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**

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**CT Imaging**

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

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**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

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**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

- 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

55 year old male fell skiing; rule out fracture

- Completed” Proximal Femoral Stress Fracture (Marathon Runner)

- 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

Triceps tear/avulsion of the posterior component

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Femoral Neck Stress Fractures in Runners

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- Pitchers, football linemen and weightlifters
- Repetitive activities, olecranon bursitis
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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

T-1 Weighted image

Edema sensitive STIR
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

Tibial plateau  Scaphoid  Die Punch/DRF

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

Shoulder Instability

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

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

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

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

East Branch of the Hell’s Angels!

Trauma

MRI Defines Occult Lower Extremity Fractures

- 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

Osteomyelitis

- Freiberg Infraction

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 Trigonom 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

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**
Plantar Fasciitis

- Windlass Mechanism
- Enthophyte
- 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

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
**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 Tendonopathy
- “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 tendinopathy
- Flexor substitution
- ATT tear

PTT Dysfunction
Calcaneal Eversion/Peroneal Tendon Impingement

Secondary Findings of Posterior Tibial Tendon Dysfunction
- Sinus tarsitis
- Achilles tendinosis
- Peroneal tendinopathy
- Plantar fasciitis
- Baxter’s denervation of abductor digiti quinti

PTT Talonavicular Subluxtion

Torn Peroneus Brevis

Peroneus Quartus

Peroneus Brevis
Peroneal Calcaneal Tubercle Edema

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

Peroneus Longus Tears

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 RSNA 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 Sportsmedine, 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

Repairs 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

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

Accessory Soleus

Plantar Neuroma
Tarsal Tunnel/Ganglion

Tarsal Tunnel/Ganglion

Tarsal Tunnel/Ganglion

Tarsal Tunnel/Ganglion

Tarsal Tunnel Syndrome/Flexor Digitorum Accessorius Muscle

Tarsal Tunnel Synovitis

Schwannoma of Tarsal Tunnel
Sural Schwannoma

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