



Osteomyelitis and the Diabetic Foot

- Plain film x-ray should be the first imaging examination for suspected osteomyelitis in the diabetic foot
- If the initial x-ray is negative, the absence of osteomyelitis can be confirmed by repeat examination 2-4 weeks later
- MRI can be useful if x-ray images are equivocal or if there is concern for soft tissue infection
- If MRI is not possible, a ^{99m}Tc MDP triple phase bone scan can be used to distinguish an osseous from a soft tissue process but the exam is nonspecific for the diagnosis of infection

Diabetic foot infections are associated with significant morbidity, account for the largest number of diabetes-related hospital bed days and contribute to 50% of all lower extremity amputations in the United States. The annual incidence of foot ulcers in diabetic patients is about 2%, which, given that there are now 15-20 million diabetics nationally, extrapolates to over 300,000 cases per year. Approximately 15% of foot ulcers in diabetics will progress to osteomyelitis, which is much more difficult to treat than soft tissue infection and greatly increases the risk of amputation.

Patients who have soft tissue infections for more than two weeks are at high risk for osteomyelitis. Osteomyelitis should be considered in any patient with a deep or extensive ulcer, especially if it is chronic or occurs over a bony prominence. Osteomyelitis should also be suspected when an ulcer does not heal after ≥ 6 weeks of appropriate care and off-loading, if bone is visible, or can be palpated by a sterile blunt probe. Other symptoms suggestive of osteomyelitis in a diabetic include foot or toe swelling in a patient with a history of foot ulceration, unexplained high WBC count or other inflammatory markers, or hyperglycemia.

A definitive diagnosis of osteomyelitis is made with bone biopsy and subsequent examination by histology and microbiology. But this invasive procedure is not always advisable for patients with advanced vascular disease or Charcot arthropathy due to difficulty with healing and nonspecific inflammatory changes, respectively. Consequently, imaging is often used as an aid to diagnosis.



Figure 1. Radiographic image of a diabetic patient who previously underwent a transmetatarsal amputation shows lucency in the distal fifth metatarsal (arrow), suggestive of osteomyelitis.

Standard Plain Film Radiography

Radiographs are important for initial patient evaluation and are diagnostic when cortical bone abnormalities characteristic of osteomyelitis are seen, such as cortical erosion, periosteal reaction, and lucency or osteolysis. However, these abnormalities may not be apparent until

7-15 days after the onset of acute clinical osteomyelitis and the early subtle changes are not easily differentiated from those due to Charcot osteoarthropathy. Consequently, the sensitivity and specificity of initial x-ray examinations are low.

If an initial x-ray examination of a diabetic patient with suspected osteomyelitis is negative, a follow up examination should be performed 2-4 weeks later. If the imaging findings are unchanged, then it is likely that the infection is confined to soft tissue. A positive diagnosis of osteomyelitis can be made if the characteristic cortical abnormalities are seen. If the radiographic findings are equivocal, i.e. consistent with but not diagnostic of osteomyelitis, further imaging examinations can be considered.

Clinical Indications of Osteomyelitis	
Osteomyelitis should be considered if:	
-	Deep or extensive ulcer, especially if chronic or over bony prominence
Osteomyelitis should be suspected if:	
-	Unhealed ulcer after ≥ 6 weeks medical care and off-loading
-	Visible bone
-	Bone palpable with a probe
Other symptoms suggestive of osteomyelitis	
-	Foot or toe swelling with history of ulceration
-	Unexplained elevated WBC count or other markers of inflammation



Figure 2. MR images of same patient. A. T1-weighted image showing decreased bone marrow signal (arrows), due to edema consistent with osteomyelitis and B. T2-weighted image of the same patient showing increased signal from bone marrow (arrow), cutaneous ulcer (arrowhead), and a soft tissue collection (dashed arrow).

MRI

Of the alternate imaging examinations for osteomyelitis, MRI has been shown to be most useful because it can reliably detect primary bone marrow abnormalities and secondary abnormalities including cortical bone destruction, cellulitis, phlegmon, abscess, and sinus tracts. The primary findings of osteomyelitis are decreased signal on T1 weighted images, increased signal on T2 weighted images, and enhancement following contrast administration in the bone marrow. However, the indicators with the highest positive predictive value for osteomyelitis are the secondary findings of cortical bone interruption, cutaneous ulcer, and a sinus tract adjacent to areas of bone marrow signal abnormality. In the absence of these specific criteria, false positive diagnoses of osteomyelitis may occur due to similarity of the imaging findings of osteomyelitis to those of reactive bone marrow, neuropathic arthropathy or stress

reaction. These conditions are especially common in diabetics and can coexist with osteomyelitis, further complicating the ability to obtain an accurate diagnosis.

Range of Reported Sensitivity and Specificity of Imaging Methods for the Diagnosis of Osteomyelitis		
Imaging Exam	Sensitivity	Specificity
Plain film X-ray	60%(28-93)	66%(50-92)
^{99m} Tc three phase bone scan*	70-90%	38-79%
¹¹¹ In Oxyquinolone WBC scan	80-100%	70-90%
MRI *	88-99%	83%
*Highest and lowest values excluded		



Figure 3. Image of the same patient from third phase of ^{99m}Tc -MDP bone scan, showing increased uptake of radioactivity (arrow) in fifth metatarsal bone.

Nuclear Medicine Studies

If an MRI is not possible, nuclear medicine offers several alternatives. The most commonly used nuclear medicine examination is the three phase bone scan. This consists of a "perfusion" phase (obtained during injection of the tracer), which shows hyperemia, an "equilibrium" phase (obtained about one minute after injection of tracer), which shows soft tissue abnormalities, and a "delayed" phase (obtained about 2-3 hours after injection), which is specific for bone abnormalities. Acute osteomyelitis typically appears as abnormalities on all three phases of the scan while soft tissue infections without bone involvement (e.g. cellulitis without osteomyelitis) will appear abnormal on the first two phases. Degenerative and other chronic bone changes will appear as abnormalities only on the third phase.

Although very sensitive for osteomyelitis, the three phase scan loses specificity in the setting of recent trauma or surgery since either of these will mimic osteomyelitis. In addition, Charcot foot also displays abnormalities in all three phases of the bone scan and can be confused with osteomyelitis. The two conditions can sometimes be differentiated by the more generalized joint involvement in Charcot's neuropathy and by the clinical scenario.

An alternative nuclear imaging technique is the ^{111}In -labeled white blood cell scan. Although this examination is sensitive to the presence of infection, image resolution is poor and often fails to distinguish whether the infection is in bone, soft tissue, or both. A combined approach using labeled white blood cells and a standard bone scan of the area of concern demonstrates similar imaging sensitivity and specificity to MRI; however, this usually requires two visits by the patient, one for injection and a second visit, 24 hours later, for imaging.

Scheduling

Radiology examinations may be ordered through ROE (<http://mghroe/>) or by telephone 617-724-XRAY (9729) for all locations. Radiography is performed at the MGH Main Campus, Mass General West Imaging Waltham, MGH Charlestown Health Center, MGH Chelsea Health Center, and MGH Revere Health Center. MRI is performed Mass General West Imaging - Waltham, Mass General Imaging - Charlestown, and Mass General Imaging - Chelsea. Nuclear imaging is performed at the MGH Main Campus and Mass General West Imaging Waltham.

Further Information

For further questions, please contact [Kevin Hoover, M.D., Ph.D.](#), Musculoskeletal Radiology, 617-724-4255.

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