

Magnetic Resonance Imaging of Minor Trauma: January 2014

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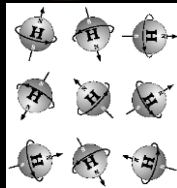
Utility of MR In Musculoskeletal Imaging

- Noninvasive
- Multiplanar capabilities
- No ionizing radiation
- High sensitivity with excellent spatial resolution=early detection



How Does MRI Form A Picture?

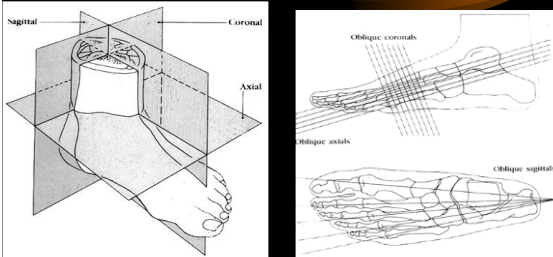
- Fat and Water in the Human body have an abundance of protons
- They resonate in a random frequency and orientation



A Paradox

- "Simplicity, simplicity, simplicity! I say, let your affairs be as two or three, and not a hundred or a thousand; instead of a million count half a dozen, and keep your accounts on your thumbnail." HD Thoreau, *Walden*, "Where I Lived and What I Lived For" (1854)
- "Simplify, but don't oversimplify" A. Einstein
- For today, we're going with the Concordian

All Three Planes



Basics Imaging of The Musculoskeletal System

- Radiographs are insensitive to non-displaced fractures, infiltrative processes and marrow edema states
- Think of Radiographs as the "sed rate" of imaging

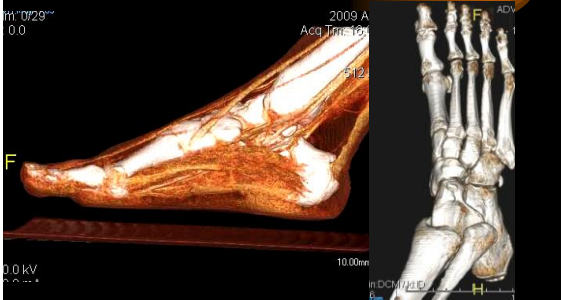
MRI Appearance Cortical bone & tendons



CT based on Hounsfield Units- Attenuation Coefficient



CT Imaging



CT defines cortical margins, small avulsions and fracture planes, but some processes are CT occult



CT versus MRI

- Insensitive to occult bone marrow edema
- Can be useful to define fracture planes, avulsions
- Beneficial for incomplete or non-union, due to "edge enhancement"
- Can show small osseous bodies, define osteoid matrices and calcific periosteal reactions
- Compliments MRI in certain fractures such as Lisfranc fracture dislocations, subtalar and tibial plateau fractures

OSSEOUS TRAUMA

• CASE STUDIES

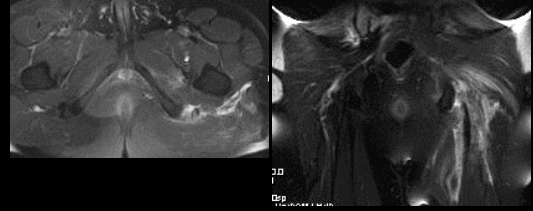


Imaging versus Physical Examination

- Gym Story
- “A man’s got to know his limitations” – Eastwood
- “So do we clinicians...” Robbins



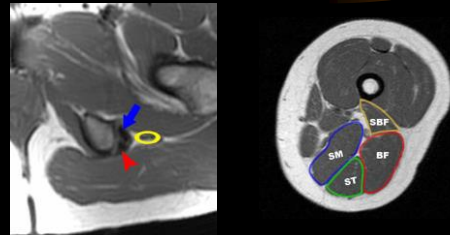
45 year-old male fell “Rule out hip fracture; negative X-rays”



Hamstring Muscle Complex

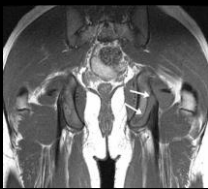
- Osseous avulsions often seen in adolescents -incomplete fusion of ischial tuberosities
- Radiographs can often be helpful as edema can hide small osseous avulsions on MRI
- Under 2 cm of distraction: conservative tx
- Tendon avulsion; callus or hematoma-can cause sciatic neuropathy

Anatomy Hamstring Muscle Complex

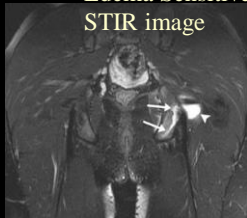


Ischial Tuberosity Avulsion- (origin injury)

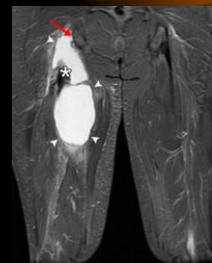
- T-1 weighted image



- Edema Sensitive STIR image



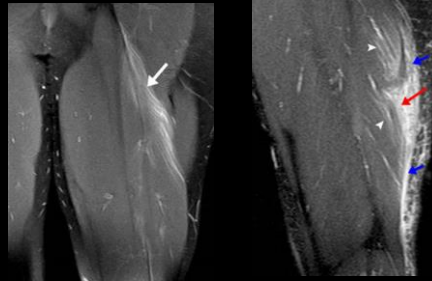
Complete Avulsion



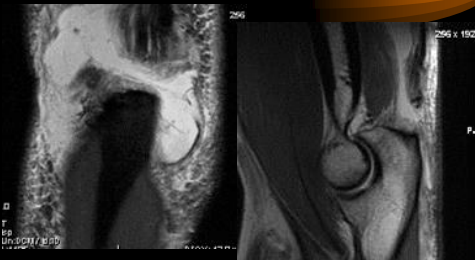
Hamstring Tears

- Spectrum of tendon tearing, osseous or apophyseal avulsion, vs muscle strain
- Span two joints, eccentric contraction
- Heal slowly and recur, multiple levels
- Mimic fractures and adjacent sciatic sx
- MRI locates site and helps with treatment and prognosis

Muscle strain & Grade II Tear



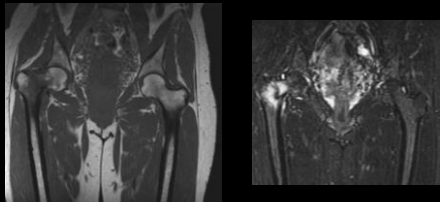
55 year old male fell skiing; rule out fracture



Triceps tear/avulsion of the posterior component

- Combined lateral and long head of triceps muscle-laminar anatomy
- Medial head inserts as an anterior muscle in many patients
- Pitchers, football linemen and weightlifters
- Repetitive activities, olecranon bursitis
- Partial injuries can be hard to distinguish from complete on MRI

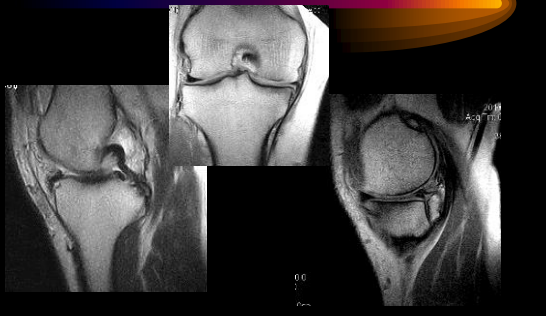
“Completed” Proximal Femoral Stress Fracture (Marathon Runner)



Femoral Neck Stress Fractures in Runners

- Difficult to diagnose
- Referred pain to back and thigh
- Failure to diagnose can lead to AVN, ORIF, or THR in otherwise young, healthy athletes
- Stress, insufficiency, and pathologic fractures– risk factors important
- Vitamin D deficiency, osteopenia, steroids

Consequence of a Missed ACL tear



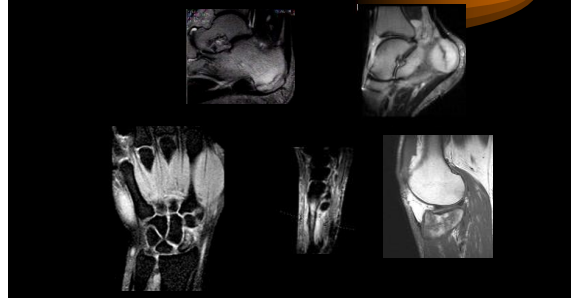
ACL insufficiency

- Primary restraint to anterior translation of the tibia with respect to femur
- Anteromedial band tighter in flexion
- Posterolateral band tight in extension
- Early diagnosis prevents re-injury, meniscal tears, secondary injury to primary restraints, chondral injuries

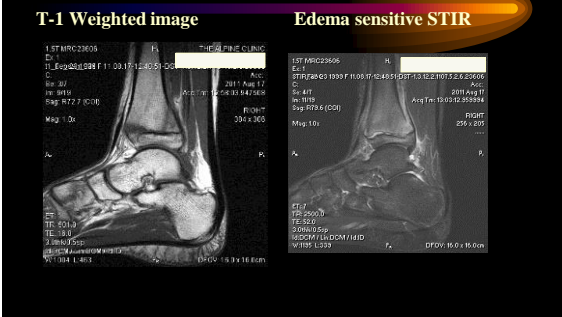
Missed PCL Avulsion



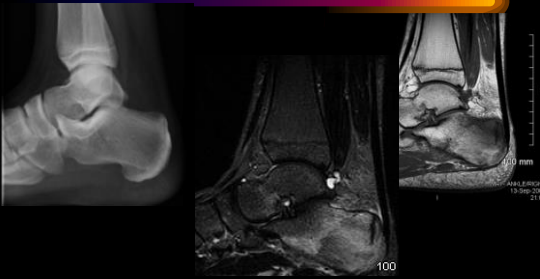
OCCULT FRACTURES



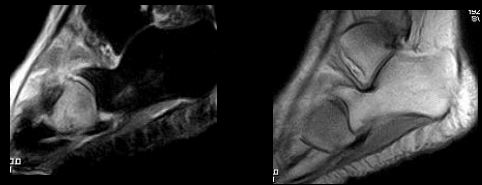
Triplanar Radiographically occult fracture



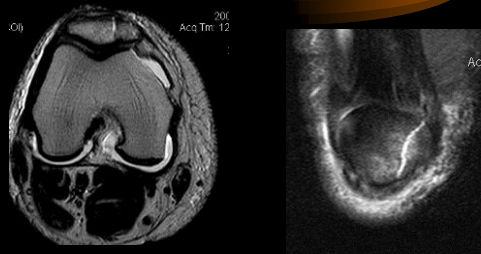
15 year-old male with repetitive hindfoot compression injury



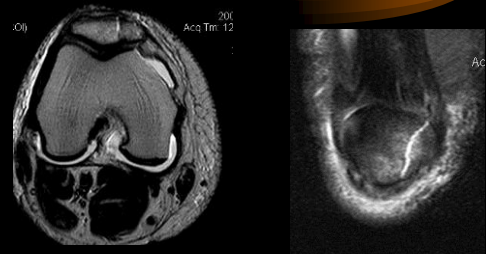
57 year old female with trauma; "Rule out ATAF Sprain"



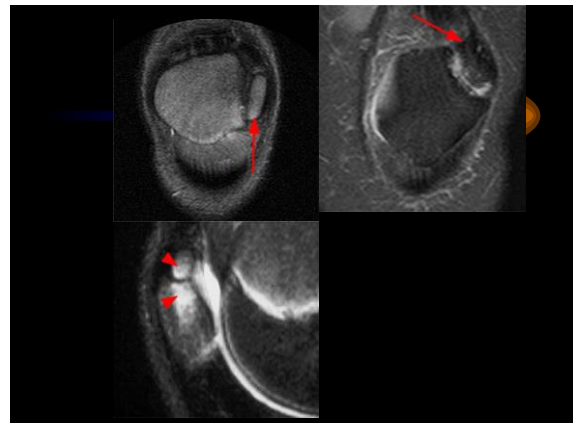
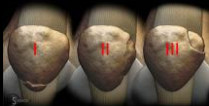
Fall onto Knee; R/O ACL tear



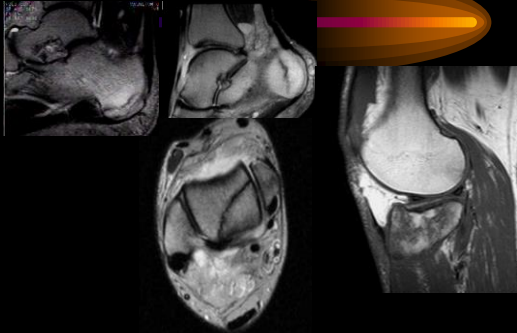
Fall onto Knee; R/O ACL tear



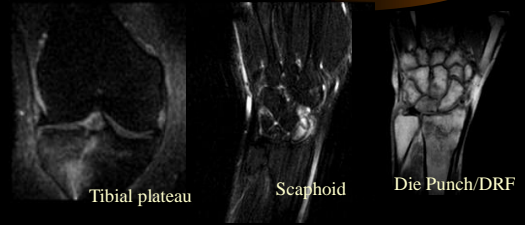
Bipartate Patella



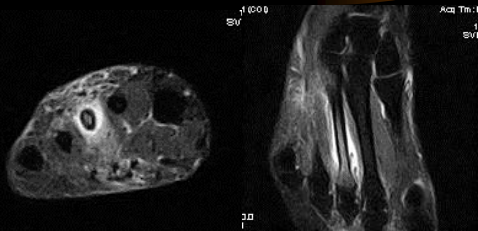
OCCULT FRACTURES



Serious Occult Fractures



29 year-old female with pain and normal radiographs



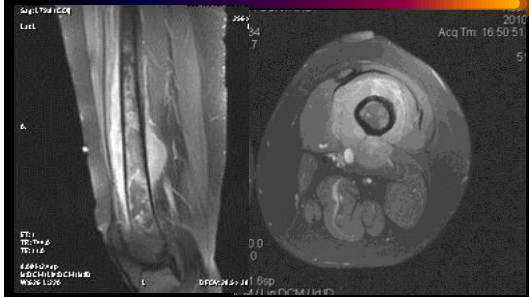
Edema and periosteal reaction diaphysis

- Stress fracture
- Osteomyelitis
- Ewing Sarcoma
- EG (Langerhans Cell Histiocytosis)
- Metastatic neuroblastoma
- Clinical information and radiographic correlation is essential & follow-up

52 year-old female with knee pain/negative X ray



Follow-up images...



47 year old male; seizure 3 weeks ago. Severe pain on ambulation.

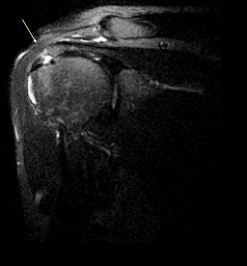


Tendon Pathology

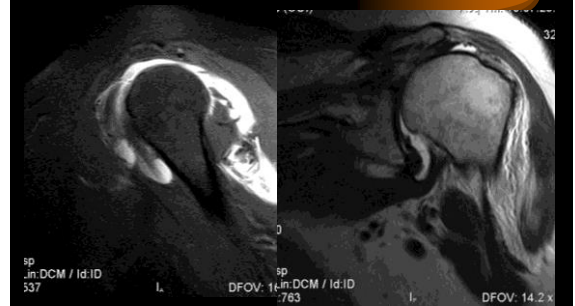
- Fifty-year old female with shoulder pain and weakness

Rotator Cuff Tendon Tear

- Size
- Location
- Depth
- Retraction
- Musculature
- AC Joint arthrosis
- AC joint morphology
- Associated pathology



Rotator Cuff Tendon Re-tear MR-Arthrogram



Anatomy of the Rotator Cuff



Rotator Cuff Depressor Function

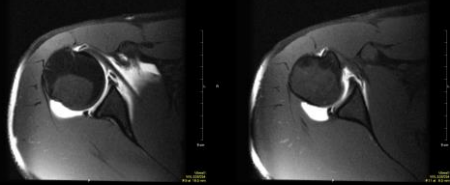


Shoulder Instability

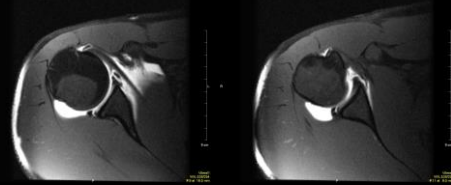
- SLAP –Superior Labral Anterior to Posterior tears
- Bankart Lesion
- Hill Sachs Lesion
- Reversed Bankart tear/Bennett lesion



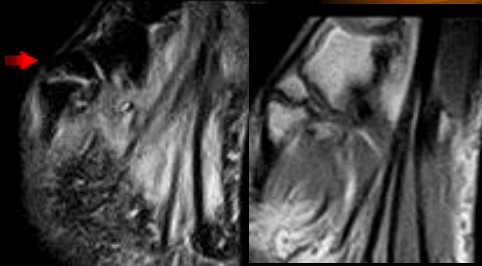
Posterior Labral Tear



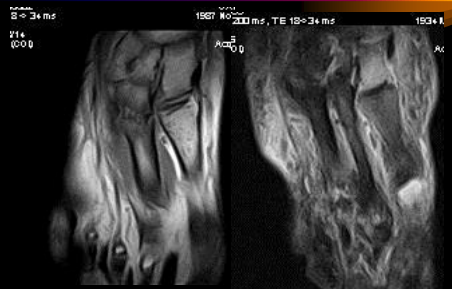
Posterior Labral Tear



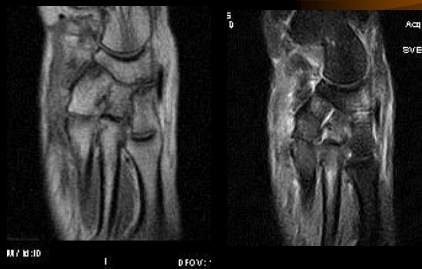
Acute versus Old Fracture?



Fracture: Ligament Integrity



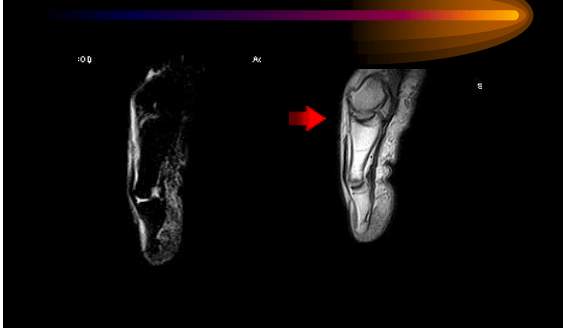
Companion Case: Post-trauma Torn Lisfranc Ligament



40 year-old-male with hyperflexion trauma/x ray "4 mm chip fx"



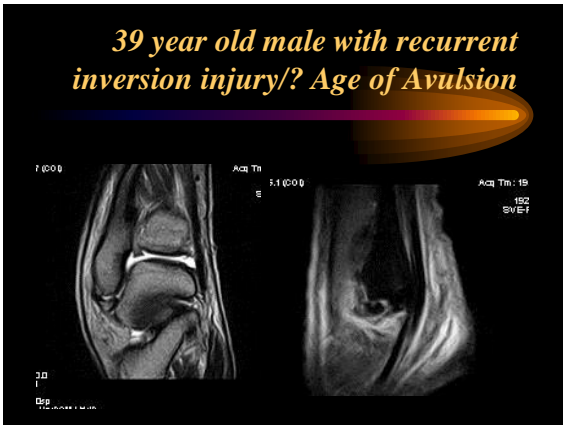
*Dropped blade on foot/EHL
Laceration*



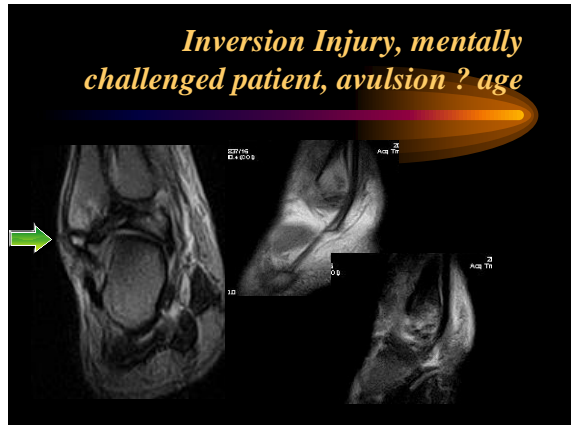
*Inability to Extend Great Toe Post
Correction of Hallux Valgus*



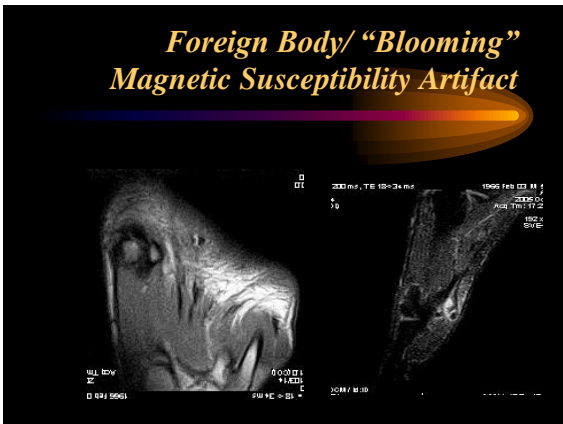
*39 year old male with recurrent
inversion injury/? Age of Avulsion*



*Inversion Injury, mentally
challenged patient, avulsion ? age*



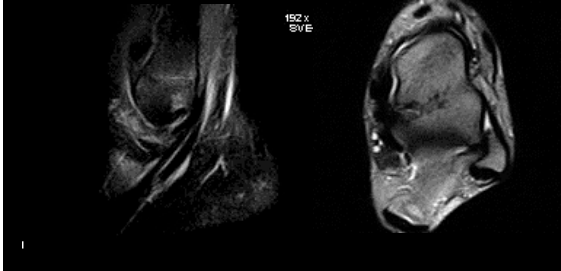
*Foreign Body/ "Blooming"
Magnetic Susceptibility Artifact*



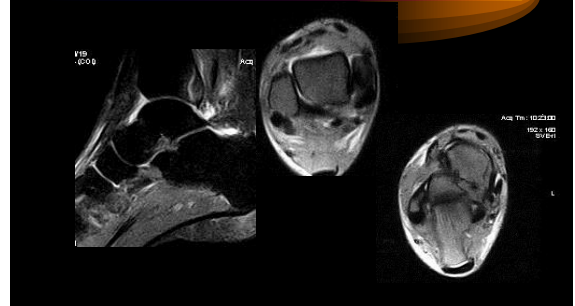
*6 year-old stepped on nail 4 weeks
ago*



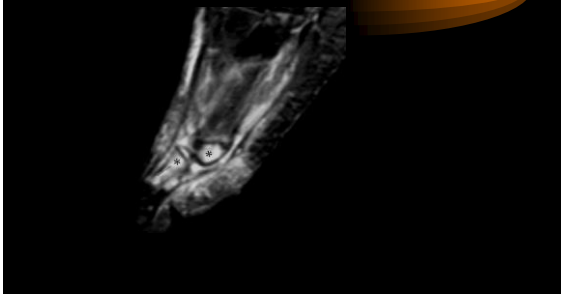
14 year-old female athlete with inversion injury and ongoing pain



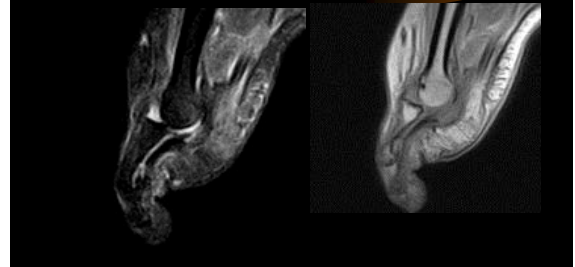
22 year-old female tripped on stairs; Lateral ligament injury?



*Penetrating Trauma/
Osteomyelitis Septic Arthritis/Plantar plate
disruption*



Pre-dislocation Syndrome



The Paradox of Fitness

- “The human body is the one machine that becomes stronger the more it is used.”
-Motto Painted on the Old Lowell YMCA circa 1965

“All matter proceeds toward entropy.”
-Albert Einstein

My Corollary

- The axial and appendicular joints undergo progressive attrition as a result of chronic repetitive trauma. This process is accelerated by acute tensile forces, loading stress, congenital, acquired, or developmental biomechanical imbalance.

Lowell, Massachusetts

- Jack Kerouac
- James Abbott McNeill Whistler
- Whistler's mother
- Ed McMahon
- Senator Paul Tsongas
- Bette Davis
- Michael Chicklis
- Olympia Dukakis
- Mickey Ward
- Eastern Branch of the Hell's Angels!

Trauma

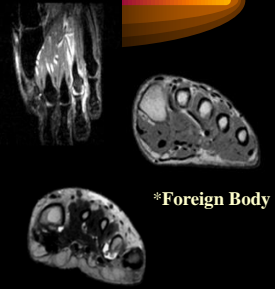


MRI Defines Occult Lower Extremity Fractures



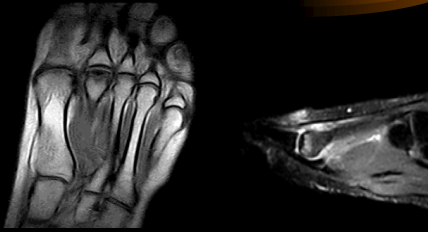
Osteomyelitis

- Low T1 signal; STIR hyperintensity
- Fluid, abscess, phlegmon will not enhance
- "Blooming" Artifact Detects Foreign Bodies*
- Better spatial resolution than bone scan
- Compliments tagged Leukocyte Scanning

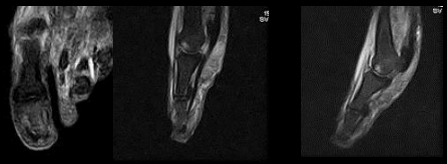


*Foreign Body

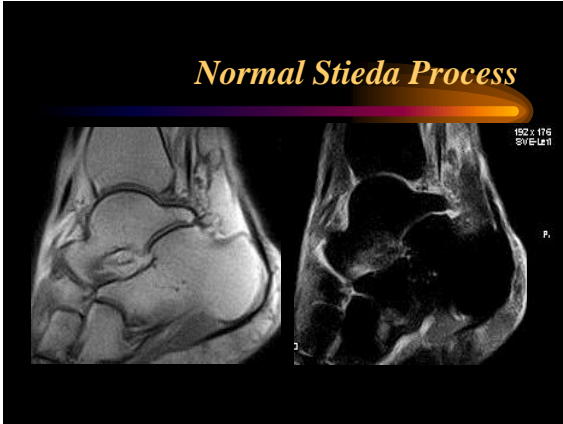
Freiberg Infracion



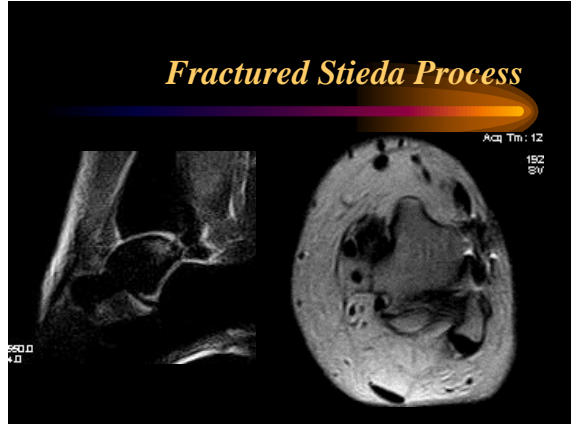
Osteomyelitis, monitor tx response 65-year-old diabetic male



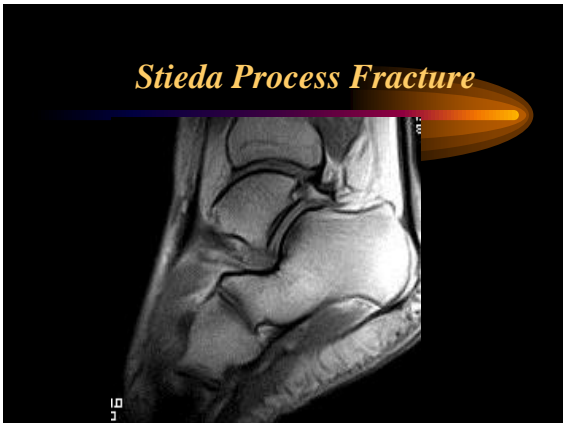
Normal Stieda Process



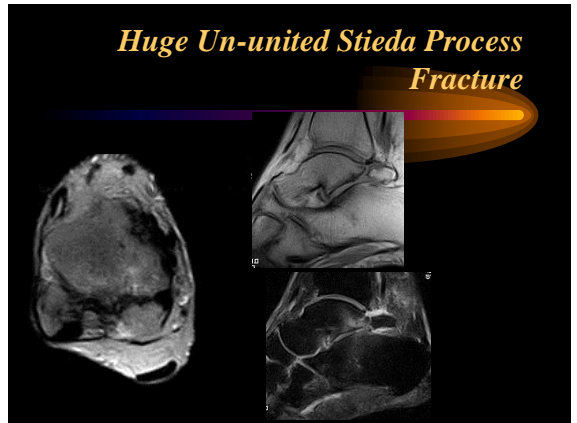
Fractured Stieda Process



Stieda Process Fracture



Huge Un-united Stieda Process Fracture



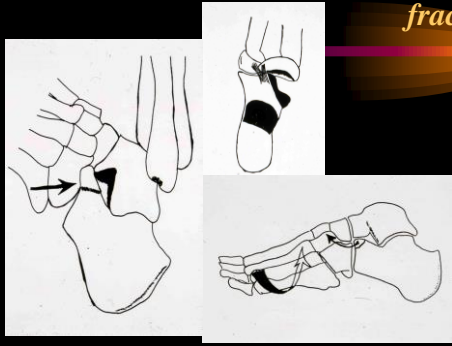
Os Trigonum Syndrome



OCCULT STRESS RESPONSE

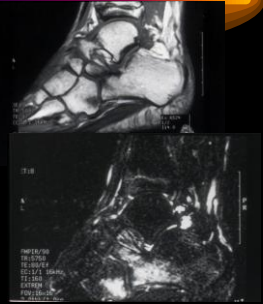


Anterosuperior calcaneal process fracture

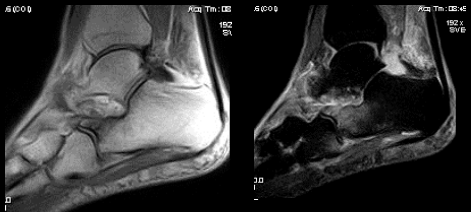


Anterosuperior Calcaneal Process Fractures

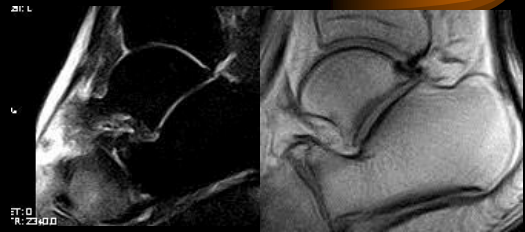
- Bifurcate ligament avulsion (forceful inversion)
- Cuboid impaction (eversion)
- Painful non-union of not recognized
- Radiographically occult



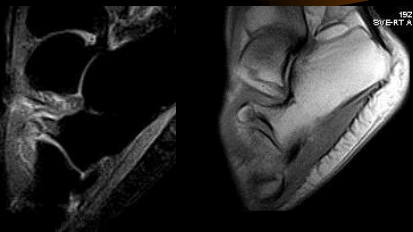
Eversion (Impaction) Anterosuperior Calcaneal Process Fracture



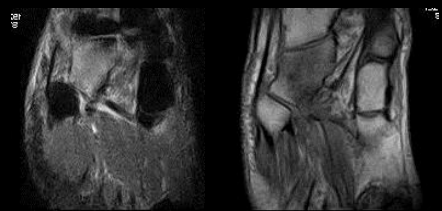
Bifurcate Ligament



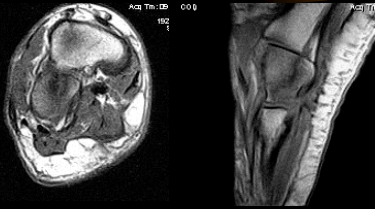
Acute Anterosuperior Calcaneal Process Fracture



Intra-articular Cuboid Fracture



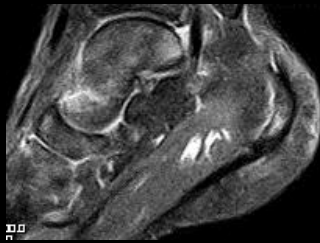
*Intra-articular cuboid fracture
Delineation of Fracture Planes*



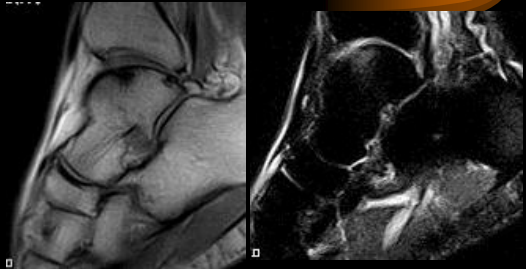
*Pathologic Fracture in a
75-year-old female*



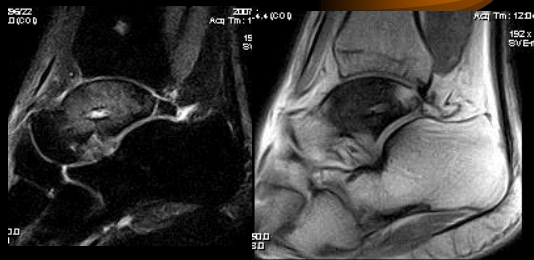
*Marrow Edema States/RSD
12-year-old male*



Stage I OCD



*Osteonecrosis of Talus/Core
decompression*



Risk Factors for Osteonecrosis

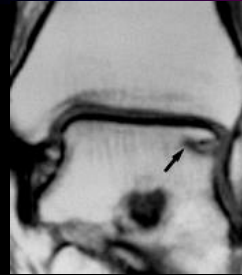
- Clinical worst case:
- An alcoholic skindiver, with Gaucher's disease and sickle cell anemia, crashes car, and gets pancreatitis



*Stage I
OCD Lesion*



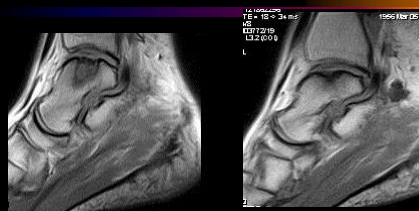
*Stage II
OCD Lesion*



*Stage III
OCD Lesion*

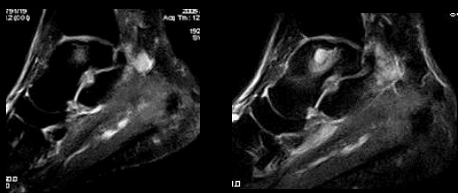


*Progression: Stage III OCD lesion
Old trauma with talofibular scarring*

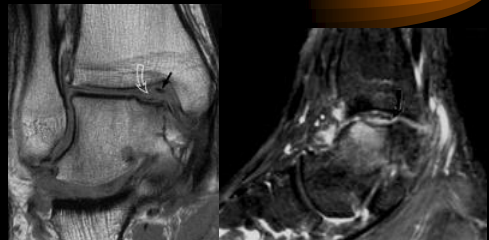


- 2005
- 2007
- Tarsal tunnel ganglion resolved
- ATAF and CFL scarring

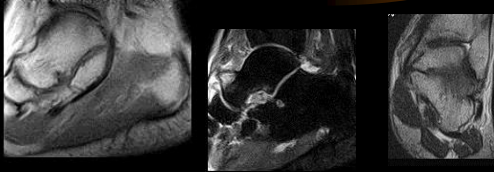
Interval Progression OCD Stage III



*Stage IV Lesion/Unstable In-situ
fragment*



42 year old male with pes planus, medial pain, rule out PTT tear

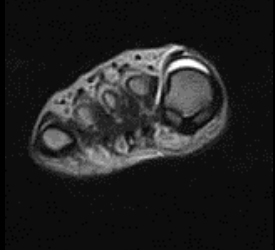


Sesamoid pathology

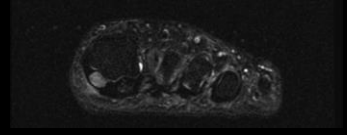
- Sesamoiditis / Stress reaction
 - Low or normal T1, increase T2/Stir
 - No fracture line or arthritic change.
 - Often adjacent edema / Fibular sesamoid involvement
- Sesamoid fracture
 - Often difficult to distinguish from Bi-partite sesamoid (Look at size, cortex)
- Avascular necrosis
 - Low all sequences, no enhancement
 - Early increase T2 / Stir: Very difficult to distinguish from sesamoiditis / stress rxn / contusion

Hallucal Sesamoids/Anatomic Considerations

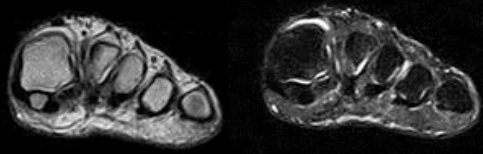
- Plantar plate
- Intersesamoid Ligament
- First MPJ integrity
- Crista
- Capsular ligaments
- FHB tendons
- FHL tendons



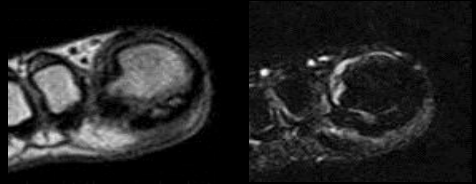
Sesamoiditis



Sesamoid Osteonecrosis



Sesamoid Osteonecrosis



Plantar Fasciits

- Windlass Mechanism
- Entrophyte
- Marrow Stress edema
- Intrinsic foot muscle atrophy
- Baxter's nerve entrapment



28 year-old female runner with heel pain



Acute Tear in a 72 year-old female with dog leash mishap



Plantar Spur Fracture



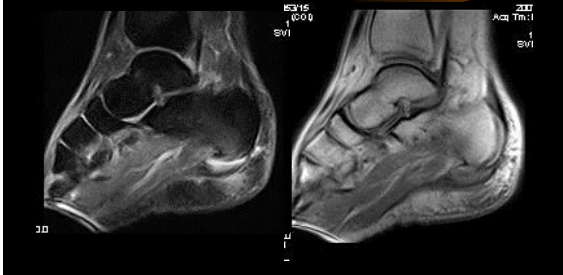
"Sharp" Spur and Plantar Fascial Tearing



Baxter's Denervation of the Abductor Digiti Minimi



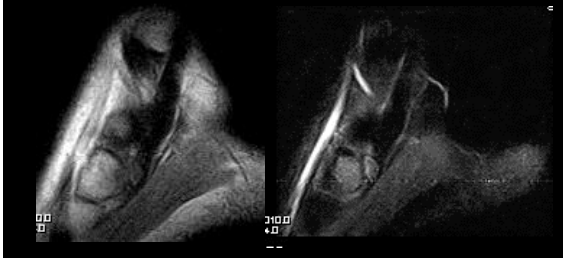
Baseball Injury/Plantar Fascial Rupture



Plantar Fascial Tear and foot muscles

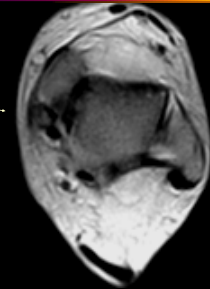


29 year-old female with trauma and PTT dysfunction



Posterior Tibial Tendon Tear

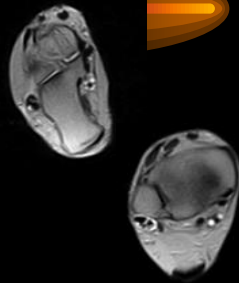
- Type I: Hypertrophic
- Type II :Attrition/partial tear
- Type III: Complete tear with tendon gap
- PTT dysfunction can occur without morphologic alteration of the tendon



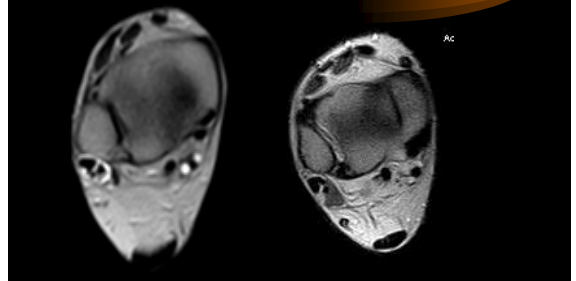
Peroneal Tendon Tears



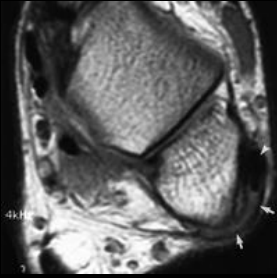
- Tenosynovitis
- Type I hypertrophic longitudinal split tears
- Subluxation from retromalleolar groove
- Peroneus Longus
- Peroneus Quartus



Peroneus Quartus and Peroneal Tendinopathy



Peroneal Subluxation/Retinacular "Stripping"



SUMMARY

- MRI is useful for diagnosis of radiographically occult injuries of the foot and ankle.
- Alters the management and improves the outcome of many disorders that would otherwise go undetected, especially, cartilage tendon and ligament injuries associated with fractures.
- Few Pathologies Occur in Isolation
- Pattern Recognition "Tells the Story" of underlying etiology

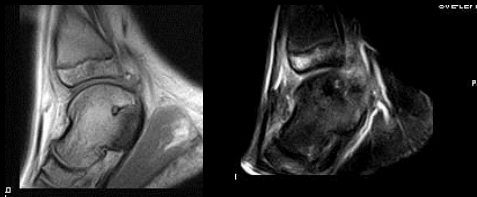
THANKS!



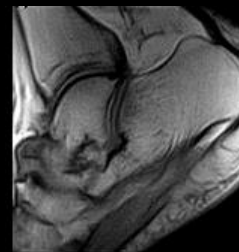
Concept of "Cascading Pathology"

- A healthy joint is a balanced joint
- Rigid "Fixed" Stabilizers (Bones)
- Ligamentous stabilizers
- Dynamic Stabilizers (Tendons, Fascia)
- Effectors (muscles)
- Few injuries occur in isolation

Tarsal Coalition



Unusual Anterior Subtalar Coalition



Example of Cascading Pathology

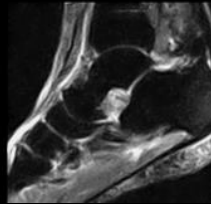
- POSTERIOR TIBIAL TENDINOPATHY
- Flexor substitution, overburdened tibiospring
- Medial crural fascia, marrow stress edema
- Midfoot pronation
- ATT, peroneal, Achilles tendonopathy
- Heel valgus/peroneal entrapment
- Sinus tarsi syndrome
- Plantar fasciitis
- Talonavicular arthrosis; pes planovalgus

Characterization of Tarsal Coalitions

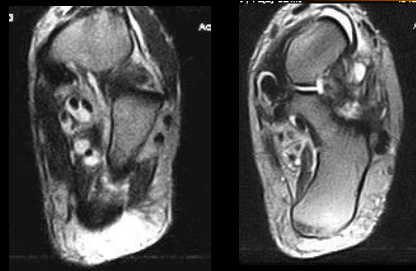
- Multiplanar
- Can identify edema along osseous, fibrous or chondral neoarticulations
- Associated ligament and tendon pathology (tears, tenosynovitis, hypoplasia)
- Supplements radiographic findings (talar beaking, "C-sign", ball-and-socket tibiotalar joint, "ant eater sign")

Secondary Signs of an Unbalanced Foot

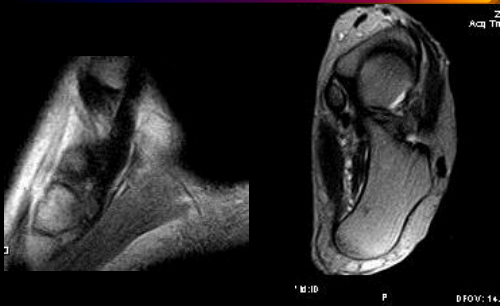
- Plantar Fasciitis
- Sinus tarsi syndrome
- Achilles Tendinopathy
- "taut" subtalar ligaments, anterior talofibular ligament



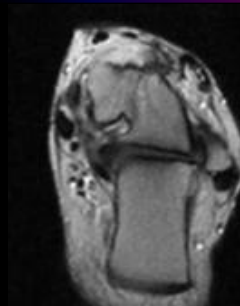
Flexor Substitution



Os tibiale externum/atraumatic PTT dysfunction



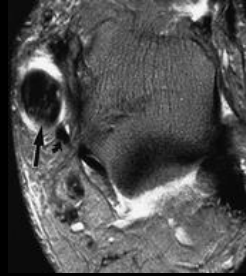
Early PTT dysfunction



Posterior Tibial Tendon Fissure



Type I PTT tear



Hypertrophic Type I PT Tear

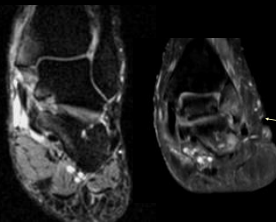


*Complete Type III PTT Tear
(No esta aqui).*

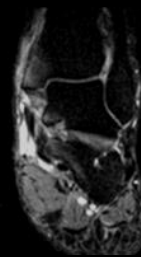


Posterior Tibial Tendon

- Early PTT Dysfunction
- Medial crural fascial edema, marrow stress
- Late: Collapsing Pes Planovalgus Deformity
- Heel valgus, peroneal subluxation
- Plantar fasciitis
- Achilles tendonopathy
- Flexor substitution
- ATT tear



PTT Dysfunction

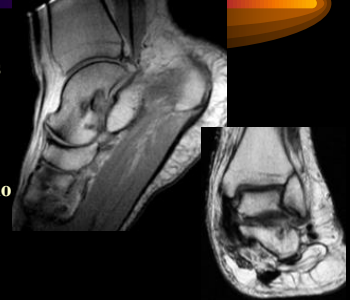


Calcaneal Eversion/Peroneal Tendon Impingment



Secondary Findings of Posterior Tibial Tendon Dysfunction

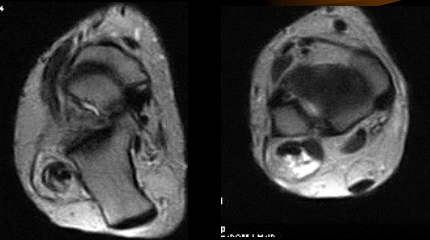
- Sinus tarsiitis
- Achilles tendinosis
- Peroneal tendinopathy
- Plantar fasciitis
- Baxter's denervation of abductor digiti quinti



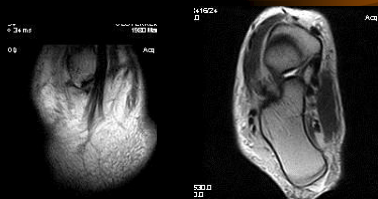
PTT Talonavicular Subluxation



Torn Peroneus Brevis



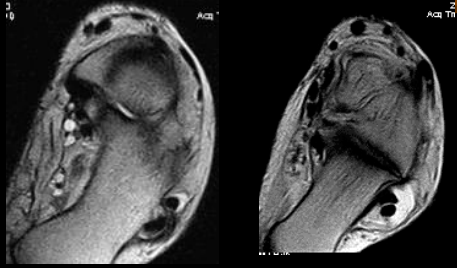
Peroneus Quartus



Peroneus Brevis

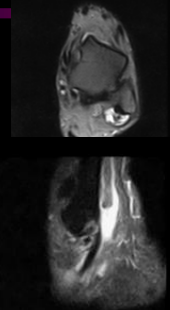


*Peroneal Calcaneal Tubercle
Edema*



Peroneus Longus Tears

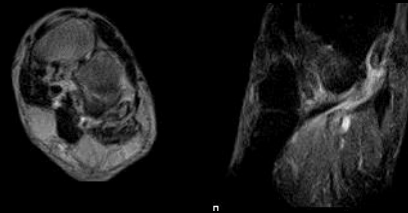
- Follow tendon into cubital tunnel
- Associated with peroneal ossicles
- Associated with hypertrophic peroneal calcaneal tubercle



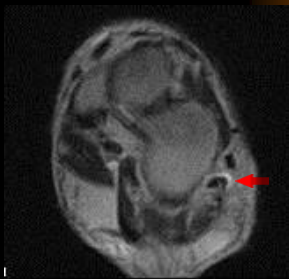
Tear of Peroneus Longus: Fissure



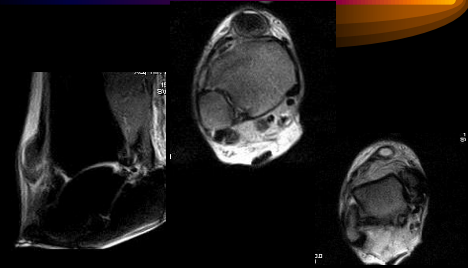
*Lateral Midfoot Discomfort/Painful
Os Peroneum Syndrome*



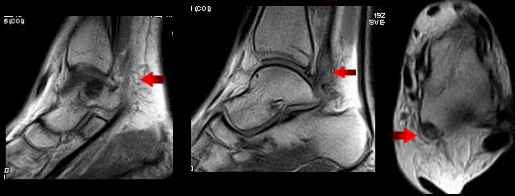
*Painful Os Peroneum
Peroneus longus fissure*



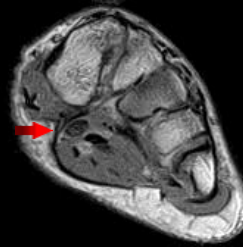
*69 year old male presents with ankle
mass/rule out ganglion*



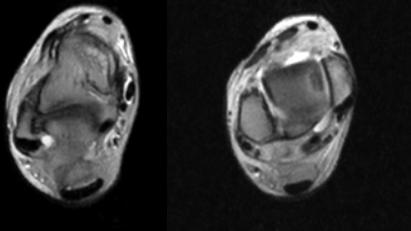
Flexor Hallucis Longus Tear/61 year-old female with squatting injury



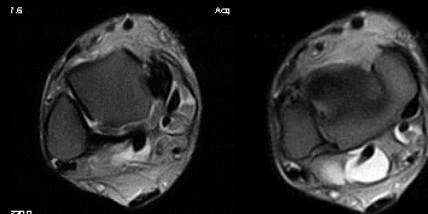
Midfoot FHL Partial Tear



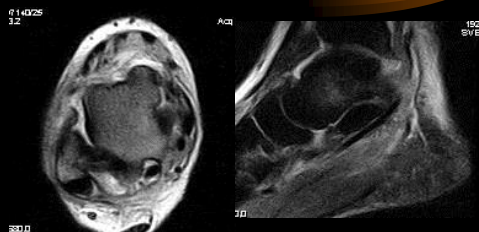
Ligament Tears



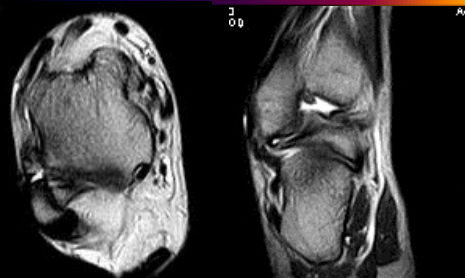
*49 year-old male
PTT, PB, syndesmotic tear*



Acute Tear of Anterior Talofibular Ligament/Medial Talar Contusion



Torn Anterior Talofibular Ligament/Meniscoid Lesion



Anatomy of the Posterior Compartment



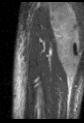
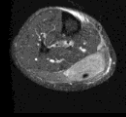
Soleus



Plantaris

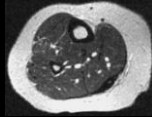
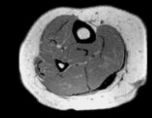
Acute Plantaris Tear

EDEMA AND HEMORRHAGE IN THE DEEP POSTERIOR COMPARTMENT

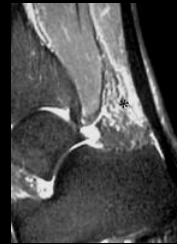


CHRONIC PLANTARIS TENDON TEAR

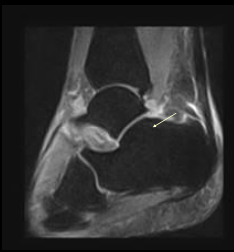
- ABRUPT ONSET OF CALF PAIN
- CAN IMITATE DVT OR CALF SARCOMA
- LOW SIGNAL ON ALL SEQUENCES
- MORE LOCALIZED THAN "COMPARTMENT SYNDROMES"



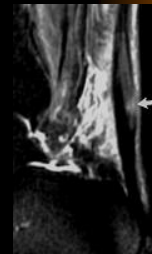
Acute Achilles Peritendinitis



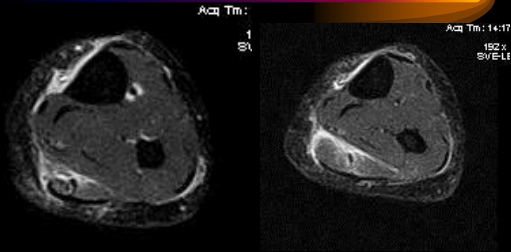
Low Grade Achilles Pathology



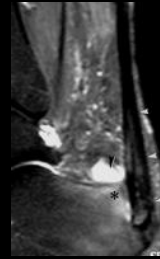
Chronic Achilles Tendinosis



Acute Myotendinous Strain in a 50 year-old Marathon Runner



Tendinosis, Retrocalcaneal Bursitis, Haglund Deformity & Stress Edema



Complete Traumatic Achilles Tendon Rupture

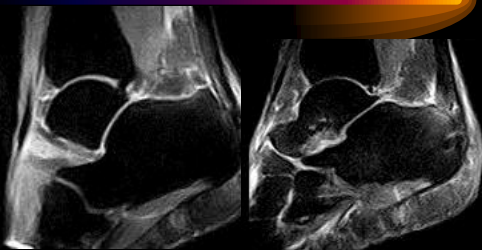
- Avascular critical “watershed zone”
- Assess insertion
- Musculotendinous Junction
- Plantaris tendon integrity



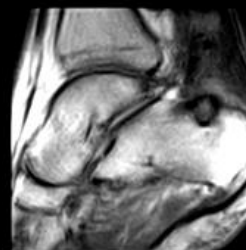
Utility of MRI for Achilles Repair

- Three phases of repair: Inflammatory, angiogenesis, and remodeling.
- MRIs of 68 Achilles tears, 47 repaired
- On T2 weighted images, low signal should be present by six weeks post op with no bright fluid signal (Scheidler et al. 2006 RSN abstract)
- Persistent fluid signal correlates with persistent symptoms and less favorable outcome
- Explosive acceleration athletes less than 30 are more prone to re-tear, even after rehabilitation (Am Journal of Sportsmedicine, January 2005)

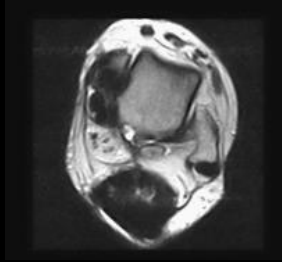
Pre and Post Operative Haglund/Partial Retear



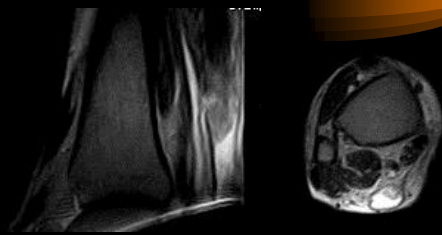
Achilles Postoperative



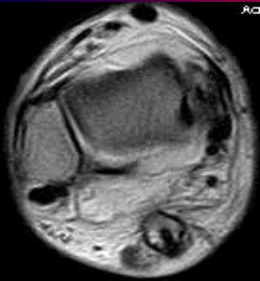
Achilles Postoperative



Preoperative Achilles Tear



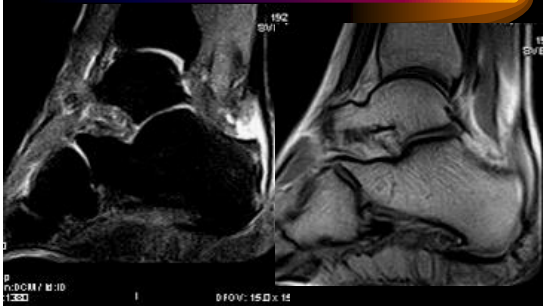
Repair with FHL Graft and Porcine basement membrane wrap



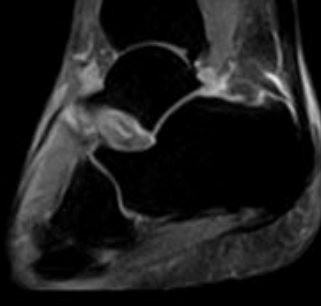
Repaired Achilles Early Postoperative Phase/Anchors



Haglund Deformity, Insertional Tear, & Peroneocalcaneus Internus



Haglund Deformity



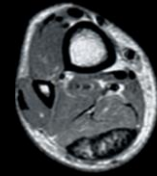
"Healed" Achilles Tendon Tear

- Retraction
- Attrition
- Deficient plantar flexion
- Tendon lengthening



Severely Thickened Achilles

- Chronic partial tearing is most common or post op
- "Lumpy Bumpy" deposition diseases
- Xanthoma
- Amyloid
- Tophus

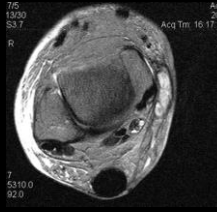


1.8ip
1.282 PI

Achilles Xanthoma



Post-operative Achilles Tendon 75 y-old with trauma; intact repair



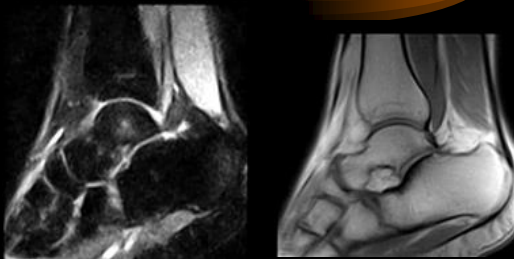
76
1390
S3.7
R
7
53100
920

Acc: 208
AcqTm: 16:17:27
5

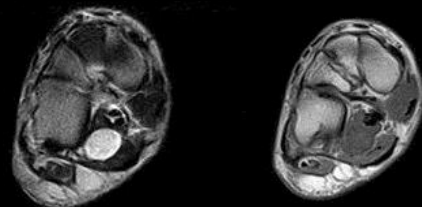


30 11 00g
08 0/5
1m 0:26
Sag: R39.8 (OCJ)
Let: R
16:48:10
1E: 16.0
R: 0.1000000
16 DCM / LIPDCY No.10

Accessory Soleus



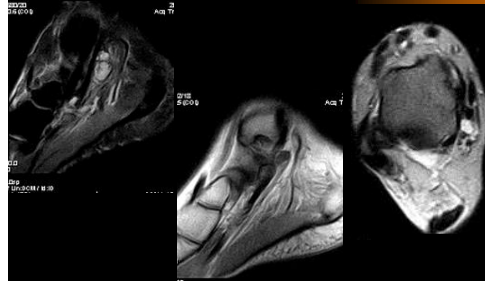
Plantar Neuroma



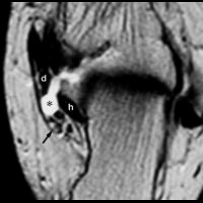
Tarsal Tunnel/Anatomy of the Medial and Lateral Plantar Nerves



Tarsal Tunnel Ganglion



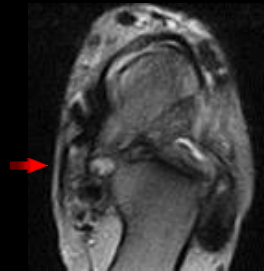
Tarsal Tunnel Ganglion



Tarsal Tunnel Syndrome/Flexor Digitorum Accessorius Muscle



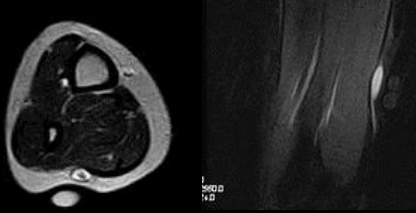
Tarsal Tunnel Synovitis



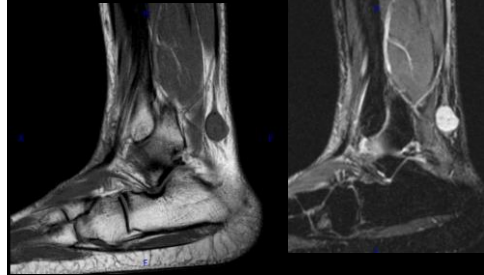
Schwannoma of Tarsal Tunnel



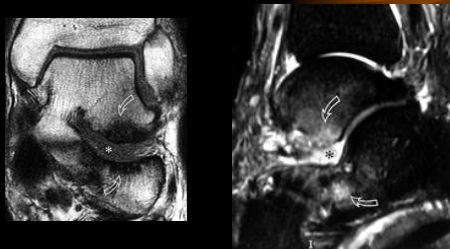
Sural Schwannoma



Sural Schwannoma



Rheumatoid Arthritis



Rheumatoid Arthritis

- MTP joints often first affected in RA. Often before wrist and hand.
- Fifth MTP most common affected.
- Generally, bilateral and symmetric

Rheumatoid Arthritis

- 3 types of lesions
 - Marrow edema: Ill-defined high T2 signal
 - Pre-erosions (bone defects, subcortical cyst): Sharp margins with intact cortex
 - Erosions: Sharp margins with cortical disruption
- Usually at “bare area” of met head

Rheumatoid Synovitis

- Synovial hypertrophy (pannus) with or without effusion
- Must be careful with timing of contrast. Contrast will diffuse into joint, overestimate degree of synovitis (important for monitoring)



Tenosynovitis in RA

