MR Imaging of the Ankle and Foot

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- Supine in extremity coil
- Padding for immobilization
- Saturation pads for good fat sat
- Unilateral imaging with small FOV
- Focus on hindfoot or forefoot whenever possible
- 3 planes of imaging
<table>
<thead>
<tr>
<th>Plane</th>
<th>Seq</th>
<th>TR/TE</th>
<th>FOV</th>
<th>Matrix</th>
<th>Slice</th>
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<tbody>
<tr>
<td>Localizer</td>
<td>Fast IR</td>
<td>2800/30</td>
<td>10</td>
<td>128</td>
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<tr>
<td>Axial</td>
<td>PD FSE</td>
<td>2500/20</td>
<td>10</td>
<td>256</td>
<td>512</td>
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<tr>
<td>Axial</td>
<td>T2 - fs FSE</td>
<td>2500/80</td>
<td>10</td>
<td>256</td>
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<tr>
<td>Sagittal</td>
<td>T1</td>
<td>600/20</td>
<td>14</td>
<td>192</td>
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<tr>
<td>Sagittal</td>
<td>T2 - fs FSE</td>
<td>2500/80</td>
<td>12</td>
<td>256</td>
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<tr>
<td>Coronal</td>
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Ankle MR Arthrography indications

- Osteochondritis dissecans of the talus
- Intraarticular body
- Ligament or syndesmosis tear
• Local anesthesia

• Anterior approach using fluoroscopic guidance into tibiotalar joint

• Placement confirmed with 1 cc of iodinated contrast

• Injection of 2-4 cc of Gd-DTPA
Ligaments

Syndesmotic

- Interosseous
- Anterior Tibiofibular
- Posterior Tibiofibular
- Transverse Tibiofibular

Med

- Superficial Deltoid
- Deep Deltoid

Lat

- Anterior Talofibular
- Calcaneofibular
- Posterior Talofibular
- **Interosseous**
  - Tibiofibular
- **Lateral**
  - Fibula to foot
- **Medial**
  - Tibia to foot
• Tibiofibular ligaments and syndesmosis

• Talofibular and calcaneofibular ligaments
Ligament injury
Radiograph
Malalignment
Stress views
Laxity
Arthrography
Contrast
eXtravasation
CT
Nonvisualization
Thickening
MR
Thickening
High signal
Nonvisualization
- Overlying edema
- Fluid extravasation from joint
- High signal within substance
- Focal disruption
- Retraction
- Thickening of ligament
- Anterior tibiofibular
- Interosseous membrane
- Posterior tibiofibular

Drawing from http://www.nist.gov
- Anterior talofibular ligament tears first
- Calcaneofibular next
- Posterior talofibular rarely torn
- Complication of ligament injury
- Entrapment and impingement of soft tissue in anterolateral gutter of ankle
- Fibrotic mass anterior to fibula
- Nonvisualization of ligament
- Sensitivity of MR low without effusion
• Fatty cone of tissue between anterior talus and calcaneus

• Contains cervical and interosseous ligament

Cervical ligament (1)
Interosseous talocalcaneal ligament (3)
Medial (2), Intermediate (4) and lateral (5) roots of the inferior extensor retinaculum.

AF = anterior facet, MF = medial facet, PF = posterior facet.
- Appears high signal on T1-w images
- Linear ligaments and vessels within fatty cone
Sinus Tarsi syndrome

- Trauma, inflammatory arthritis, foot deformity
- Lateral hindfoot pain and sensation of hindfoot instability

Lektrakul et al, Radiology 219:802, 2001
• Inflammation, synovial proliferation and scarring in tarsal sinus

• May have bursal distention as well

• Typically responds to steroid injection

Lektrakul et al, Radiology 219:802, 2001
• Fan-shaped ligament
• Several distinct bands
Ankle tendons

Peroneus brevis
Peroneus longus

Achilles

Posterior tibialis
Flexor digitorum
Flexor hallucis
Anterior tibialis
Extensor hallucis
Extensor digitorum
- Type 1
  - Hypertrophic tear

- Type 2
  - Atretic tear

- Type 3
  - Complete tear with gap
- Dislocation
- Tenosynovitis
- Hypertrophy
- Atresia
- Tear
- Tenosynovitis
- Tendinopathy
- Tear of tibialis anterior (rare)
- Tenosynovitis
- Partial tear
  - Hypertrophic
  - Atretic
- Complete tear
• Normally communicates with ankle joint

• Ankle effusion distends tendon sheath

• Fluid in isolation due to tenosynovitis
Posterior ankle impingement

- Compression of posterior talus or os trigonum

- Caused by repetitive or acute forced plantar flexion (e.g., ballet dancers)

- Posterior ankle pain
- Bone marrow edema
- Distention of posterior joint with fluid
- Tenosynovitis of FHL tendon
- Os trigonum common

• Normal function is to support medial arch

• Insufficient tendon results in pain, sagging of midfoot and flatfoot deformity

• Tears most common just distal to medial malleolus
- Tenosynovitis
- Tendon dislocation
- Partial tear
  - Split biceps tendon
- Complete tear
• Peroneus quartus muscle and tendon
• Normal variant
• Seen in up to 20%
• Typically asymptomatic
• May crowd peroneals and increase risk of tear
- Normal tendons lie posterior and medial to lateral fibular border
- Contained by peroneal retinaculum
- Subluxation or dislocation
• Normally, peroneus brevis is a C-shaped tendon

• Lies anterior to peroneus longus tendon

• Chronically rubbed from behind by peroneus longus

• Longitudinal splitting tear
Peroneus Longus Tendon

- Passes behind fibula, under peroneal tubercle and then under the cuboid to insert on plantar aspect of medial cuneiform and 1st metatarsal.

- Tears uncommon.
- Tendinopathy
- Linear tear within substance
- Partial tear
- Complete tear
• Uniform width
• Low signal
• Anterior border flat or concave (kidney bean)
Degenerative process
Tendon enlarged, normal signal on T2-weighted images
• Myotendinous junction is at midcalf level

• Tears most common 6-10 cm proximal to insertion
• Location

• Extent

• Size of gap

• Quality of underlying tendon
• Tears can occur at insertion of Achilles at calcaneus

• Typically due to underlying tendinopathy
• Achilles tendon has no sheath

• Soft tissue inflammation in fat pad anterior to Achilles known as peritendonitis

Karjalainen et al, AJR 175:251, 2000
- Achilles tendon
- Bursitis
- Heel spur
- Plantar fasciitis
- Calcaneal fracture
- Heel fat pad
• Distension of bursa between tendon and superior calcaneal tuberosity

• Frequently seen as part of “pump bump” syndrome

- Enthesophyte at plantar fascia attachment
- Often asymptomatic
- Bone pain
- Irritation of plantar fascia
- Inflammation of overlying fat pad
- Adventitial bursa
- May be large and irregular in patients with inflammatory arthritis
• Multilayered fibrous aponeurosis

• Normal fascia is uniform low signal

• 3-4 mm thickness
• Thickening of plantar fascia
• High signal within fascia
• Fluid surrounding fascia
• Edema in calcaneus adjacent to insertion
- Uncommon injury
- Athletes
- Acute onset of plantar pain
• Vascular insufficiency
• Soft tissue atrophy
• Ulceration
• Osteomyelitis
• Neuroarthropathy
• Superficial ulceration leads to deep infection
• Ultimately, bone is involved
• Osteomyelitis occurs at typical pressure points
- Used combination of T1-w SE, T2-w FSE fatsat, post Gd-DTPA
- 82% sensitivity
- 80% specificity
- MR useful for delineating extent of disease
• Loss of marrow signal on T1-w

• Increased marrow signal on STIR and T2-w

• Enhancement with Gd-DTPA
- Morphologic changes in periosteum and cortex
- Overlying alterations in soft tissues
• Ulcers develop over pressure points

• Nonhealing ulcers may develop

• 33% of patients with nonhealing ulcer develop osteomyelitis

• 95% of diabetics with foot osteomyelitis have an overlying associated skin ulcer

Boutin et al, Diabetic Foot Disease, Magnetic Resonance Update
- Cortical interruption
- Rim-enhancing abscess within bone
- Sequestrum formation
- Sinus track from bone to skin
- Cellulitis adjacent to osseous abnormality

Morrison WB et al, Radiology 196:557-564, 1995
• Metastases

• Primary benign
  • Lipoma
  • Chondroblastoma
  • Giant cell tumor
  • ABC

• Primary malignant
  • Ewing's sarcoma
  • Lymphoma
- Bunion
- Ganglion
- Plantar fibroma
- Plantar fibromatosis
- Morton's neuroma
- Synovial cell sarcoma
- Lipoma
- Firm, nontender superficial plantar mass
- Below midportion of first metatarsal
- Superficial to flexor hallucis longus tendon
- Often adherent to plantar fascia
- Up to 50% bilateral

image from Robbin et al, Radiographics 21:585, 2001
Morton neuroma

- Middle aged females
- Focal posttraumatic thickening of interosseous nerve at level of metatarsal heads
- Most common in 3rd and 2nd interspaces
- Frequently bilateral or multiple neuromas
- Painful
Morton neuroma

- Focal thickening of nerve
- 2 mm to 1 cm nodule
- Extends into interosseous plantar fat
- Low signal on all sequences
- Mild to moderate enhancement with Gd
• Low signal mass on T1 and T2

• Gadolinium enhancement
- Intact cartilage, subchondral lesion
- Partial disruption of cartilage with hinge or flap
- Loose, complete cartilage disruption, bone undisplaced
- Loose, displaced
Stress fractures

- Fatigue
  - Overuse
  - Weekend athlete
  - Toddlers

- Insufficiency
  - Metabolic bone disease
  - Neuroarthropathy
  - Immobilization
Calcaneal insufficiency fracture

• Common in elderly

• Typically due to walking or running

• Involve posterior tuberosity

• Linear band with surrounding edema