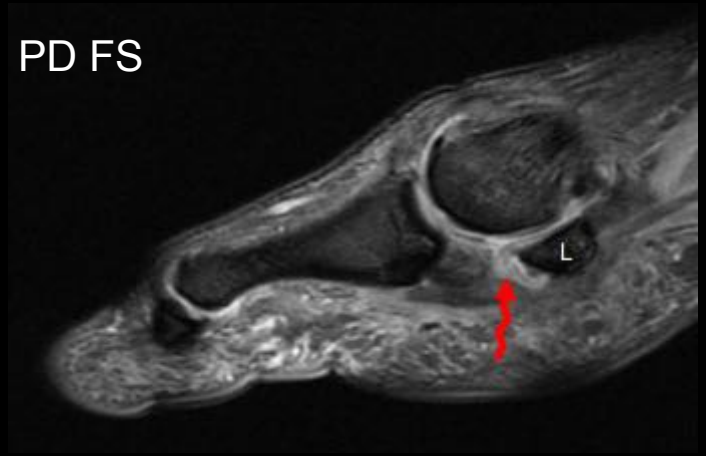
Parasagittal T2 FS image demonstrating the medial sesamophalangeal ligament



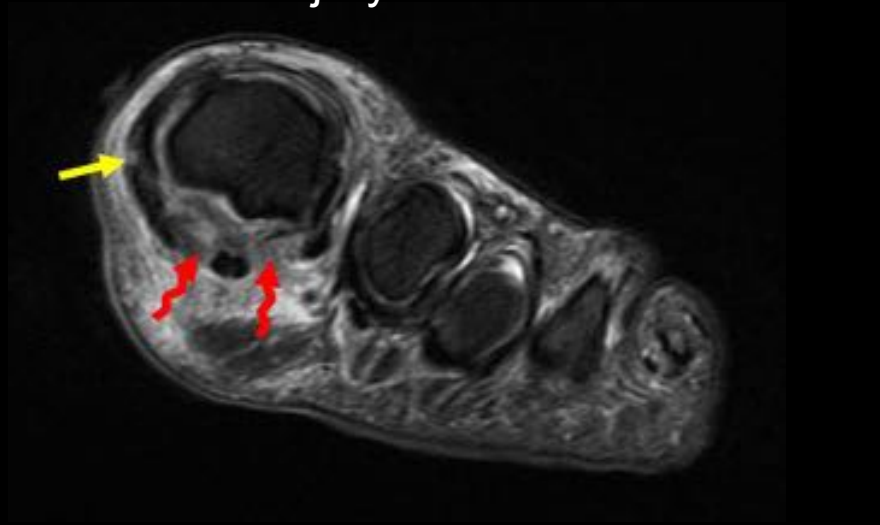
Midline T2 FS image demonstrating the FHL tendon and underlying plantar plate proper with a normal small distal recess

Acute turf toe injury in a 24 year old football player





Sagittal and short axis coronal MR images of the 1st MTP joint demonstrate complete tears of the medial and lateral sesamophalangeal ligaments, with sprain of the accessory MCL and abductor hallucis tendon, compatible with a high grade turf toe injury



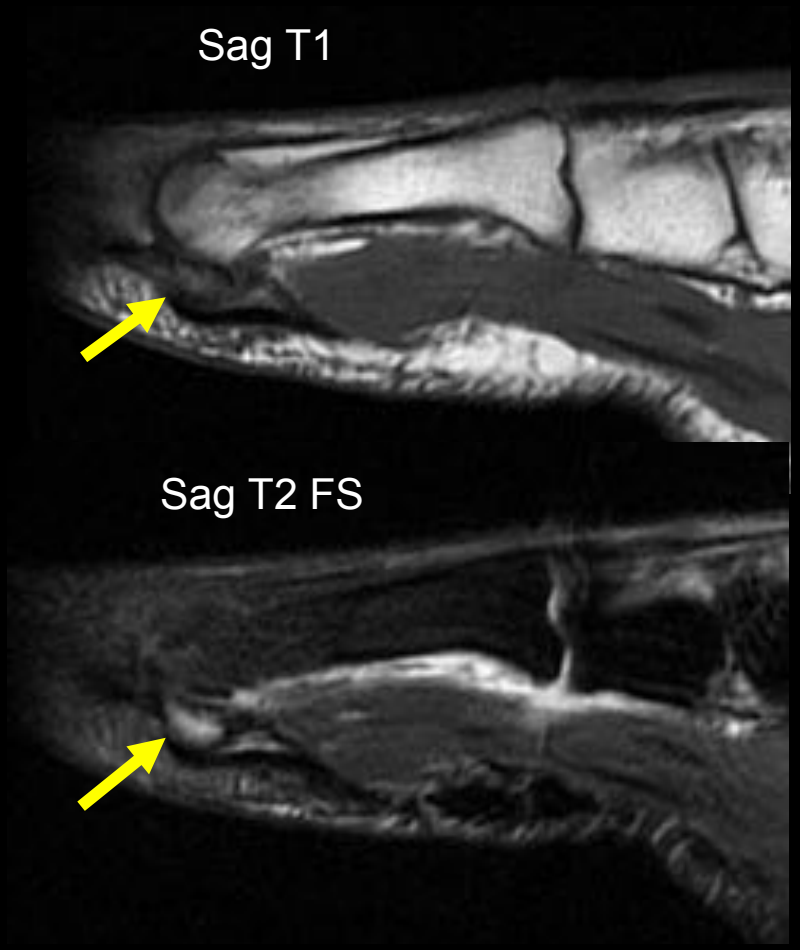
29 year old professional football player with old turf toe injury

Lateral radiograph and sagittal and 3D CT reformatted images demonstrate dystrophic ossification in the medial sesamophalangeal ligament

Sagittal MR images demonstrate evidence of prior high grade sprain of the medial sesamophalangeal ligament with dystrophic ossification. The lateral sesamophalangeal ligament is intact

Sesamoiditis

- Repetitive, excess pressure on forefoot (ballet dancing, walking)
- Gradual onset dull pain on plantar aspect of great toe
- MRI – normal or mildly decreased T1 and increased T2 signal within a hallux sesamoid
- Usually responds to conservative treatment eg rest, ice, NSAID's, taping

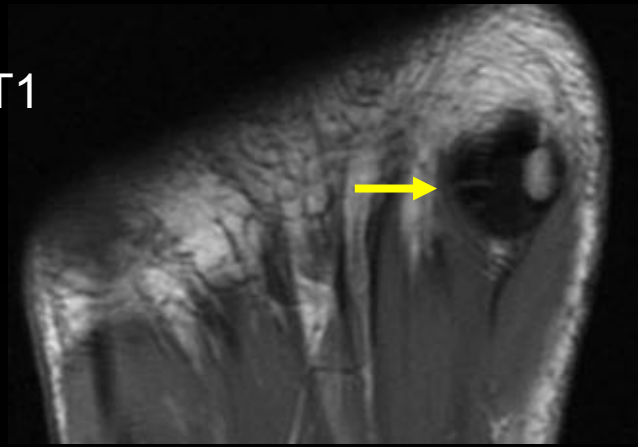


Avascular necrosis of sesamoids

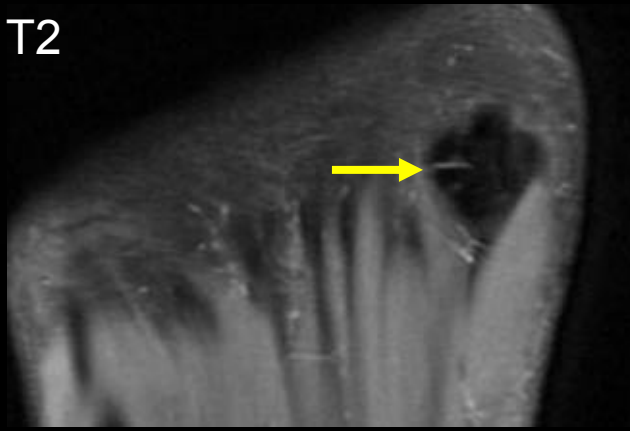
- Young adults
- Females > males
- Lateral > medial hallux sesamoid
- Compromised vascular supply secondary to repetitive injury, fracture, dislocation, infection,
- Early MRI findings similar to sesamoiditis
- Later findings include subtle sclerosis on x-ray and CT and low signal on T1 and T2 (+/- fracture)

DP oblique radiograph

T1

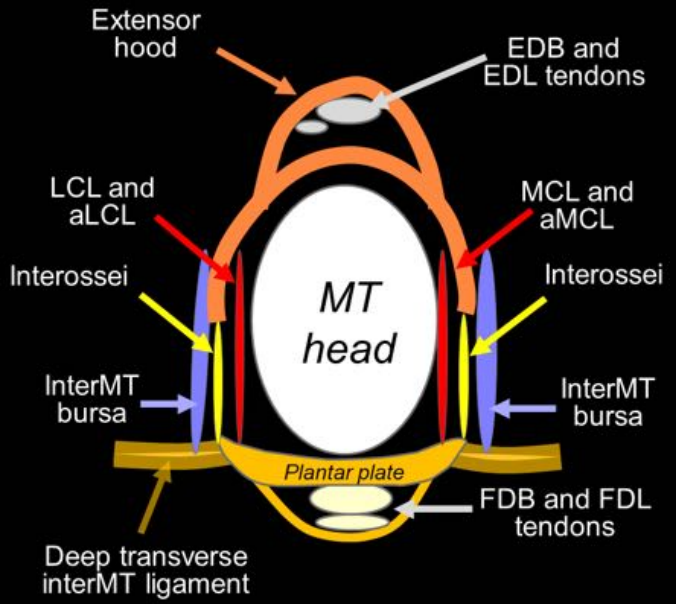


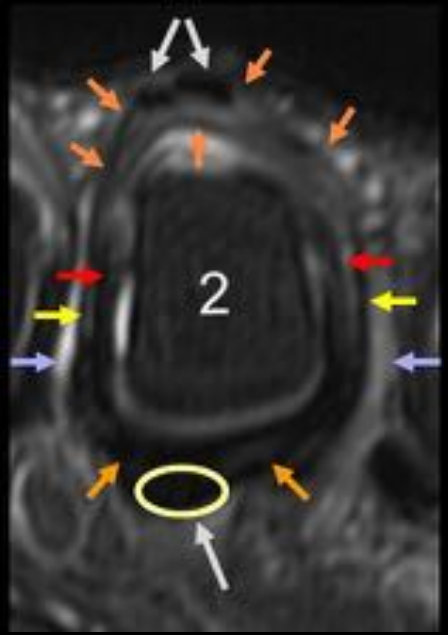
T2

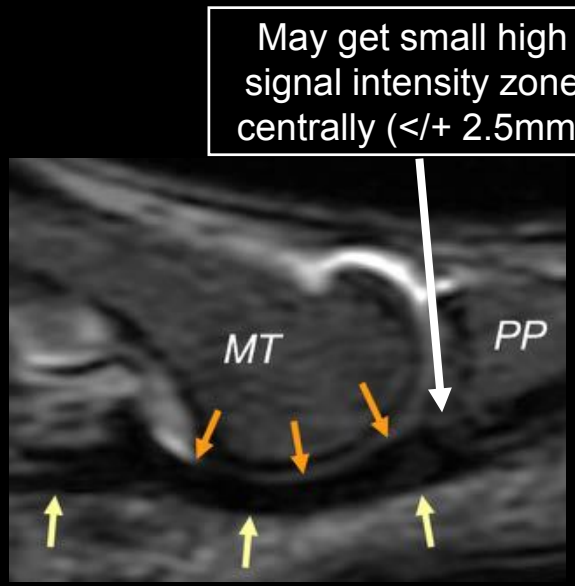


Lesser plantar plate anatomy and injuries

Fibrocartilaginous plantar plates are major stabilizers of lesser MTP joints, cushioning MT heads and absorbing compressive loads in weight-bearing and tensile loads in dorsiflexion,







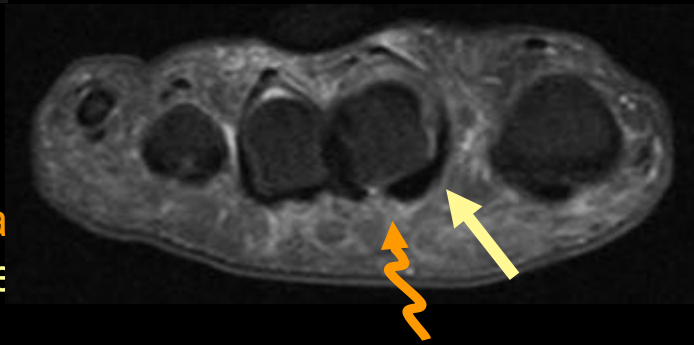
Normal anatomy of the second plantar plate mechanism

Lesser plantar plate anatomy and injuries

- Injuries usually degenerative due to chronic overload of plantar plates → acute pain, swelling and deformity
- 2nd toe most commonly affected
- 2nd metatarsal elongated > 4mm
- Hallux valgus
- High heels → narrow toe and hyperextension
- Females > males

48-year-old female with pain centered over the 2nd MTP joint. There is splaying of the second and third digits and relative elongation of the 2nd MT with respect to the 1st and 3rd

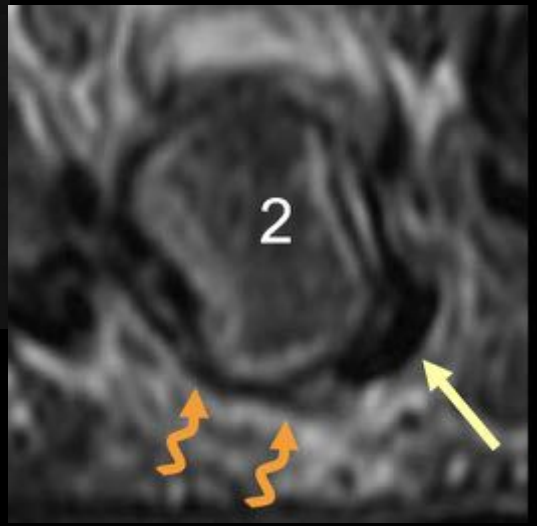
Short axis T2 FS MR image demonstrates a second plantar plate tea with medialization of the flexor tendon

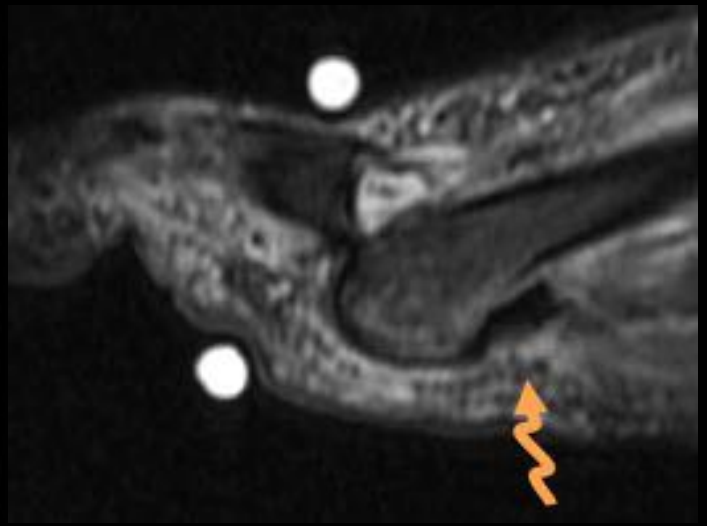


Lesser plantar plate anatomy and injuries

X-ray in a 45-year-old male with severe forefoot pain demonstrates dislocation of the 2nd MTP joint

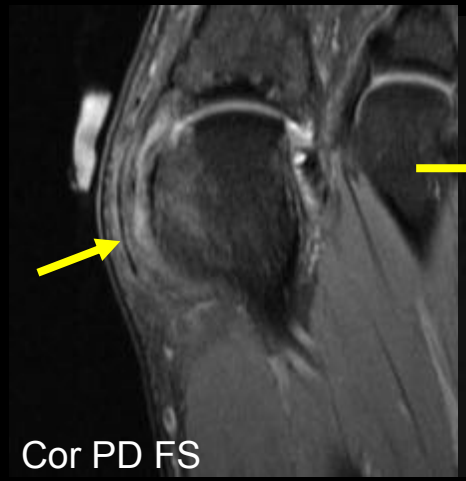
Axial and sagittal T2 FS images demonstrate a tear of the 2nd plantar plate tear with retraction, and associated medialization of the flexor tendon

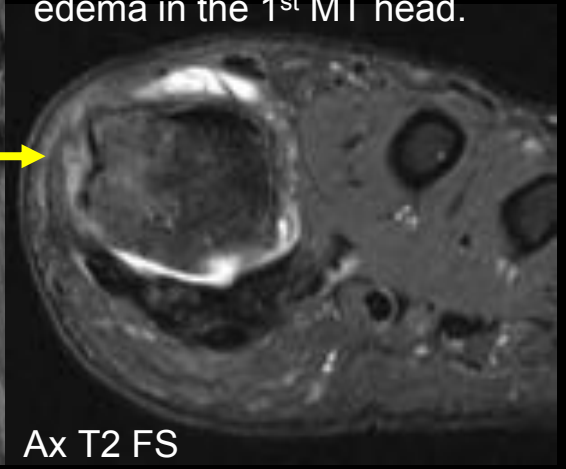


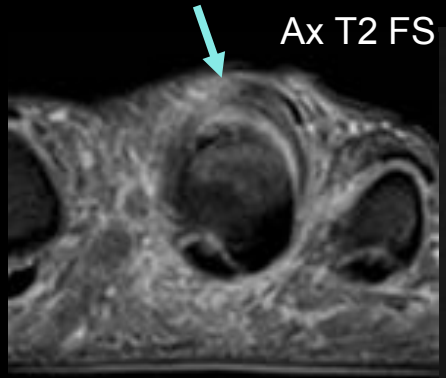


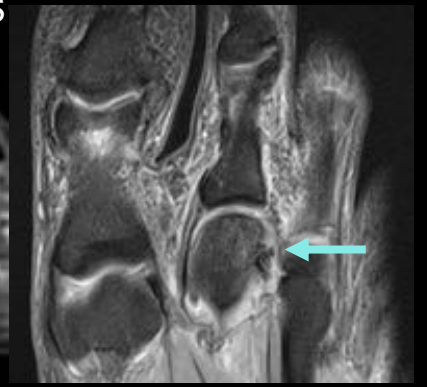
Other traumatic capsular injuries

33 year old male with soccer injury to 1st MTP joint 4 months ago. A small joint effusion was present but the plantar plate mechanism was intact. However, there was a high grade tear of the medial collateral ligament complex proximally, with bone marrow edema in the 1st MT head.

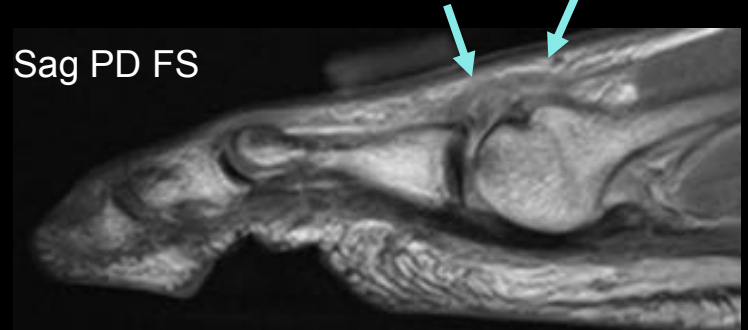






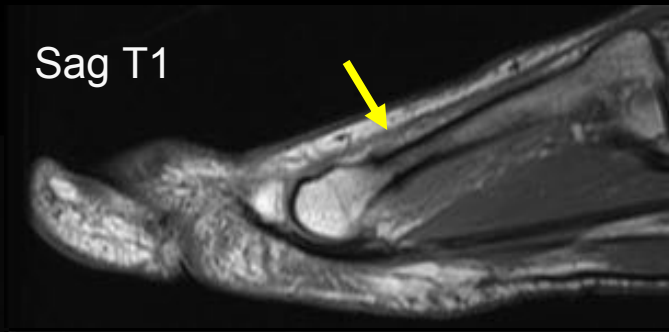


22 year old female with acute injury to 2nd MTP joint demonstrating irregularity of the dorsal capsule and lateral capsule with adjacent edema, compatible with high grade sprain



Stress fractures and subchondral fractures

- Stress fractures are most common in runners, ballet dancers, gymnasts, military recruits
- Occur in middle or distal aspect of 2^{nd}-4^{th} metatarsals
- Subchondral stress or insufficiency fractures appear similar and can occur in metatarsal heads
- X-rays often normal in the acute phase in both, followed by periosteal reaction in MT shaft and flattening of the articular surface in MT head
- Both can manifest as a band of low signal intensity contiguous with the cortex on T1 and T2 with BME



Stress fracture of the 3^{rd} MT in a 48-year-old female runner showing periosteal reaction along the 3rd MT shaft on x-ray, and a linear fracture line through the distal diaphysis with surrounding bone marrow and soft tissue edema on MRI

Stress fractures and subchondral fractures

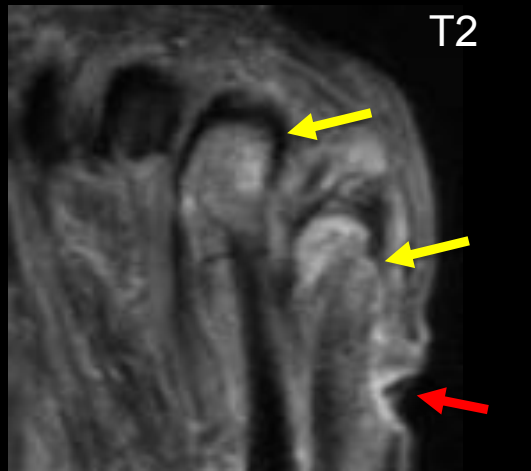
56-year-old female with forefoot pain demonstrates subtle subchondral lucency in the lateral aspect of the 2nd MT head on X-ray. On MRI there are subchondral fractures in the 2nd and 3rd MT heads, as well as bone marrow edema on T2. A small Morton's neuroma is seen in the 3rd interspace on T1.

Infection

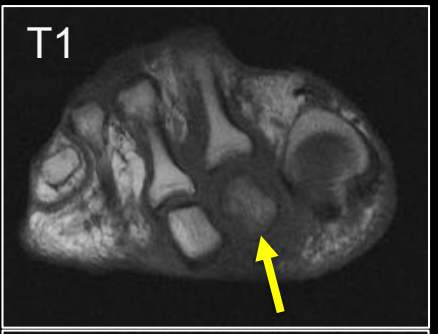
- Most commonly results from transcutaneous spread of infection in diabetic patients
- Ulcerations occur at pressure points and become infected, with spread to underlying metatarsal head/MTP joint
- X-ray:
  - soft tissue swelling, gas, ulceration, demineralization, periosteal reaction, cortical irregularity, and frank osseous destruction
- MRI:
  - Low T1, high T2/STIR, contrast enhancement
  - Look for cutaneous ulcer, cellulitis, phlegmon, soft tissue abscess, sinus tract, cortical interruption

X-ray in a 53 year old diabetic demonstrates a soft tissue ulcer over the 5th metatarsal, with bony destructive change of the 4th and 5th distal MT and 5th proximal and middle phalanges. Vascular calcification is present.

MR images show bony destruction of the 5th MT and low T1 and highT2 signal in the 4th and 5th MT heads subjacent to the ulcer compatible with osteomyelitis.

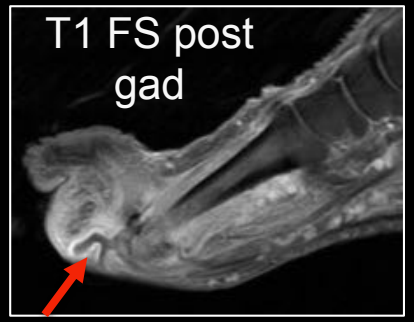


73-year-old diabetic male with ulcers on toes



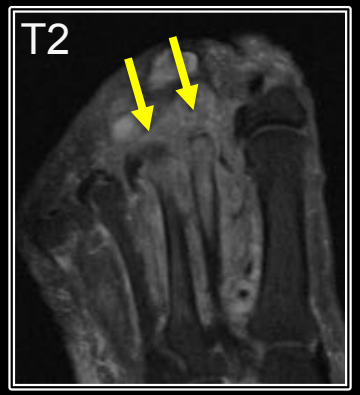
Soft tissue swelling with confluent low T1 and high T2 signal in the 2nd MT head, compatible with osteomyelitis

Postcontrast imaging with gadolinium helps identify sinus tracts, phlegmon and abscess



3 month FU x-rays demonstrate soft tissue swelling and dislocation of 2nd and 3rd MTP joints and erosions of the 2nd MT head

3 month MRI shows rim enhancing fluid collection extending into the 2nd MTPJ consistent with septic arthritis and osteomyelitis of 2nd and 3rd MT head



Arthritis

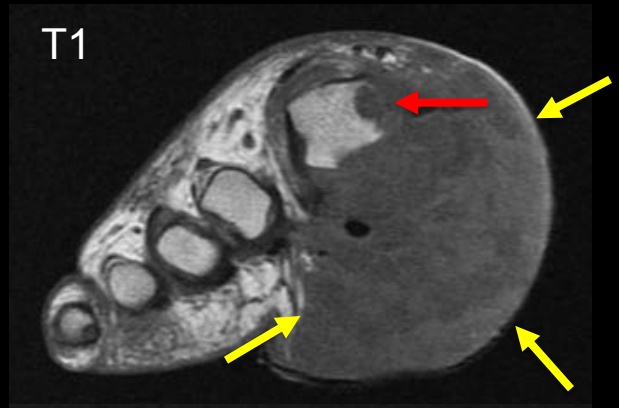
- Osteoarthritis (OA) is common in the 1st MTP joint produced by repetitive loading injury.
  - X-ray : Joint space narrowing, marginal osteophytes, subchondral cysts, subchondral sclerosis
  - MRI : Chondral thinning, subchondral cysts, bone marrow edema (BME), osteophytes
- Gout is caused by deposition of sodium urate crystals in joints, bones, tendons, bursae, periarticular tissue
  - X ray: juxta-articular erosions with sclerotic margins and overhanging edges with preservation of joint spaces
  - MRI: acute- joint effusion, synovial thickening, chronic-tophaceous gout and erosions. Tophi are variable on MR (int/low on T1, heterogenous low T2)
  - Differential diagnosis: Rheumatoid arthritis (RA), septic arthritis, neoplasm
- RA commonly affects the feet, with earliest changes seen at the MTP joints
  - X ray: periarticular soft-tissue swelling, juxta-articular osteopenia, proximal joint space involvement
  - US: synovial proliferation, hyperemia, and erosions
  - MRI: pannus (low/int T1, heterogenous T2), fibrous pannus can have hemosiderin deposition (low T2), marginal erosions, joint effusion, chondral thinning, subchondral cysts and BME, tenosynovitis, bursitis

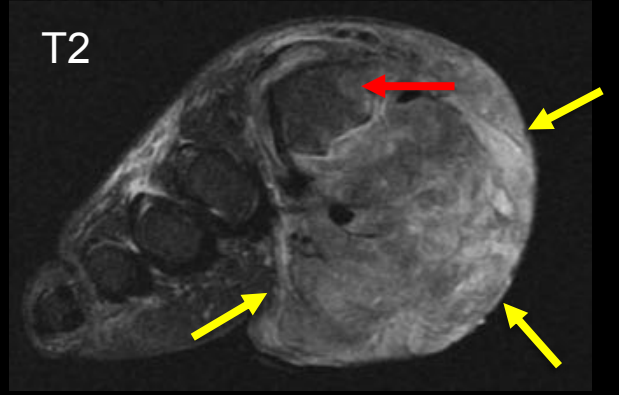
Severe OA of 1st MTP joint in 57-year-old female

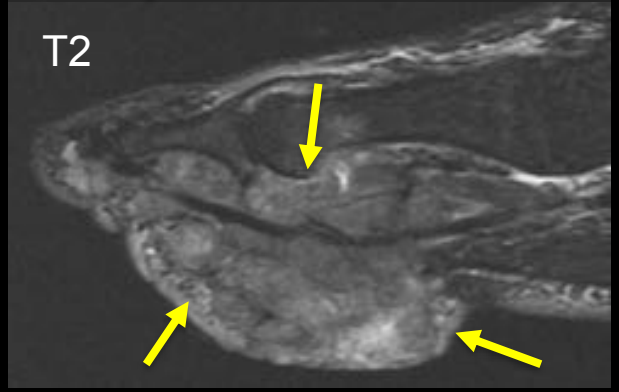
Joint space narrowing with subchondral cystic change, sclerosis, bone marrow edema and marginal osteophytosis is seen at the 1st MTP joint, with a small joint effusion and synovitis

Gout in patient with chronic renal disease

X-ray shows diffuse soft tissue swelling around the 1st MTP joint with characteristic well-defined punched out peri-articular erosions with overhanging edges



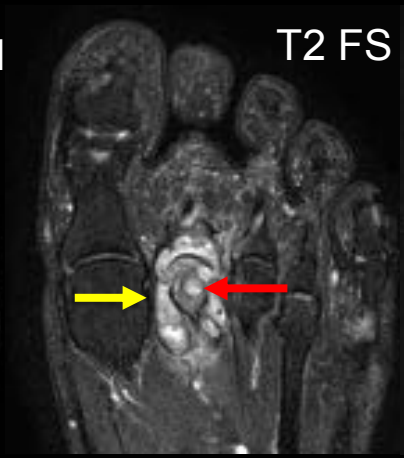




MR images demonstrate extensive low signal intensity gouty tophi around the 1st MTP joint with associated erosion of the 1st MT head

Rheumatoid arthritis

43-year-old female with 2nd MTP joint pain for 2 years. X-rays demonstrate soft tissue and periarticular osteopenia of the 2nd MTP joint and likely erosions of the 2nd metatarsal head and proximal phalangeal base. MR images show a large joint effusion with enhancing synovitis, and periarticular erosions. Synovial biopsy confirmed RA.

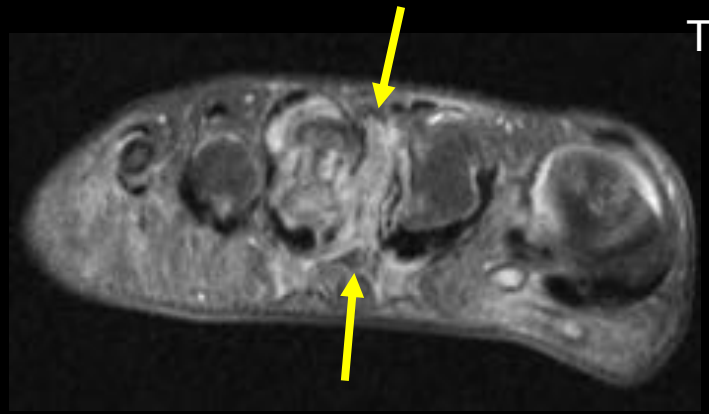


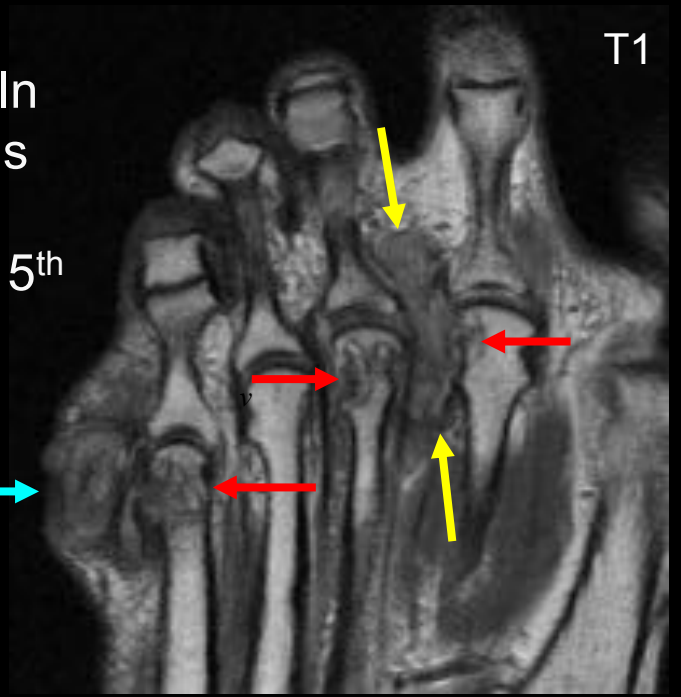
Courtesy of Kyung Jin Suh MD

Rheumatoid arthritis

Patient with long-standing RA and chronic intermetatarsal bursitis of the second interspace. There are peri-articular erosions of the metatarsal heads.

The second intermetatarsal bursa is distended with severe synovitis and a markedly thickened capsule. In addition there is a rheumatoid nodule (granulomatous lesion with areas of central necrosis) in the subcutaneous tissues along the lateral aspect of the 5th metatarsal head.





Courtesy of James Linklater MD

Tendon and Muscle Disorders

- Tendinosis is characterized by hyperplasia, degeneration and necrosis of the tendon with little or no inflammatory cells
  - MRI: increased signal on T1 and proton density (PD), both short TE sequences, and normal or minimally increased signal on T2
- Calcific tendinosis occurs when calcium hydroxyapatite crystals are deposited in the tendon
  - MRI: focal deposit of low signal intensity within the tendon on all sequences, often with inflammatory change in the surrounding soft tissues
- Tenosynovitis is inflammation of the tendon sheath due to synovial inflammatory disease, infection or mechanical irritation
  - MRI: Hyperintense T2 fluid in tendon sheath and post contrast enhancement of the tendon sheath

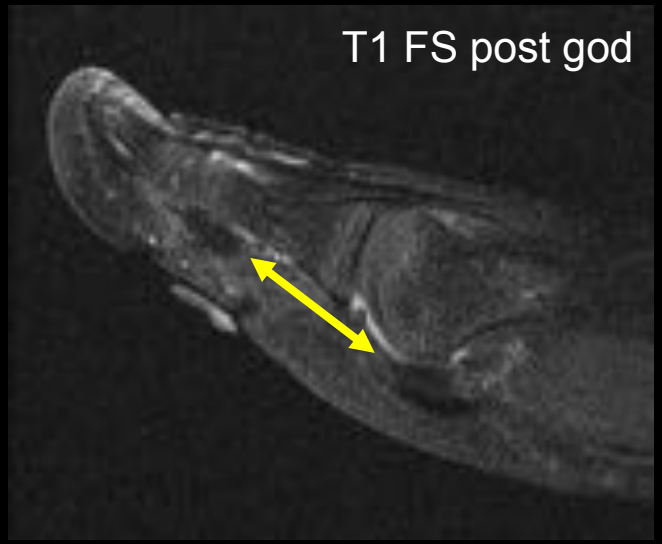
Calcific tendinosis

Patient with left first MTP joint pain for a month. Calcifications are seen in the soft tissues proximal to the lateral hallux sesamoid, with corresponding low signal on PD FS MR images compatible with calcific tendinosis of the lateral head of flexor hallucis brevis

Courtesy of Kyung Jin Suh MD, South Korea

Tendon and Muscle Disorders

- Tendon rupture can occur after trauma or in tendons weakened by degeneration, repetitive microtrauma, infection or systemic diseases
  - US: discontinuity with absence of normal tendon motion +/- tenosynovitis
  - MRI: discontinuity of tendon with intervening edema on T2

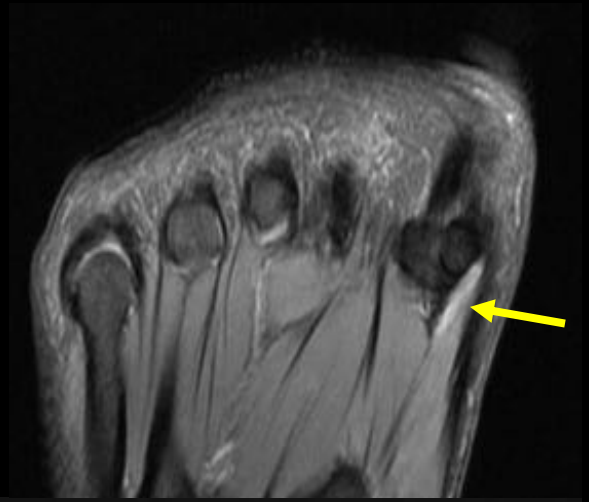


4 year-old-male who stepped on something sharp several months ago and is unable to flex big toe. The FHL tendon is transected with retracted tendon ends, but no significant enhancement

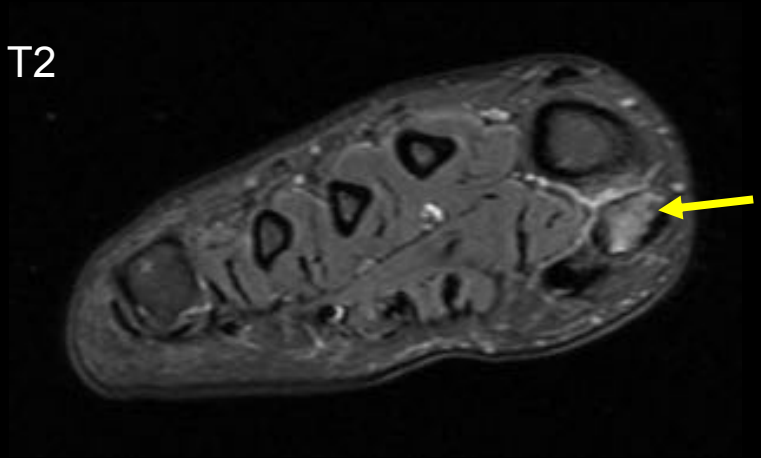
Tendon and Muscle Disorders

21-year-old college softball player with foot injury demonstrates edema in the lateral head of flexor hallucis brevis, compatible with a muscle strain

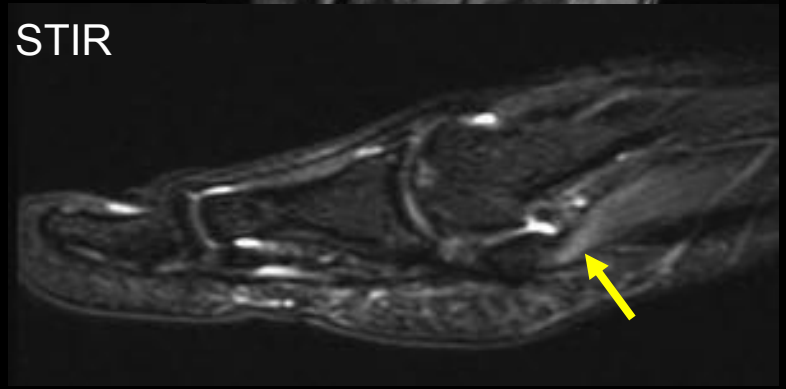
PD FS



T2

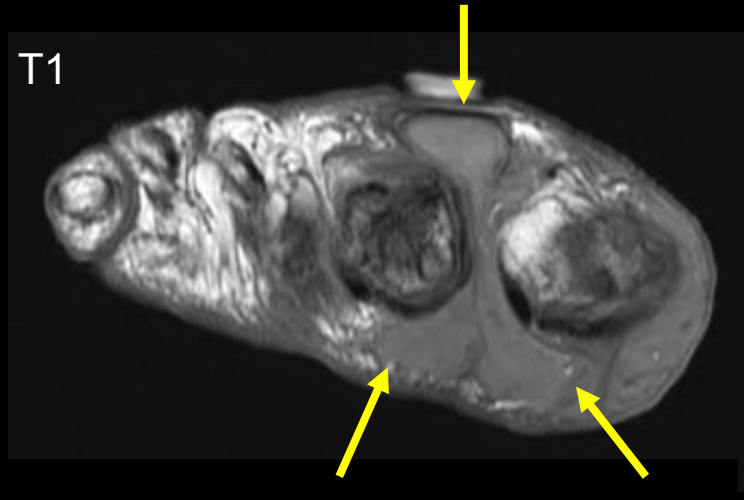


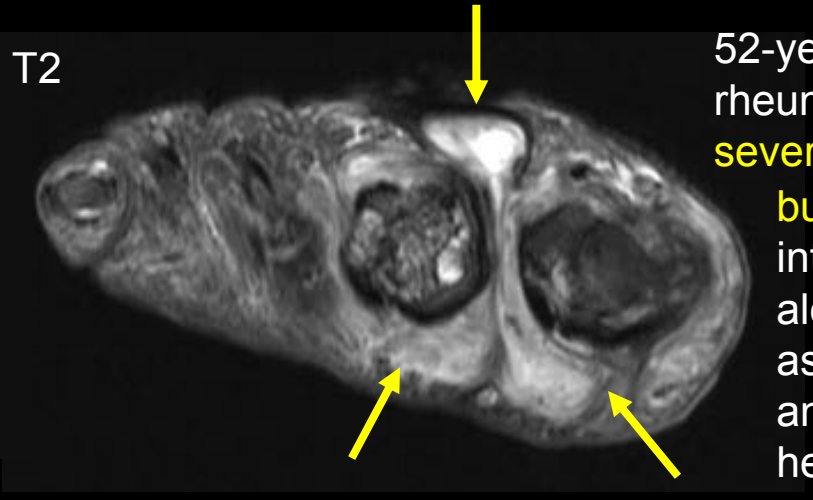
STIR



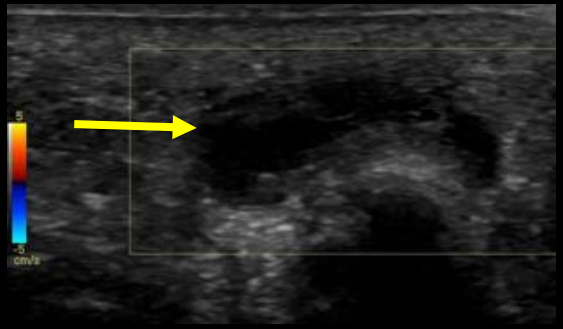
Soft tissue masses

- The vast majority of soft tissue masses of the foot are nonneoplastic
- Inflammatory lesions such has bursitis can be painful while noninflammatory masses may cause pain due to mass effect
- Bursitis may involve the intermetatarsal bursa or adventitial bursae beneath the metatarsal heads
  - MR: low T1/high T2 fluid collection at a pressure point +/- synovitis



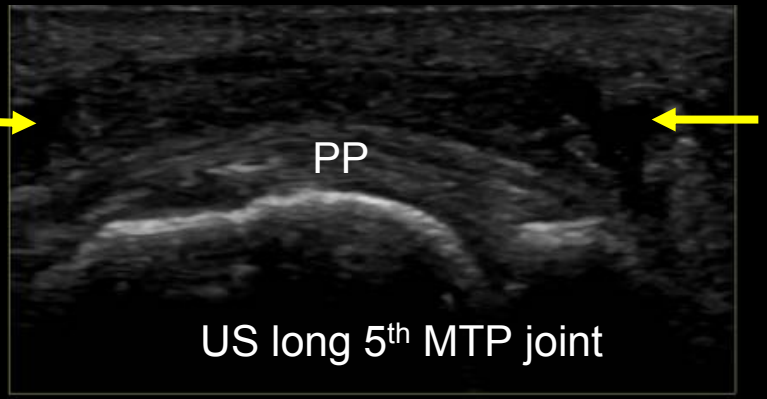


52-year-old female with rheumatoid arthritis and severe intermetatarsal bursitis in the 1st interspace extending along the plantar aspects of the 1st and 2nd metatarsal heads



US transverse 5th MTP joint

40-year-old female with adventitial bursa under 5th MTP joint. An anechoic collection with no hyperemia is seen on US immediately adjacent to the plantar plate (PP). A complex focal fluid collection with synovitis is seen in the plantar subcutaneous tissues under the 5th MTP joint on MRI

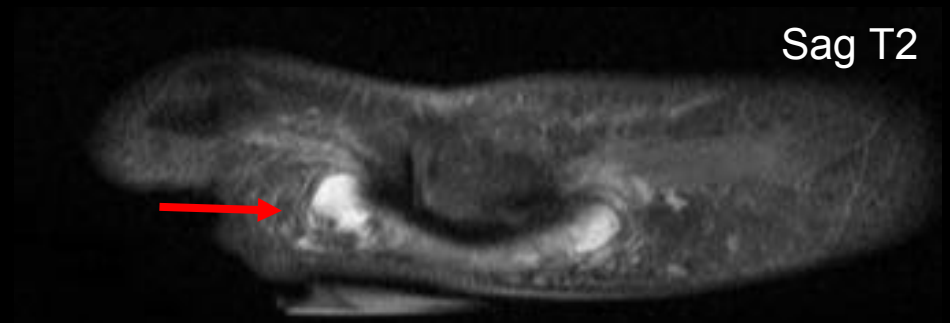


US long 5th MTP joint

T1

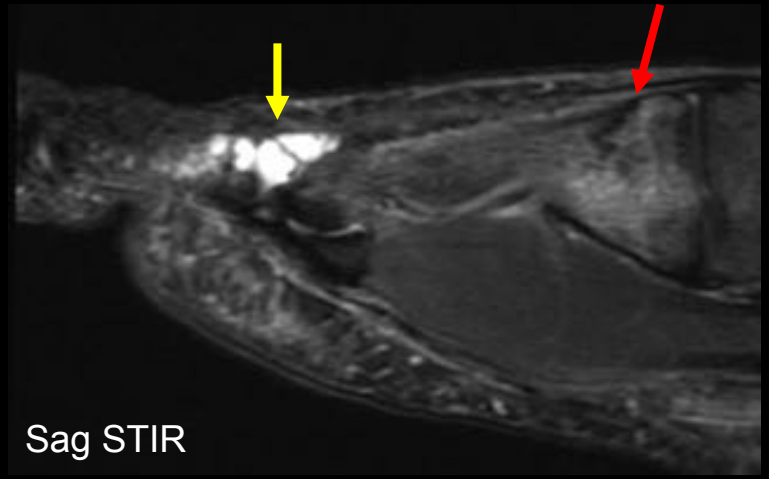
T2

Sag T2



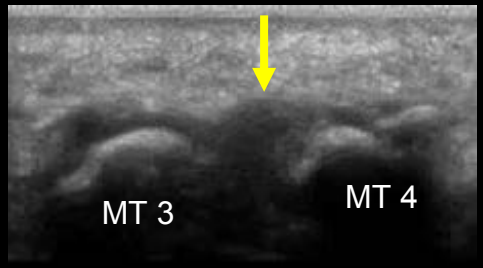
Soft tissue masses

32-year-old female with history of pain and intermittent swelling adjacent to the 1st MTP joint. MRI requested to rule out ganglion cyst in 1st interspace. A lobulated ganglion cyst is seen along the lateral capsule of the 1st MTP joint. However, there is also an incomplete stress fracture with extensive bone marrow edema, periosteal edema and adjacent soft tissue edema along the dorsal aspect of the 1st proximal metatarsal, presumably accounting for the recent increase in pain

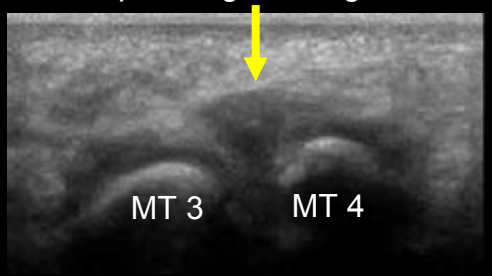


Soft tissue masses

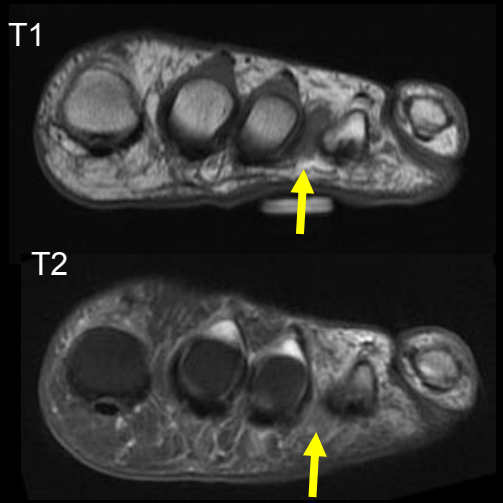
- Morton's neuromas are masses composed of interdigital perineural fibrosis, and nerve degeneration. Most common in 3rd intermetatarsal space. Pain radiating from metatarsal heads to toes
  - US: low echogenicity mass between metatarsal heads, with plantar displacement on squeezing toes together (Mulder's maneuver)
  - MRI: iso/hyperintense on T1, iso/hypointense T2, and enhances with gadolinium



"Mulder's maneuver" - compressing toes together

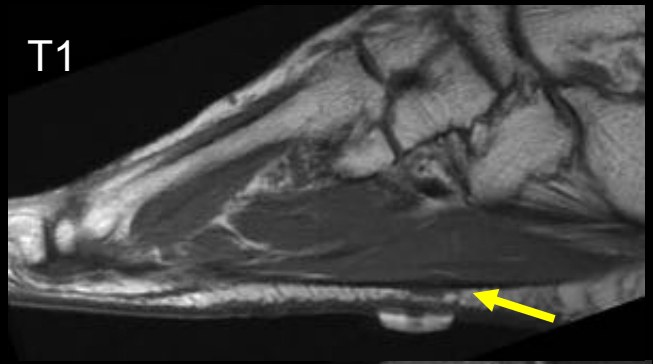


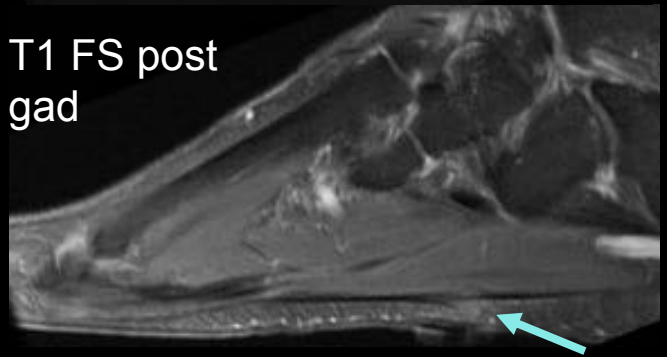
Transverse US images of the forefoot demonstrate a hypoechoic mass between the MT heads, compatible with a Morton's neuroma



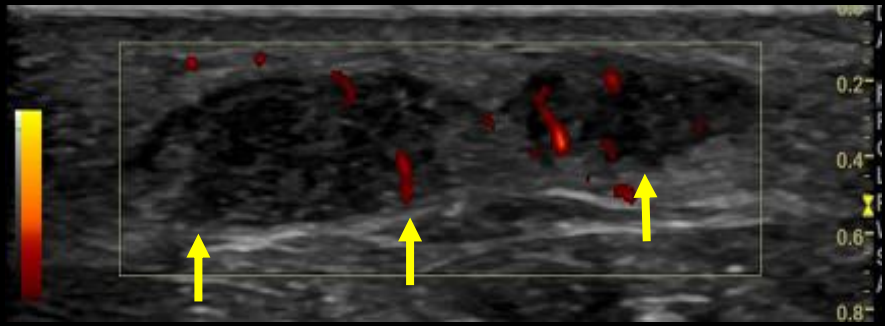
Short axis MR images of the forefoot demonstrate a low T1 and T2 signal intensity mass between the 3rd and 4th MT heads, compatible with a Morton's neuroma. The neuroma is more readily apparent on T1-weighted images due to the adjacent fat

- Plantar fibromatosis is localized benign proliferative disease of the plantar fascia leading to formation of fibrous nodules

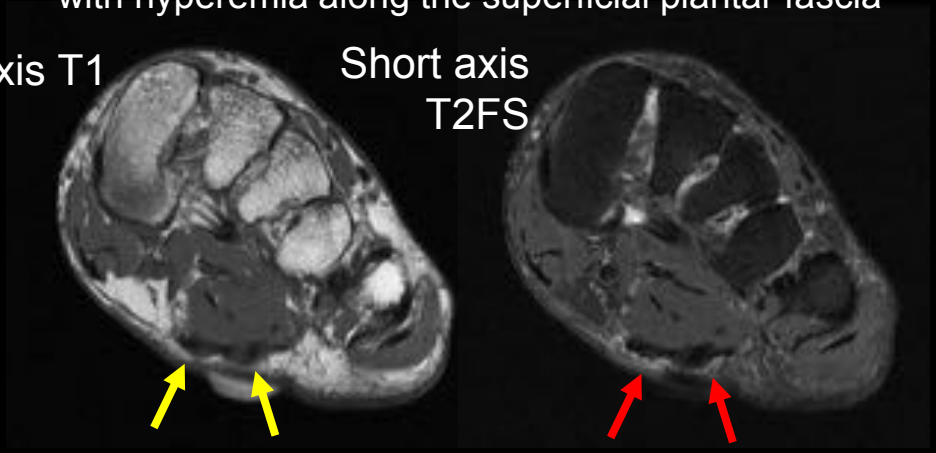




Sagittal MR images show a small low signal intensity fusiform mass along the central cord of the plantar fascia, with mild enhancement following gadolinium.

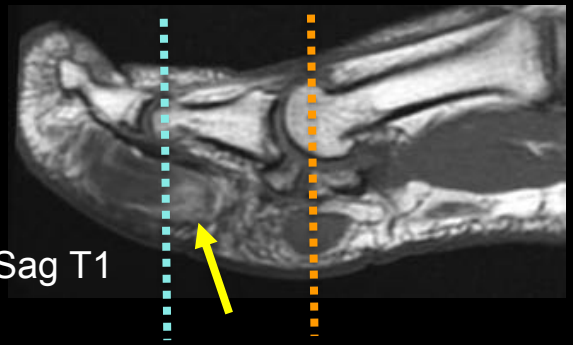


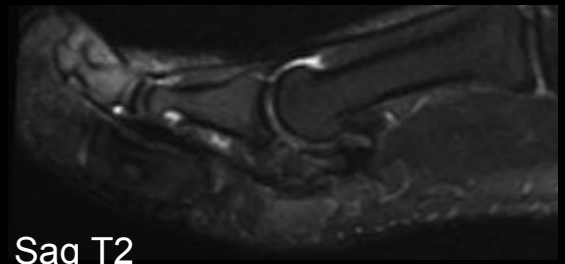
Transverse US images show a bilobed soft tissue mass with hyperemia along the superficial plantar fascia

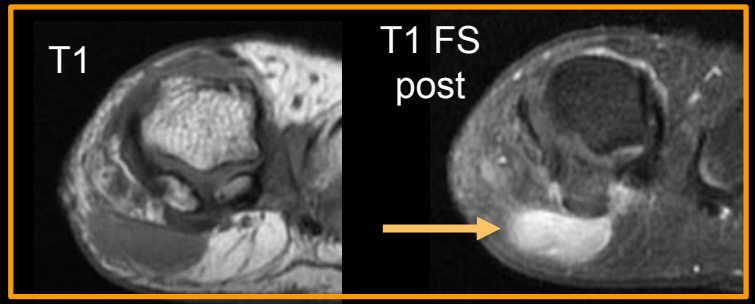


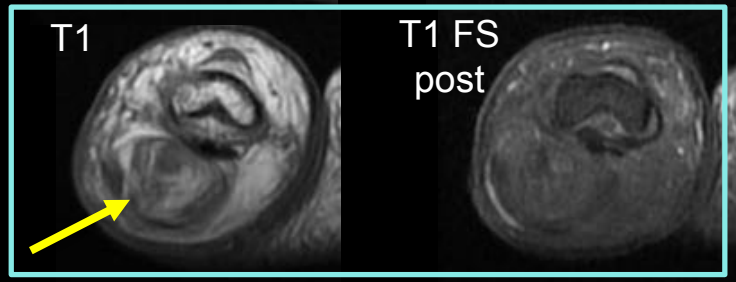
Short axis MR images demonstrate a bilobed low signal intensity mass along the central cord of the plantar fascia, with minimal adjacent soft tissue edema on T2

Soft tissue masses









28- year-old female with diffuse enlargement of the great toe and palpable soft tissue masses along the plantar aspect. The mass under the 1st MT head is of homogeneous low T1 and high T2 signal intensity with enhancement after intravenous gadolinium, whereas the more distal mass is heterogeneous and contains areas of fat on T1. These were both path proven to be fibrolipomatous hamartomas of the medial digital plantar nerve, in a patient with Proteus or Proteus-like syndrome. Fibrolipomatous hamartoma is a benign neoplasm of nerves due to anomalous growth of fibroadipose tissue of the nerve sheath.

CONCLUSION

- Metatarsalgia is a common clinical problem with a wide differential diagnosis
- Multiple imaging modalities can help diagnose the etiology of the patient's pain
- However, MRI allows a comprehensive evaluation of forefoot anatomy and allows the clinician to appropriately diagnose, manage and treat the cause of metatarsalgia

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THANKS

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