MRI interpretation of the foot

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Outlines

- Technique
- Forefoot
  - First MTP joint
  - Lesser MTP & metatarsalgia
    - Plantar plate injury
    - Intermetatarsal space (morton neuroma, intermetatarsal bursitis)
    - Pressure lesions: soft tissue callus, adventitial bursitis
- Midfoot
  - Lisfranc ligament complex
- Osseous structures: BME
Standard MRI sequences

- Often focusing on a specific portion of the foot: ankle/hindfoot, midfoot, or forefoot
- Sagittal, short axis (coronal ankle) and long axis (axial ankle) planes relative to metatarsals
- Sagittal and short axis images: plantar plates, sesamoid bones and flexor and extensor tendons; intermetatarsal structures (short axis)
- Long axis images: collateral ligaments, Lisfranc ligament complex
# Foot protocol (3 Tesla)

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From approximately the mid subtalar joint to the proximal metatarsals

Suggested protocol for imaging the midfoot

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Coronal, parallel to the bottom of the foot; Axial, transverse to the longitudinal arch of the foot.

From approximately the mid subtalar joint to the proximal metatarsals
Suggested protocol for imaging the forefoot

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Coronal, parallel to the bottom of the foot; Axial, Transverse to the longitudinal arch of the foot.

From approximately the naviculocuneiform articulation through the toes.
Lesser MTP and Metatarsalgia

- Plantar plate
- Morton neuroma
- Intermetatarsal bursitis
- Soft tissue callus
- Adventitial bursitis
Plantar plate

- Primary stabilizer of the lesser MTP joints, especially in the dorsal-plantar direction
- Articulates directly with the plantar surface of the lesser metatarsal head
- A firm, flexible fibrocartilaginous structure that has a mean length of 20 mm and average thickness of 2 mm at the second MTP joint
Plantar plate anatomy

- Uniform dark signal deep to the metatarsal head
- Flexor digitorum tendon courses beneath and non-discernable intervening cleavage plane.
- Normal capsular recess, 47% in the midsagittal plane*

Plantar plate anatomy

- Plantar plate: a thick c-shaped low signal band
- Central groove for flexor digitorum longus and brevis tendons
- Proper collateral ligaments blend with the plantar plate at base of proximal phalanx insertions.
Medial and lateral collateral ligaments

- Best for evaluating the attachment of collateral ligaments onto the bilateral base of the proximal phalanges

- Collateral ligaments have a close relationship with the interosseous, abductor digiti minimi, and flexor digiti minimi brevis tendons
Plantar plate injury

- Typically a chronic acquired degenerative condition
- Common at 2\textsuperscript{nd} MTP
- Predisposing factors:
  - A long second metatarsal
  - Relative shortening of the first ray: cavus foot, mildly increased metatarsus adductus, a supinated foot, or a forefoot varus deformity (plantar flexed “shortened” position of the first ray)
- Plantar plate rupture: MC at the distal, lateral insertion onto the proximal phalangeal base
Second metatarsal protrusion

- > 4 mm, trend toward correlation with plantar plate tear*

The “crossover toe” end-stage disabling deformity
Plantar plate tear

- Partial or complete discontinuity at the insertion
- Focal high T2W SI of the plantar plate

buttonhole appearance
Plantar plate tear

- Thinning or non-visualization of the plantar plate
- Increased distance between the distal margin of plantar plate and the base of the proximal phalanx
- Distortion of the interosseous tendon and collateral ligament complex
Plantar plate tear
Morton neuroma

- Fibrosis and neural degeneration surrounding the plantar digital nerve
- More commonly in women, possibly a result of wearing higher heeled shoes
- Most likely due to repetitive compression and irritation of the nerve
- 2nd and 3rd intermetatarsal spaces, along plantar aspect of transverse intermetatarsal ligament

[Image: Illustration of Morton's neuroma]
Morton neuroma

- Rounded, or dumbbell-shaped masses between the metatarsal heads
- Isointense to muscle on T1W, hypointense relative to fat on T2W and varying enhancement
Morton neuroma

- Dumbbell-shaped masses between the metatarsal heads
- Isointense to muscle on T1W, hypointense relative to fat on T2W and varying enhancement

STIR

T1W

T1+Gd
Intermetatarsal bursitis

- Homogeneous low T1/high T2 mass between metatarsal head, peripheral enhancement
- Extends dorsal to the level of intermetatarsal ligament, no plantar extension
- Small fluid collections with a transverse diameter ≤ 3 mm in the 1st three intermetatarsal bursae may be physiologic.
Pressure lesions - soft tissue callus

- Benign fibroblastic response to chronic mechanical pressure
- Focal masslike infiltration in superficial plantar subcutaneous fat
- Typically in forefoot (beneath the 1st & 5th metatarsal heads and distal phalanx of the hallux) and heel; deep to the cuboid in rocker bottom deformities
- MRI: low signal compared with surrounding fat on T1W and T2W, enhances
- In DM, can become ulcerated and infected, and a conduit for deep infection
Soft tissue callus
Adventitial bursitis

- Develop sporadically owing to increased friction
- Chronic friction at the callus can lead to overlying adventitial bursitis.
- May be asymptomatic or present as a painful mass (when inflamed)
- In the fat plantar to 1st metatarsal & plantar and lateral to 5th metatarsal head; retro-Achilles bursa; and malleolar bursae (medial > lateral)
- Inflamed bursae $\rightarrow$ fill with fluid and/or thickened synovium
Adventitial bursitis

- Tend to have a pliable, discoid shape
- Iso- or slightly hyperintense to muscle on T1W, high SI on T2W, thin rim of enhancement
- Inflamed bursae: thickened, enhancing rim peripherally and more complex internal enhancement
- Fibrosis predominately: low T2 signal
Midfoot

- Lisfranc ligament complex
Lisfranc joint complex
Lisfranc ligament

- 3 parts
  - Interosseous Lisfranc ligament (strongest)
  - Dorsal component, weak

Oblique ligaments extend from medial cuneiform to 2\textsuperscript{nd} metatarsal base.

- Plantar component: C1 to bases of M2 & M3
Lisfranc joint complex injury

- High-energy vs low-energy trauma
- Midfoot sprains
  - Sports-related and due to indirect forces
  - Nunley and Vertullo classification

<table>
<thead>
<tr>
<th>Stage</th>
<th>Clinical findings</th>
<th>Radiographic findings*</th>
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<tbody>
<tr>
<td>I</td>
<td>Low-grade sprain and dorsal capsular tear with intact joint stability</td>
<td>Normal</td>
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</table>
| II    | Elongation or disruption of Lisfranc ligament with intact plantar capsular structures | AP: 2–5-mm M1-M2 diastasis  
Lateral: no loss of arch height |
| III   | Loss of arch height and disruption of the interosseous and plantar Lisfranc ligaments | AP: >5-mm M1-M2 diastasis  
Lateral: decreased distance between the plantar surfaces of C1 and M5 |

*Anteroposterior, lateral, and 30° internally rotated oblique weight-bearing films
Lisfranc ligament injury

- Fluid surrounding the Lisfranc ligament
- Ligament irregularity or frank disruption
- Abnormal signal intensity within the ligament

Images from http://radiologycases.blogspot.com
Lisfranc ligament injury
Lisfranc ligament injury

Fleck-sign: small avulsion fractures at base of the M2 or C1
Lisfranc ligament injury

- Fractures along the 2nd cuneometatarsal joint
- Contusions at the tarsometatarsal joints
- Soft tissue edema surrounding the 2nd metatarsal
- Edema in the 1st dorsal interosseous muscle
Lisfranc ligament injury

- Thickening of the interosseous Lisfranc ligament, particularly in setting of tarsometatarsal osteoarthrosis typically indicate old midfoot sprain.
Bone marrow edema pattern

- Challenging in diabetic foot
  - Early osteomyelitis vs stress response/bone marrow reaction
  - Early neuropathic arthropathy vs infection

- Early osteomyelitis
  - Identify a site of direct inoculation (skin/soft tissue defect with a sinus tract or abscess extending to the bones)
  - Focal or diffuse replacement of normal marrow fat on T1W → most reliable
  - Frank cortical destruction and/or periosteal reaction
  - Geographic enhancement on T1 post contrast
DM with direct osteomyelitis from ulcer
Bone marrow response to surrounding soft tissue infection
# Bone marrow edema patterns

## Early neuropathic arthropathy
- Diffuse soft tissue and bone marrow edema with increased enhancement
- Common at Lisfranc, Chopart or MTP joints
- Multiple bone and joint involvements
- Joint centered, and tend to occur symmetrically on either side of the joint

## Early osteomyelitis
- Site of direct inoculation
- Occur distal to TMT joint, and in malleoli and calcaneus
- Single bone involvement
- Tend to be limited to one side of a joint (in absence of septic arthritis)
Neuropathic arthropathy-DM
Reference