Overuse Syndromes of the Ankle

Repetitive Activity Injuries

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BIDMC Core Clerkship in Radiology
Objectives

• Illustrate anatomy of the foot and ankle
• Discuss menu of tests available to evaluate the ankle
• Discuss basics of MRI
• Provide examples of several specific overuse syndromes
• Discuss Posterior Ankle Impingement Syndrome
• Illustrate bone marrow edema
Foot Anatomy: Muscles/Tendons

www.sportspodiatry.co.uk/foot_footanatomy.htm
Bone scan of 25-year-old player on the German National Field Hockey Team with diffuse pain around the posterior ankle.

Menu of Tests

- **Radiograph** will show bony abnormalities and may show stress fracture
- **CT** more sensitive than plain film for stress fracture
- **Ultrasound** used for guided corticosteroid injections
- **MRI** sensitive for early bone marrow edema, stress fracture, soft tissue structures and pathology
- **Bone scintigraphy** sensitive for bone stress, but does not provide useful info for therapy

*Journal of Arthroscopic and Related Surgery, Vol 20, No 4 (April), 2004: E4, H. Lohrer*
Normal Ankle MRI

Sagittal T1 weighted MRI images

http://www.med.nagasaki-u.ac.jp/radiolgy
MRI Basics

1. Alignment of protons in magnetic field

2. Administration of radiofrequency pulse

3. At TE (echo time), measure energy created by differential realignment of protons

4. Readminister RF pulse at TR (repetition time), and repeat cycle until adequate amount of data obtained.
T1 and T2 Weighted MRI

**T1 weighted**
- Short TR and TE
- Good for anatomy
- Fluid shows low signal (dark)

**T2 weighted**
- Long TR and TE
- Good for pathology
- Fluid shows high signal (bright)
- Proton Density image can be taken early in sequence
Alternative Sequences

- Fat saturation sequences suppress signal from fat to highlight fluid.
  - STIR sequences good for marrow
  - Gradient Echo good for cartilage

- Other sequences available to maximize intrinsic contrast between tissues.
Our Patient BF: History

- B.F. is a 31 year old marine who suffered an inversion injury while running during deployment in Iraq.

- Experienced ankle weakness, especially with pushing off laterally. Intermittent soreness and pain with exercise.

- Saw an orthopedist at Camp Fallujah, but decided to forego treatment until finishing his deployment.

- He would finish his career with the Marines within the next year and apply with the FBI doing field work.
Overuse Syndromes of the Ankle

- Stress Fracture
- Osteochondritis Dessicans
- Anterior Impingement syndrome
- Achilles Peritendinitis
- Achilles Tendinosis and Bursitis
- Tibialis Anterior Tenosynovitis
- Plantar Fasciitis
- Peroneal Splits Syndrome
- Tarsal Sinus Syndrome
Companion Pt. 1 - Stress Fracture on CT and MRI

Tri-athlete with stress fractures of both tali

Eur Radiol (2007) 17: 3056–3065, Robinson
Stress Fracture Pathophysiology

- Altered bone homeostasis, increased resorption relative to formation
- Repetitive stress
- Focal trabecular microfractures, edema, hemorrhage (stress response)

- Runners and jumpers most prone to foot/ankle stress fracture
- Tibia, fibula and calcaneus most commonly involved
- MRI highly sensitive for early changes
Companion Pt. 2 - Osteochondritis Dessicans on MRI

- Repetitive inversion injury, common in military recruits.

- Talus is prone because of convex surface of the joint.

- Conventional radiographs not sensitive.

- MRI can visualise the condition of the articular cartilage and assess whether the fragment is still situated in its fracture bed or whether loosening has occurred.

Coronal T1-weighted SE

Eur Radiol (2007) 17: 3056–3065, Robinson
Companion Pt. 3 - Anterior Impingement on MRI

- Repetitive inversion injuries.
- Repetitive bouncing of anterior tibia onto the neck of the talus
- Thickening of the anterior tibiofibular ligament, synovial hyperplasia and fluid.
- Entrapment of synovial tissue between the talus and tibia leads to osteophytes - maintains synovial irritation

21 year old female runner. Axial proton density weighted fast spin-echo MR.

Eur Radiol (2007) 17: 3056–3065, Robinson
Fluid around the posterior aspect of the Achilles tendon.

The tendon thickened compared to normal left side.

Intratendinous signal intensity.

Mucoid degeneration hemorrhage leads to weakness of the tendon, increasing the risk of a rupture.
Companion Pt. 5 - Achilles Tendinosis and Bursitis on MRI

- Inflamed Achilles tendon and retrocalcaneal bursitis.
- Fluid in bursa between Achilles tendon and calcaneus.
- Increased signal intensity in the distal Achilles tendon.

Long-distance runner, 29 years old, Sagittal and axial T2-weighted GRE MR images

Eur Radiol (2007) 17: 3056–3065, Robinson
38 years old sportsman. Sagittal T2 gradient echo MR and Axial T2 fast spin-echo GRE MR

- Tibialis anterior tendon surrounded by fluid in tendon sheath
- Repetitive microtrauma in runners causes increase in synovial fluid with distention of tendinous sheath
- Chronic tendinitis leads to thickening, predisposition to rupture

Eur Radiol (2007) 17: 3056–3065, Robinson
Fluid in the enlarged tendon sheath.

Splitting of the peroneal brevis tendon in anterior part of tendon sheath: tendon seen as two separate structures.

The peroneus longus tendon seen posteriorly is normal.
Our Patient BF: MRI Demonstrates Peroneus Brevis Tendon Tear

- Patient B.F. received an MRI upon his return from Iraq which showed a 5cm longitudinal tear along the peroneus brevis tendon.

- He elected physical therapy and use of an ASO brace over surgical repair.
Plantar fascia: thick aponeurosis arising from medial calcaneal tuberosity. Inserts onto base of each proximal phalanx.

Microtears in runners leads to inflammation, fibrous repair, focal thickening, edema, signal heterogeneity on MR

In chronic plantar fasciitis, entire fascia is thickened.

Heel spur often found on X-ray films, presence spur is not reliable for making diagnosis.
Companion Pt. 9 - Sinus Tarsi Syndrome on MRI

- Tarsal sinus: anatomic space between inferior talus and superior calcaneus, anterior to posterior subtalar joint

- Ligaments, vessels, nerves, connective and fatty tissue.

- Repetitive inversion injury leads to stretching/tearing of ligamentous structures of the sinus tarsi, leading to subtalar instability

- Image shows diffuse infiltration of left tarsal sinus obliterating the fat and interosseous talocalcaneal ligament.

22 years old female runner. T1 coronal spin-echo MR

Eur Radiol (2007) 17: 3056–3065, Robinson
Companion Pt. 10 - Tarsal Tunnel Syndrome on MRI

Accessory Soleus Muscle seen at the left ankle of a 38 year old runner on Axial T1 MRI. Right side is normal

Eur Radiol (2007) 17: 3056–3065, Robinson
Companion Pt. 10 - Tarsal Tunnel Syndrome on MRI

- Tumors, ganglion-cysts, or a large accessory soleus muscle compressing the entrance to the tarsal tunnel.

- Blood supply of the soleus muscle is marginal and therefore exercise may induce ischemia and edema in the muscle.

- After sports training, the medial neurovascular bundle is compressed, the patient notices burning pain in the heel and reduced sensation in the sole of the foot.

Eur Radiol (2007) 17: 3056–3065, Robinson
Posterior Ankle Impingement Syndrome (PAIS)

Inflammatory changes in the posterior ankle secondary to repetitive plantar flexion

MRI features of PAIS:

- Bone marrow edema
- Posterior synovitis
- Posterior capsular thickening
- Tenosynovitis of FHL
- High signal at muscle/tendon junction FHL
- Tibiotalar joint effusion
Companion Pt. 11 - Posterior Ankle Impingement Syndrome on MRI

- Posterior synovitis → thickened edematous synovium surrounding a fluid collection (black arrow).

- Bone marrow edema within posterior talus (white arrow)

Sagittal STIR image during plantar flexion

Companion Pt. 12 - Posterior Ankle Impingement Syndrome on MRI

24 years old runner. Sagittal T2-weighted GRE MR image

- Hypertrophied synovia caused by repetitive entrapment of the talus and soft tissue between the tibia and calcaneus during hyperflexion of the foot.
Anatomic Variants Predisposing to PAIS

1. Os trigonum
2. Prominent down-sloping tibia
3. Prominent Calcaneal tuberosity
1. Os Trigonum on Plain Film

- Accessory ossification found along posterior aspect of talus in 5-15% of population.

- Called trigonal (Stieda's) process when it is fused to the talus.

- Called os trigonum if remains unfused with talus

- Inferior surface typically articulates with the calcaneus.

44 years old ballet dancer.
1. Os Trigonum on MRI

- Impingement of an os trigonum during plantar flexion (white arrow)
- Thickened adjacent posterior capsule (black arrow)

Sagittal T1-weighted turbo spin-echo

1. Os Trigonom on MRI

- Marrow edema within the os trigonum
- Increased signal within thickened soft tissues indicating posterior synovitis.

Sagittal STIR image during plantar flexion

2. Prominent Downsloping Tibia

3. Prominent Superior Calcaneal Tuberosity

T1-weighted turbo spin-echo image during plantar flexion demonstrating prominent superior calcaneal tuberosity

50 yo woman with persistent posterior ankle pain 3 months following calcaneal fracture, especially when walking down stairs.

Posterior bone spike secondary to healed calcaneal fracture impinging onto distal tibia during plantarflexion.

Endoscopic bone spike resection
Before

and

After

Knee Surg Sports Trauma Arthroscopy, T.H Lui
Bone Stress Injury in Ballet Dancers

Bone marrow edema seen in Talus in 9/12 patients

DDx of BME:

- trauma
- avascular necrosis
- osteochondral defect
- tumors and tumor-like conditions
- metabolic disease

- tarsal coalition
- infection
- arthritis
- tendinopathy
- plantar fasciitis

BMC Musculoskelet Disord. 2008, Elias, I
Marrow Edema on Sagittal STIR MRI

24 year old male

34 year old female

BMC Musculoskelet Disord. 2008, Elias, I
Bone Marrow Edema on Sagittal STIR MRI

25 year old male. High signal in body and subchondral dome.

BMC Musculoskelet Disord. 2008, Elias, I
Bone Marrow Edema on T1 Weighted MRI

Patchy low signal on T1 (lower than fat higher than muscle)

BMC Musculoskelet Disord. 2008, Elias, I
Correlation of bone marrow edema and ankle pain.

<table>
<thead>
<tr>
<th>Pain</th>
<th>Bone Marrow Edema</th>
<th>No Bone Marrow Edema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>8 (A)</td>
<td>1 (C)</td>
</tr>
<tr>
<td>No pain</td>
<td>0 (B)</td>
<td>2 (D)</td>
</tr>
</tbody>
</table>

(n = 11)

BMC Musculoskelet Disord. 2008, Elias, I
Our Patient BF in Follow Up
(16 months later)

• B.F. was making no further gains with physical therapy, and had persistent discomfort posteriorly as well as over the ATFL (anterior talofibular ligament)

• Underwent open surgical tendon repair.

• 6 months s/p surgery, he reports having 60% of his pre-injury strength and is optimistic.
Summary

- MRI features associated with these conditions should be cautiously interpreted, especially in athletes where some capsular and osseous changes can be asymptomatic.

- MR imaging is valuable in assessing the possible soft tissue and osseous abnormalities implicated in a particular clinical setting of ankle impingement.

- Provides a global assessment of the joint and soft tissues prior to treatment, allowing for ultrasound-guided steroid injection injection or surgical planning.

- Early changes detected in high performing athletes may influence training strategies.
References

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