Bone Marrow Oedema in the Foot: MRI Clues for Diagnosis and Characterization

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Learning objectives

To describe the patterns of bone marrow oedema observed on MRI and their relevance in distinguishing among pathological entities.

Background

Term "bone oedema"? Used by radiologists to describe swelling within bone.

Which entities can trigger it? Trauma, infection/inflammation, osteochondral lesion, infarction, neoplasia, coalition and altered biomechanics.

How many in body? Osseous oedema is moderately frequent in the foot in comparison with other parts of the body.

Which is the pattern of oedema? It has different characteristics on MR images, but sometimes clinical and/or laboratory data and other, complementary imaging examinations such as X-ray and/or CT are needed to establish the correct diagnosis.

What is the focus of the article? On the MR findings that allow being clue for the diagnosis of the cause of bone oedema.

Population study: 500 patients aged 16 to 84 years with positive findings for bone marrow oedema on MRI examination done for acute or chronic foot pain in the last 3 years.

Technique: MRI examination with or without intravenous gadolinium contrast in the axial, sagittal and coronal planes using T1-W, PD, T2-W, spin-echo and/or fast spin-echo sequences + axial GE and/or spin-echo T1-W sequences + STIR or FS T1-W sequences.

Imaging findings OR Procedure Details

MR characteristics of bone marrow oedema (BMO) of the foot: Hypointensity on T1-W sequence and hyperintensity on T2-W, STIR and/or FS T1-W sequences.
Examples (one or several) of cases of BMO with additional MR findings of each entity (trauma, infection/inflammation, osteochondral lesion, infarction, neoplasia, coalition and altered biomechanics) that provide valuable clues to the cause of the BMO, which are described below:

TRAUMA:

**Case 01**: 27-year-old woman.

*Clinical background*: Foot pain. Marathon runner.

*MR interpretation clues*: Hyperintense BMO with a line of low signal intensity in STIR (Fig. 1 on page 16) and subchondral hypointense area with a line of low signal intensity in T1-W (Fig. 2 on page 16) of the proximal first metatarsal of the right foot in relation to the start sclerosis or repair of the fracture.

*Diagnosis*: **Stress fracture**.

**Case 2**: 40-year-old woman.

*Clinical background*: Chronic sprain. Suspected Achilles' rupture.

*MR interpretation clues*: Hyperintense BMO with a line of low signal intensity in STIR (Fig. 3 on page 17) and subchondral hypointense area with a line of low signal intensity in T1-W (Fig. 4 on page 18) on the posterior inferior surface of the body of talus of the left ankle.

*Diagnosis*: **Stress fracture**.

**Case 03**: 47-year-old woman.

*Clinical background*: Blunt trauma. Fall.
**MR interpretation clues:** Extensive hyperintense area of BMO in STIR (Fig. 5 on page 19) with a low intensity signal line, more evident in T1-W (Fig. 6 on page 20), in the posterior part of the calcaneus of the right foot.

*Diagnosis:* **Traumatic fracture.**

**Case 04:** 40-year-old athletic woman.

*Clinical background:* High-impact exercise over the heel led to intense pain, swelling, and bruises on the left foot.

*MR interpretation clues:* Hyperintense area of BMO in STIR (Fig. 7 on page 21) at the avulsed plantar surface of the calcaneus with a tear in the plantar fascia.

*Diagnosis:* **Rupture-avulsion of the plantar fascia.**

**Case 05:** 55-year-old man.

*Clinical background:* Sprain.

*MR interpretation clues:* Hyperintense area of BMO in STIR without evidence of a fracture line and with preserved adjacent cortical osseous signal in the head of the talus (Fig. 8 on page 22) of the right foot.

*Diagnosis:* **Bruised bone.**

**Case 06:** 62-year-old woman.

*Clinical background:* Gradual onset of left forefoot pain over three months. No known history of trauma.

*MR interpretation clues:* Dorsal dislocation with reactive BMO of the proximal phalanx of the second toe, with nearly complete discontinuity of the plantar plate ligament (Fig. 9 on page 23).
Diagnosis: Dislocation.

NON-TRAUMA:

Case 07: 49-year-old diabetic man.

Clinical background: Diabetes type 2. Septic process on the right foot with possible entry point for Achilles keratosis. No history of trauma.

MR interpretation clues: BMO (hyperintense in STIR and hypointense in T1-W) at displaced fracture of the calcaneus with avulsion of its posterior tuberosity (Fig. 10 on page 24) secondary to osseous fragmentation by necrosis.

Diagnosis: Pathological fracture.

Case 08: 59-year-old man.

Clinical background: No known trauma; diffuse pain, puffy swelling, redness, and warmth of the right foot. The contralateral foot was also affected.

MR interpretation clues: In the first MR examination, STIR showed hyperintensity in several tarsal bones (Fig. 11 on page 25). In follow-up examinations over the following 5 months, it appeared that BMO had migrated to other tarsal and metatarsal bones (Fig. 12 on page 26). X-ray and CT were negative.

Diagnosis: Sudeck’s osteoporosis (Complex Regional Pain Syndrome).

Case 09: 62-year-old woman.

Clinical background: Longstanding ankle pain.

MR interpretation clues: Focal BMO, hyperintense in STIR (Fig. 13 on page 27) and hypointense in T1-W, on the subtalar articulation with superficial irregularity and subchondral lesion on the superior articular facet of the calcaneus and inferior facet of
the talar (Fig. 14 on page 28), corresponding to osteochondral lesions in relation with degenerative arthropathy.

*Diagnosis:* **Degenerative arthropathy.**

**Case 10:** 61-year-old woman.

*Clinical background:* History of increased stress on the left foot related to standing or activity.

*MR interpretation clues:* Hyperintense thickening of the proximal plantar fascia affecting the bone at the calcaneal insertion producing a hyperintense area in STIR that corresponds to inflammatory changes with reactive subchondral calcaneal BMO (Fig. 15 on page 29).

*Diagnosis:* **Plantar fasciitis (enthesopathy).**

**Case 11:** 51-year-old woman.

*Clinical background:* Pain on weight bearing. Tenderness in the heel on palpation.

*MR interpretation clues:* Thickening and hyperintense mucoid degeneration at the distal insertion of the Achilles tendon, affecting the bone and causing reactive BMO, seen as a hyperintense retrocalcaneal area in STIR (Fig. 16 on page 30).

*Diagnosis:* **Achilles enthesopathy.**

**Case 12:** 57-year-old woman.

*Clinical background:* Retrocalcaneal pain.

*MR interpretation clues:* Hyperintense retrocalcaneal BMO in STIR with Haglund's deformity and hyperintense thickening and longitudinal degeneration of the distal third of the Achilles tendon (Fig. 17 on page 31).
**Diagnosis:** Haglund syndrome.

**Case 13:** 37-year-old woman.

**Clinical background:** Progressive congenital malformation known from childhood especially involving the foot. Study prior to palliative surgery for chronic invalidating pain.

**MR interpretation clues:** STIR shows patchy hyperintense reactive BMO on several deformed tarsal bones (Fig. 18 on page 32) with intertarsal ankylosis, hyperostosis, and generalized degenerative arthropathy, more evident in the forefoot (confirmed on CT (Fig. 19 on page 33)).

**Diagnosis:** Proteus syndrome.

**INFECTION/INFLAMMATION:**

**Case 14:** 64-year-old man.

**Clinical background:** Patient with decompensated diabetes. Suspicion of infection at stump without ulcers on the skin.

**MR interpretation clues:** BMO is seen as patches of hyperintensity in STIR which are hypointense on unenhanced T1-W (Fig. 20 on page 34) and hyperintense on contrast-enhanced T1-W (Fig. 21 on page 35) on partially resected cuboid and navicular bones with adjacent soft-tissue collections in the stump. *Staphylococcus aureus* was confirmed at histology.

**Diagnosis:** Acute osteomyelitis.

**Case 15:** 66-year-old man.

**Clinical background:** Nondiabetic man with a right femorotibial bypass; right foot pain.
**MR interpretation clues:** STIR shows extensive BMO as a hyperintense area in the calcaneus; note the plantar fistula through the hyperintense adjacent soft-tissue at a pressure point of the foot (Fig. 22 on page 36).

**Diagnosis:** Focal osteomyelitis/bony inflammatory process.

**Case 16:** 61-year-old man.

**Clinical background:** Patient with types II diabetes. Cellulitis by Staphylococcus aureus at amputated intermetatarsal, foot stump with several suppurated ulcers.

**MR interpretation clues:** Patches of BMO on proximal metatarsal bones with marked involvement of the adjacent soft tissues are hyperintense in STIR (Fig. 23 on page 37), hypointense on unenhanced T1-W (Fig. 24 on page 38), and hyperintense on enhanced T1-W.

**Diagnosis:** Diabetic foot.

**Case 17:** 51-year-old man.

**Clinical background:** Patient with type II diabetes. Deformity of the right foot. Painless swelling with erythema. Polyneuropathy.

**MR interpretation clues:** Diffuse BMO is hyperintense in STIR (Fig. 26 on page 40), hypointense on unenhanced T1-W (Fig. 27 on page 41), and hyperintense on enhanced T1-W (Fig. 28 on page 42); BMO involves the tarsal and metatarsal bones, with cortical destruction involving midfoot joints and reactive oedema of the adjacent soft tissue without overlying ulcer. X-ray confirmed worsening of the Charcot process over two years, with osteopenia, cortical destruction, and dislocation of the Lisfranc joint (Fig. 29 on page 43).

**Diagnosis:** Charcot's neuropathic arthropathy.

**Case 18:** 52-year-old man.
**Clinical background:** Known chronic osteochondral lesion of the astragal bone, without clinical improvement. Soreness of the right foot. Suspected SHAPO syndrome.

**MR interpretation clues:** Low signal on T1 and high signal on STIR, representing BMO, surrounding an ill-defined osseous lesion at the posterior facet of the talus on the first MR examination (Fig. 30 on page 44). Follow-up MR 4 years later shows an osseous lesion with sclerotic margins, thick fibro-osseous trabeculae, and cystic formations (Fig. 31 on page 45). These findings were well visualized on the CT. The lesion was biopsied and the histological results are pending.

**Diagnosis:** Chronic myelitis or hyperostosis.

**Case 19:** 50-year-old black African man.

**Clinical background:** Painful swelling with erythema and suppurated ulcer on the left big toe.

**MR interpretation clues:** Low signal on T1W (Fig. 32 on page 46) and slightly high signal on STIR, surrounded by two rings and an poorly defined outer zone with low signal on T1W and high signal on T2W and STIR, representing BMO. A sinus tract is seen extending through thickened cortical bone adjacent to the intraosseous abscess and enhancing on T1W (Fig. 33 on page 47). CT-guided puncture biopsy (Fig. 34 on page 48) confirmed acute osteomyelitis with abundant hyphae and spore.

**Diagnosis:** Brodie's abscess.

**Case 20:** 38-year-man.

Clinical background: HLA-B27-positive patient with ankylosing spondylitis. He had pain in both ankles, elbows and right knee, as well as inflammation in the right ankle that made it impossible for walk.

**MR interpretation clues:** Diffused BMO on calcaneus is hyperintense in STIR (Fig. 35 on page 49).

**Diagnosis:** Inflammatory arthritis.
*Case 21*: 23-year-man.

*Clinical background*: Probable traumatic pain in the right foot of a professional soccer player.

*MR interpretation clues*: On the first MR examination, BMO was seen on the fourth metatarsal head and the basal proximal phalange: it was hypointense in T1 (Fig. 36 on page 50) and hyperintense with hyperintense surrounding reactive soft-tissue oedema in STIR. Within a month, cortical destruction was evident, with extensive BMO seen as hypointense in T1 (Fig. 37 on page 51) and hyperintense in STIR throughout the fourth metatarsal respecting the base and the proximal third of the proximal phalange (Fig. 38 on page 52); these findings were confirmed on the play-film X-ray (Fig. 39 on page 53). Microscopic study after needle puncture and aspiration established *Pseudomonas aeruginosa*.

*Diagnosis*: **Septic arthritis.**

*Case 22*: 70-year-old woman.

*Clinical background*: Pain in the left forefoot. Suspected Morton’s neuroma.

*MR interpretation clues*: BMO is shown in STIR as a hyperintense area in a sesamoid bone lateral to the first metatarsal head with synovitis at the first metatarsophalangeal articulation (Fig. 40 on page 54).

*Diagnosis*: **Sesamoiditis.**

*Case 23*: 17-year-old man.

*Clinical background*: Chronic pain in the posterior ankle of an athlete.

*MR interpretation clues*: Hyperintensity on STIR denotes BMO across the synchondrosis at the lateral tubercle of the posterior talar process and os trigonum, with synovitis posterior to the talus and surrounding the os trigonum (Fig. 41 on page 55).
Diagnosis: **Os trigonum syndrome.**

**Case 24:** 57-year-old man.

Clinical background: Pain in the lateral part of a foot and bruising.

**MR interpretation clues:** Hyperintensity on STIR representing reactive BMO with a gigantic peroneal tubercle on the lateral aspect of the calcaneus which entraps the peroneus longus tendon (Fig. 42 on page 56).

Diagnosis: **Painful os peroneum syndrome.**

**Case 25:** 35-year-old woman.

Clinical background: Pain in the mid-foot and medial arch, especially with activity, accompanied by redness and swelling as well as extreme sensitivity to pressure over this bony prominence.

**MR interpretation clues:** Hyperintensity on STIR representing reactive BMO with an accessory navicular (os navicularum or os tibiale externum) (Fig. 43 on page 57).

Diagnosis: **Accessory navicular syndrome.**

OSTEOCHONDRAL LESION:

**Case 26:** 67-year-old woman.

Clinical background: Persistent pain in a foot with known degenerative arthropathy.

**MR interpretation clues:** Subchondral lesions with surrounding reactive BMO in the Lisfranc joint are hypointense on T1W (Fig. 44 on page 58) and hyperintense on STIR (Fig. 45 on page 59).

Diagnosis: **Degenerative osteochondral lesions.**
INFARCTION:

Case 27: 55-year-old woman.

Clinical background: Forefoot pain that increases with weight bearing.

MR interpretation clues: Low signal focal sclerosis with well-defined margins on the second metatarsal head surrounded by diffuse high signal BMO on STIR (Fig. 46 on page 60).

Diagnosis: Freiberg's infarction.

Case 28: 15-year-old girl.

Clinical background: Localized pain at the second metatarsal head.

MR interpretation clues: Flattening of the metatarsal head with a focal hypointense subchondral lesion on T1W and STIR, surrounded by BMO that is hypointense on T1W and hyperintense on STIR (Fig. 47 on page 61).

Diagnosis: Freiberg's infarction.

Case 29: 79-year-old woman.

Clinical background: Pain on weight bearing.

MR interpretation clues: Peripheral BMO is hyperintense on STIR (Fig. 48 on page 62) and hypointense on T1W; there is a subchondral ischemic focus in the tarsal navicular bone (Fig. 49 on page 63).

Diagnosis: Avascular Necrosis.
Case 30: 47-year-old woman.

Clinical background: Diffuse midfoot pain.

MR interpretation clues: Peripheral BMO is hyperintense on STIR (Fig. 50 on page 64) and hypointense on T1W; there is a subchondral ischemic focus in the second cuneiform bone (Fig. 51 on page 65).

Diagnosis: Avascular Necrosis.

Case 31: 34-year-old man.

Clinical background: Severe pain and disability.

MR interpretation clues: Low signal on T1W and high signal on STIR (Fig. 52 on page 66) representing BMO at the collapsed lateral part with osseous fragmentation by necrosis and dorsal migration of the medial portion of the tarsal navicular bone.

Diagnosis: Müller-Weiss syndrome.

NEOPLASIA:

Osseous Tumor:

Case 32: 38-year-old woman.

Clinical background: Longstanding recurring pain. No history of trauma. High serum alkaline phosphatase.

MR interpretation clues: Diffuse high signal on STIR (Fig. 53 on page 67) and low signal on T1 representing fibrovascular marrow in active Paget's disease practically throughout the calcaneus. Note the area of reactive BMO at the inferior articular facet of the talus. CT-guided biopsy (Fig. 54 on page 68) confirmed monostotic Paget's disease.
Diagnosis: **Paget's disease.**

**Case 33**: 66-year-old man.

Clinical background: Mild pain.

**MR interpretation clues**: Well-defined lytic lesion in the tarsal navicular bone with low signal intensity on T1W and high signal intensity on T2-W and STIR, with peripheral reactive BMO (Fig. 55 on page 69).

Diagnosis: **Intraosseous ganglion.**

Soft-tissue Tumor:

**Case 34**: 34-year-old man.

Clinical background: Patient with chronic renal insufficiency and primary hyperparathyroidism. Elevated serum uric acid.

**MR interpretation clues**: Well-defined, marginal erosion with overhanging edges and extensive reactive peripheral BMO at the head of the first metatarsal and basal proximal phalange of the hallux, surrounded by intermediate signal within the adjacent soft tissues on T1-W (Fig. 56 on page 70) and STIR (Fig. 57 on page 71). US-guided biopsy confirmed a tophus.

Diagnosis: **Gouty tophus.**

**Case 35**: 41-year-old man.

Clinical background: Painful palpable tumours in both ankles.

**MR interpretation clues**: Multiple marginal erosions with surrounded reactive BMO at the articular facets of the tibio-talar joint with an adjacent heterogeneous soft-tissue mass on T1-W (Fig. 58 on page 72) and STIR (Fig. 59 on page 73). Histological examination diagnosed pigmented villonodular synovitis.
Diagnosis: Pigmented villonodular synovitis.

COALITION:

Case 36: 24-year-old man.

Clinical background: Worsening foot pain and lack of endurance for activity.

MR interpretation clues: Low signal fibrous talocalcaneal coalition on STIR (Fig. 60 on page 74) with subchondral BMO in the calcaneus and talus, likely related to biomechanical stress associated with the coalition.

Diagnosis: Subtarsal coalition.

ALTERED BIOMECHANICS:

Case 37: 46-year-old woman.

Clinical background: Metatarsal pain in malpositioned toes.

MR interpretation clues: Focal high signal on STIR shows BMO at the 2\textsuperscript{nd}-4\textsuperscript{th} metatarsal heads (Fig. 61 on page 75).

Diagnosis: Mechanical overloading of the joints.

Case 38: 20-year-old man.

Clinical background: Limited movement of known left flatfoot.

MR interpretation clues: Patchy high signal in STIR reveals BMO at several tarsal bones (Fig. 62 on page 76).

Diagnosis: Overloading oedema by flatfoot.
**Fig. 1:** STRESS FRACTURE. Axial STIR image of the right foot shows hyperintense BMO (asterisk) with a line of low intensity in the proximal first metatarsal (arrow) reflecting the start of sclerosis or fracture repair.
Fig. 2: STRESS FRACTURE. Sagittal T1-weighted image of the right foot shows hypointense BMO (asterisk) with a line of low intensity in the proximal first metatarsal (arrow) in relation to the start of sclerosis or fracture repair.
**Fig. 3:** STRESS FRACTURE. Sagittal STIR image of the left ankle shows hyperintense BMO (asterisk) with a low intensity linear fracture in the posterior inferior surface of the body of the talus (arrow).
Fig. 4: STRESS FRACTURE. Sagittal T1-weighted image of the left ankle shows hypointense BMO with a low intensity linear fracture in the posterior inferior surface of the body of the talus (arrow).
**Fig. 5:** TRAUMATIC FRACTURE. Sagittal STIR image of the right foot shows extensive hyperintense BMO (asterisk) with a low intensity linear fracture linear in the posterior portion of the calcaneus (arrow).
Fig. 6: TRAUMATIC FRACTURE. Sagittal T1-weighted image of the right foot shows extensive hypointense BMO (asterisk) with a low intensity linear fracture in the posterior portion of the calcaneus (arrow).
**Fig. 7:** RUPTURE-AVULSION OF THE PLANTAR FASCIA. Sagittal STIR of the left foot shows hyperintense BMO on the avulsed plantar surface of the calcaneus (asterisk) with a gap of 5 mm between the thickened fascia distal to the region and the calcaneus (long arrow), accompanied by soft-tissue edema in the adjacent area (short arrow).
**Fig. 8:** BRUISED BONE. Sagittal STIR image of the right foot shows hyperintense BMO (asterisk) without evidence of a fracture line and with preserved adjacent cortical bone in the head of the talus.
**Fig. 9:** DISLOCATION. Sagittal STIR image of the left forefoot shows dorsal proximal phalangeal dislocation with hyperintense BMO (asterisk) in the second toe, with nearly complete discontinuity of the plantar plate at the distal insertion on the base of the proximal phalanx (arrow).
Fig. 10: PATHOLOGICAL FRACTURE. Sagittal T1-weighted image of the right foot demonstrates hypointense BMO (asterisk) at a displaced calcaneus fracture (black arrow) with avulsion of its posterior tuberosity (white arrow), secondary to osseous fragmentation by necrosis.
**Fig. 11:** SUDECK’S OSTEOPOROSIS (Complex Regional Pain Syndrome). Sagittal STIR image of the right foot shows hyperintense BMO (asterisks) in several tarsal bones without evidence of a linear fracture in the first examination.
**Fig. 12:** SUDECK’S OSTEOPOROSIS (Complex Regional Pain Syndrome). Axial STIR image of the right foot shows hyperintense BMO (asterisk) in the second metatarsal that did not appear the previous MR examination 5 months earlier.
**Fig. 13:** DEGENERATIVE ARTHROPATHY. Sagittal STIR image of the left foot shows hyperintense BMO (asterisk) on the subtalar articulation with irregular superficial and subchondral lesions in the superior articular facet of the calcaneus (arrow) and inferior facet of the talus, corresponding to osteochondral lesions in relation with degenerative arthropathy.
**Fig. 14:** DEGENERATIVE ARTHROPATHY. Coronal T1-weighted image of the left foot shows hypointense irregular superficial and subchondral lesions in the superior articular facet of the calcaneus and inferior facet of the talus (arrows), corresponding to osteochondral lesions in relation with degenerative arthropathy.
Fig. 15: PLANTAR FASCITIS (enthesopathy). Sagittal STIR image of the left foot shows a hyperintense area corresponding to inflammatory change with reactive subchondral BMO in the calcaneus (asterisk), accompanied by hyperintense thickening of the proximal plantar fascia (arrow), compatible with fasciitis (enthesopathy).
Fig. 16: ACHILLES ENTHESOPATHY. Sagittal STIR image of the left ankle shows thickening and hyperintense mucoid degeneration at the distal insertion of the Achilles tendon (arrow), accompanied by extensive retrocalcaneal reactive BMO (asterisk), compatible with Achilles enthesopathy.
Fig. 17: HAGLUND SYNDROME. Sagittal fat-suppressed T1-weighted image of the left ankle demonstrates hyperintense retrocalcaneal BMO (asterisk) with Haglund's deformity (arrow) and hyperintense thickening and longitudinal degeneration of the distal third of the Achilles tendon (short arrow).
Fig. 18: PROTEUS SYNDROME. Sagittal STIR image of the left foot shows a patchy hyperintense area (BMO) on several deformed tarsal bones (asterisks).
**Fig. 19:** PROTEUS SYNDROME. Sagittal CT of the left foot confirmed MR findings of intertarsal ankylosis, hyperostosis, and generalized degenerative arthropathy in the clinical context of Proteus syndrome.
Fig. 20: ACUTE OSTEOMYELITIS. Sagittal unenhanced T1-weighted image of the right foot shows patchy hypointense BMO on partially resected cuboid bones and navicular (asterisk) with adjacent soft-tissue collections in the stump (short arrow).
**Fig. 21:** FOCAL OSTEOMYELITIS/BONY INFLAMMATORY PROCESS. Sagittal contrast-enhanced T1-weighted image of the right foot shows enhancement of altered osseous parenchyma of the partially resected cuboid bones and navicular (asterisk) with enhancement of the adjacent soft-tissue collections in the stump (short arrow). These findings are compatible with acute osteomyelitis.
**Fig. 22:** FOCAL OSTEOMYELITIS/BONY INFLAMMATORY PROCESS. Sagittal STIR image of the right foot demonstrated a hyperintensity BMO on the calcaneus (asterisk), accompanied by hyperintense soft tissue corresponding to a skin ulcer on the posterior-medial margin of the heel. The ulcer directly communicates with the BMO through a plantar fistula (arrow). These findings are compatible with an inflammatory/infectious bone process.
**Fig. 23: DIABETIC FOOT.** Sagittal STIR image of the diabetic left foot shows patches of hyperintense BMO (asterisk) in the proximal metatarsal bones with marked involvement of the adjacent soft tissue (short arrows). Note extensive bone infarction in the calcaneus (long arrow). Retrotalar articular synovitis is also present (arrowheads).
Fig. 24: DIABETIC FOOT. Axial unenhanced T1-weighted image of the diabetic left foot shows hypointense BMO (asterisk) in the proximal metatarsal bones with marked involvement of the adjacent soft tissue (short arrows). Note extensive bone infarction in the calcaneus (long arrow).
**Fig. 25:** DIABETIC FOOT. Axial contrast-enhanced T1-weighted image of the diabetic left foot shows marked enhancement of the proximal metatarsal bones (asterisk) and the adjacent soft tissue (short arrows). Note extensive bone infarction in the calcaneus (long arrow).
**Fig. 26:** CHARCOT'S NEUROPATHIC ARTHROPATHY. Axial STIR image of the diabetic right foot shows diffuse hyperintense BMO involving the tarsal and metatarsal bones (asterisks). Note the cortical destruction in the anterior facet of the cuboids (arrow).
Fig. 27: CHARCOT'S NEUROPATHIC ARTHROPATHY. Axial unenhanced T1-weighted image of the diabetic right foot demonstrates diffuse hypointense BMO involving the tarsal and metatarsal bones (asterisks). Note the cortical destruction in the anterior facet of the cuboids (arrow) and basal facet of the 4th and 5th metatarsals.
Fig. 28: CHARCOT'S NEUROPATHIC ARTHROPATHY. Axial contrast-enhanced T1-weighted image of the diabetic right foot demonstrates diffuse hyperintense BMO involving the tarsal and metatarsal bones (asterisks). Note the cortical destruction in the anterior facet of the cuboids (arrow) and basal facet of the 4th and 5th metatarsals.
**Fig. 29:** CHARCOT’S NEUROPATHIC ARTHROPATHY. Axial X-ray image of the diabetic right foot shows osseous destruction with dislocation at the Lisfranc joint.
Fig. 30: CHRONIC MYELITIS or HYPEROSTOSIS. Sagittal STIR image of the right foot shows an irregular hyperintense area of BMO in the talus (asterisk), with a small subchondral cortical lesion (arrow).
**Fig. 31:** CHRONIC MYELITIS or HYPEROSTOSIS. Sagittal STIR image of the right foot shows an irregular hyperintense area of BMO in the talus (asterisk), with ill-defined sclerotic margins, thick fibro-osseous trabeculae, and cystic formations, which are more evident than in the previous examination.
**Fig. 32: BRODIE’S ABSCESS.** Coronal unenhanced T1-weighted image of the left foot shows a hypointense area in the proximal phalange of the hallux (asterisk), surrounded by two rings and a poorly defined outer zone. A sinus tract is seen extending through thickened cortical bone adjacent to the intraosseous abscess (arrow).
**Fig. 33:** BRODIE’S ABSCESS. Coronal contrast-enhanced T1-weighted image of the left foot shows an area of increased signal intensity in the proximal phalange of the hallux (asterisk) and also in the subcutaneous soft tissue (arrow).
**Fig. 34: BRODIE’S ABSCESS.** Coronal CT image of the proximal phalange of the hallux of the left foot shows a lytic lesion with fracture of adjacent cortical bone (short arrow) and peripheral increased density in the bone marrow (asterisk). Note the involvement of the subcutaneous soft tissue (arrow).
Fig. 35: INFLAMMATORY ARTHRITIS. Sagittal fat-suppressed T1-weighted image of the right foot shows diffused hyperintensity in the calcaneus (asterisks).
Fig. 36: SEPTIC ARTHRITIS. Axial unenhanced T1-weighted image of the right foot shows a small ill-defined hypointense area on the fourth metatarsal head and the basal proximal phalange (arrows).
Fig. 37: SEPTIC ARTHRITIS. Within a month, axial unenhanced T1-weighted image of the right foot shows an expanded ill-defined hypointense area on the fourth metatarsal head and the basal proximal phalange (arrows), with marked involvement of the surrounding soft tissue.
Fig. 38: SEPTIC ARTHRITIS. Axial enhanced T1-weighted image of the right foot shows an area of markedly increased signal intensity on the fourth metatarsal head and the basal proximal phalange (asterisks).
Fig. 39: SEPTIC ARTHRITIS. X-ray image of the right foot shows cortical destruction in the fourth metatarsal head and the basal proximal phalange (arrows).
**Fig. 40:** SESAMOIDITIS. Coronal STIR image of the left forefoot shows increased signal intensity in the lateral sesamoid bone of the first metatarsal head (asterisk). Note the synovitis at the metatarsophalangeal articulation (arrow).
Fig. 41: OS TRIGONUM SYNDROME. Sagittal STIR image of the left foot shows high signal BMO at the lateral tubercle of the posterior talar process (short arrow) and os trigonum (asterisk). Note the synovitis posterior to the talus and surrounding the os trigonum (long arrow).
**Fig. 42: PAINFUL OS PERONEUS SYNDROME.** Coronal fat-suppressed T1-weighted image of the right foot demonstrates giant calcaneal spur (white arrow) with reactive BMO at the lateral margin of the calcaneus (asterisk). Note the adjacent inflamed peroneus longus tendon (black arrow).
**Fig. 43:** ACCESORY NAVICULAR SYNDROME. Sagittal fat-suppressed T1-weighted image of the left foot shows marked hyperintensity in the accessory navicular (asterisk). Note the thickening of the posterior tibial tendon with surrounding fluid (arrow).
Fig. 44: DEGENERATIVE OSTEOCHONDRAL LESIONS. Sagittal T1-weighted image of the right foot shows several hypointense subchondral lesions at the Lisfranc joint (arrows).
Fig. 45: DEGENERATIVE OSTEOCHONDRAL LESIONS. Sagittal STIR image of the right foot shows several hyperintense subchondral lesions (arrows) with surrounding reactive BMO (asterisk) at the Lisfranc joint.
**Fig. 46:** FREIBERG'S INFARCTION. Axial STIR image of the left forefoot shows low signal intensity focal sclerosis with well-defined margins on the second metatarsal head (arrow) with diffuse surrounding high signal intensity BMO (asterisk).
**Fig. 47:** FREIBERG’S INFARCTION. Axial STIR image of the right forefoot shows flattening of the second metatarsal head with a focal hypointense subchondral lesion (arrow) with surrounding BMO that is hypointense on T1-weighted image and hyperintense on the STIR image (asterisk).
**Fig. 48:** AVASCULAR NECROSIS. Sagittal STIR image of the left foot shows an ill-defined, heterogeneously hyperintense area (asterisk) with irregular anterior cortical bone in the navicular bone (arrow).
**Fig. 49:** AVASCULAR NECROSIS. Sagittal T1-weighted image of the left foot shows a heterogeneously hypointense area with collapsed anterior cortical bone in the navicular bone (arrow).
**Fig. 50:** AVASCULAR NECROSIS. Axial STIR image of the left foot shows an heterogeneous area (arrow) with a marginally hyperintensive area BMO (asterisk) in the second cuneiform bone.
**Fig. 51:** AVASCULAR NECROSIS. Axial T1-weighted image of the left foot shows a nearly well-defined hypointense area (arrow) corresponding to an ischemic focus and a marginally hypointense area BMO (asterisk) in the second cuneiform bone.
Fig. 52: MÜLLER-WEISS SYNDROME. Axial STIR image of the left foot shows a hyperintense area with collapsed lateral part (asterisk) and osseous fragmentation by necrosis and dorsal migration of the medial portion of the tarsal navicular bone.
**Fig. 53:** PAGET'S DISEASE. Sagittal fat-suppressed T1-weighted image of the left foot shows diffuse and inhomogeneous high signal practically throughout the calcaneus (white asterisk). Note the area of reactive BMO at the inferior articular facet of the talus (black asterisk).
**Fig. 54:** PAGET'S DISEASE. Sagittal CT image of the left foot shows marked diffuse sclerosis in the calcaneus with nearly preserved cortical bone.
Fig. 55: INTRAOSSEOUS GANGLION. Axial STIR image of the left foot shows a well-defined lytic lesion (arrow) with some inner septa in the tarsal navicular bone with peripheral reactive BMO (asterisk).
**Fig. 56: GOUTY TOPHUS.** Axial T1-weighted image of the right forefoot shows a well-defined marginal erosion (long arrow) with hypointense peripheral reactive BMO in the head of the first metatarsal and basal proximal phalange of the hallux (asterisk), surrounded by intermediate signal within the adjacent soft tissues (short arrow).
**Fig. 57:** GOUTY TOPHUS. Axial STIR image of the right forefoot demonstrates hyperintense peripheral reactive BMO in the head of the first metatarsal and basal proximal phalange of the hallux (asterisk), surrounded by intermediate signal within the adjacent soft tissues (short arrow). Note the marginal erosion at the head of the first metatarsal (long arrow).
**Fig. 58:** PIGMENTED VILLONODULAR SYNOVITIS. Coronal T1-weighted image of the left ankle shows multiple marginal erosions (long arrow) with surrounding reactive BMO (asterisk) at the tibiotalar joint with an adjacent heterogeneous and low-signal intensity soft-tissue mass (short arrows).
Fig. 59: PIGMENTED VILLONODULAR SYNOVITIS. Sagittal STIR image of the left ankle shows multiple marginal erosions (long arrow) with surrounding reactive BMO (asterisk) at the tibiotalar joint with an adjacent heterogeneous and low-signal intensity soft-tissue mass (short arrow).
Fig. 60: SUBTARSAL COALITION. Coronal STIR image of the right ankle shows a low signal fibrous talocalcaneal coalition (arrow) with patchy hyperintense subchondral BMO in the calcaneus and talus (asterisks).
Fig. 61: MECHANICAL OVERLOADING OF THE JOINTS. Axial fat-suppressed T1-weighted image of the left forefoot shows focal high signal BMO in the 2nd-4th metatarsal heads (asterisks).
**Fig. 62:** OVERLOADING OEDEMA BY FLATFOOT. Sagittal STIR image of the right foot shows patchy high signal BMO in several tarsal bones (asterisk).
Conclusion

BMO is frequently observed on MRI of the foot. MRI is the best imaging technique for diagnosing and characterizing BMO in the foot, providing clues to the cause of the condition. A high index of clinical suspicion, careful physical examination, and detailed history are also essential to reach the proper diagnosis.

References


Personal Information