How far can bone marrow MR signal changes help in approaching the diagnosis of diabetic foot?

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Purpose

Aim of study is to distinguish osteomyelitis from reactive bone marrow edema, neuroarthropathy (NA) from osteomyelitis, and sterile from superinfected neuropathic joint.

Methods and Materials

Thirty seven diabetic patients with suspected foot infection were recruited to the study. MRI as a non invasive tool were used to evaluate for presence of bone marrow signal change, marrow oedema, distribution, deformity and soft tissue changes. Routin MRI examination is performed with the patient lying supine with the foot positioned in an extremity coil. The foot is normally placed in the neutral position but may be plantar flexed if there is concern regarding the tendons. Examinations may be limited to the forefoot, midfoot or hindfoot but whole foot study is recomended to assess the extent of involvement. Sagittal, transverse T1-weighted images pre and post intravenous gadolinium, and transverse fat-suppressed T2-weighted images were usually obtained with a small field of view, with thin sections to optimize spatial resolution. A minimum of two planes should be obtained. The axial images allow good depiction of the tendons and delineate the compartments well, whereas coronal and sagittal images are better suited to ulcer and sinus tract evaluation. T1 weighted sequences allow excellent depiction of both normal and abnormal anatomy, whereas the T2 fat-saturated and STIR sequence are better at demonstrating oedema and inflammatory change in the soft tissues and bone. Gadolinium was used in the contrast enhanced studies to improve the evaluation of soft tissue pathology as it helps to demonstrate abscesses and sinus tracts more easily. The use of contrast may also allow differentiation of viable from non-viable bone or soft tissue.

Results

MRI findings were: 25 osteomyelitis, 15 abscess, 13 sinus, 5 ulcer, 24 cellulitis, 7 joint effusion and 5 NA. Three patients have NA with superimposed osteomyelitis and 4 cases were normal. We discuss the specific bone marrow MR signal abnormalities and site of distribution.

Soft tissue and bone infection involving the foot is particularly common in patients with diabetes mellitus. In these patients, neuropathic osteoarthropathy often co-exists. Differentiating between these two entities is often difficult but early diagnosis of foot infection is important as it allows appropriate therapy such as antibiotics and surgical
debridement (1). All foot infections result from contiguous spread. Skin ulceration, secondary to diabetes, peripheral vascular disease, peripheral neuropathy, altered biomechanics, or trauma are particular risk factors (2).

Signs of infection; osteomyelitis of the foot results from spread of infection through the skin with soft tissue changes, including skin ulceration, cellulitis, soft tissue abscess or sinus tracts (figure 1). These features can be considered as secondary signs of osteomyelitis, and their presence can improve diagnostic accuracy. Bone marrow signal abnormalities without adjacent soft tissue change are unlikely to represent infection (3,4).

Identification of specific bone marrow signal changes can help in approaching the diagnosis. MRI based diagnosis of osteomyelitis depends on revealing hypointensity on T1-images and hyperintensity on T2-images (figure 2, 3). Here is the abnormal T1 signal loss of bone marrow is the more indicative of osteomyelitis because of the true infiltration of bone by infectious process (5,6). However the isolated T2 signal abnormalities suggest reactive bone marrow edema which may reflect hyperemia secondary to inflammation or infection in adjacent soft tissues (7) (figure 4, 5, 6) as well as can be due to non infective entities as recent post surgical changes, fractures and neuroarthropathy (8,9).

Neuropathic osteoarthropathy may present with one of two patterns on MRI, depending on the chronicity of the process. The characteristic findings of chronic neuropathic osteoarthropathy are fragmentation, joint deformity or subluxation, accompanied by altered bone marrow signal manifested by low signal intensity in the subchondral bone on both T1 and T2 weighted images (figure 7,8). In the acute form, alterations in bone marrow signal may be similar to osteomyelitis (i.e. low signal on T1 and high signal on T2 and STIR, with associated contrast enhancement). On the other hand infection may be seen as superimposition to neuropathic osteoarthropathy in the diabetic feet (figure 9,10,11).

Distinguishing osteomyelitis from NA other than bone signal changes in different sequences depend on distribution of the process. The location of the disease is an important factor in differentiating between infection and neuropathic osteoarthropathy. Osteomyelitis is usually seen in a solitary site either in the metatarsal heads, toes or calcaneus. In contrast, neuropathic osteoarthropathy occurs most frequently in the intertarsal and tarsometatarsal joints followed by the metatarsophalangeal joints of the forefoot. Involvement of the interphalangeal joints is uncommon (10).

Images for this section:
**Fig. 1:** MR T2 W image displaying osteomyelitis of the calcaneus with adjacent soft tissue abscess and sinus tract in the heel.
**Fig. 2:** Figure 2 & 3 Bone marrow edema of the tarsal bones due to osteomyelitis seen as signal loss at (Fig. 2) T1W and (Fig. 3) high signal at T2W images.
**Fig. 3:** Figure 2 & 3 Bone marrow edema of the tarsal bones due to osteomyelitis seen as signal loss at (Fig.2) T1W and (fig.3) high signal at T2W images
Fig. 4: Reactive bone marrow edema versus osteomyelitis. (Fig.4) Sagittal T1W, (fig.5)Sagittal T2W and (fig.6)post contrast T1W sagittal images. Changes due to osteomyelitis seen as T1 hypointensity and T2 hyperintensity in the phalanges of the second toe however there is an isolated T2 hyperintensity in the adjacent distal part of the second metatarsal bone which is consistent with reactive marrow edema.
**Fig. 5:** Reactive bone marrow edema versus osteomyelitis. (Fig.4) Sagittal T1W, (fig.5) Sagittal T2W and (fig.6) post contrast T1W sagittal images. Changes due to osteomyelitis seen as T1 hypointensity and T2 hyperintensity in the phalanges of the second toe however there is an isolated T2 hyperintensity in the adjacent distal part of the second metatarsal bone which is consistent with reactive marrow edema.
**Fig. 6:** Reactive bone marrow edema versus osteomyelitis. (Fig.4) Sagittal T1W, (fig.5) Sagittal T2W and (fig.6) post contrast T1W sagittal images. Changes due to osteomyelitis seen as T1 hypointensity and T2 hyperintensity in the phalanges of the second toe however there is an isolated T2 hyperintensity in the adjacent distal part of the second metatarsal bone which is consistent with reactive marrow edema.
Fig. 7: The characteristic findings of chronic neuropathic osteoarthropathy are fragmentation, joint deformity or subluxation, accompanied by altered bone marrow signal manifested by low signal intensity in the subchondral bone on both T1 (fig.7) and T2 (fig. 8) weighted images.
Fig. 8: The characteristic findings of chronic neuropathic osteoarthropathy are fragmentation, joint deformity or subluxation, accompanied by altered bone marrow signal manifested by low signal intensity in the subchondral bone on both T1 (fig. 7) and T2 (fig. 8) weighted images.
**Fig. 9:** Infection superimposed on neuropathic osteoarthropathy, alterations in bone marrow signal similar to osteomyelitis seen as low signal on T1 (fig. 9) and high signal on T2 and STIR (fig. 10), with associated contrast enhancement (fig. 11).
**Fig. 10:** Infection superimposed on neuropathic osteoarthropathy, alterations in bone marrow signal similar to osteomyelitis seen as low signal on T1 (fig. 9) and high signal on T2 and STIR (fig. 10), with associated contrast enhancement (fig. 11).
**Fig. 11:** Infection superimposed on neuropathic osteoarthropathy, alterations in bone marrow signal similar to osteomyelitis seen as low signal on T1 (fig. 9) and high signal on T2 and STIR (fig. 10), with associated contrast enhancement (fig. 11).
Conclusion

Abnormal bone marrow signal is the hallmark of diabetic foot. In approaching pattern of marrow abnormality and geographic distribution of pathology, MRI found to be accurate in detecting and depicting extent of infection and useful in planning proper treatment or surgery.

References


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