IMAGING OF THE INFECTED FOOT

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Imaging of the infected foot may pose an interesting dilemma in the clinical office setting. Where clinical symptomatology is indeterminate, scintigraphy and other imaging modalities are often the next adjunctive procedures performed either before or in conjunction with incision and drainage or bone biopsy. However, practical application of these studies and varying sensitivities and specificities cast uncertainty on their usefulness.

In the presence of the infected foot with the classic signs of inflammation, the differential diagnosis broadly includes: soft tissue infection, bone/joint infection, neuroarthropathy, postoperative/fracture scenario, and rheumatologic/neoplastic disorders. Plain films are often obtained but are limited by a ten to fourteen day delay for evidence of pathology due to the osseous resorption necessary. Their usefulness may be augmented by special views specific to the case or soft tissue enhancement studies as seen with xeroradiographs or mammography film. The radionuclide studies Technetium-99 MDP, Gallium citrate-67 and Indium-111 are all limited by wide ranges of sensitivities and specificities.

Technetium-99

Technetium-99 serves as a metabolic marker binding to hydroxyapatite within the collagen lattice network and will be positive whenever bone is affected by any circumstance. Spatial resolution is marginal. Technetium scanning consists of four phases with the first two serving practically as evaluators of vascularity. The third phase, 3-5 hours post injection is labeled the bone phase and in comparison with the recent fourth phase is touted to have increased specificity for osteomyelitis. An integer count of the region of interest is of value. The literature states that increases between the third and fourth phase of greater than one whole number is consistent with bone infection. Decreases in the integer count by greater than one whole number reportedly rules out osteomyelitis and any change within +1 and -1 is indeterminate. Our clinical experience has shown this to be unreliable. Cases of negative bone biopsies for osteomyelitis when a bone scan was read as consistent with bone infection by the radiologist are not uncommon. This is particularly true in the postoperative and Charcot deformity states.

Infectious Disease consultants recommended proximal amputation on the patient in Figures 1 and 2 based on a bone scan with an integer count increase of greater than one between the

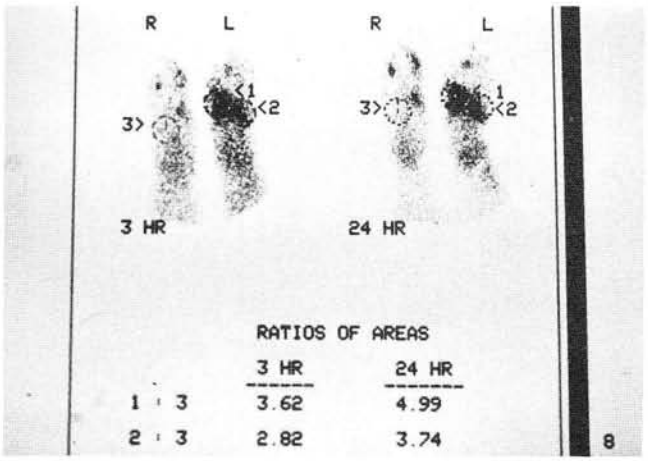

Fig. 1. Extremely positive bone scan in diabetic patient with draining plantar ulceration.

Fig. 2. Abnormal signal intensity on MRI in midfoot region of same patient. Medical management personnel recommended proximal amputation.

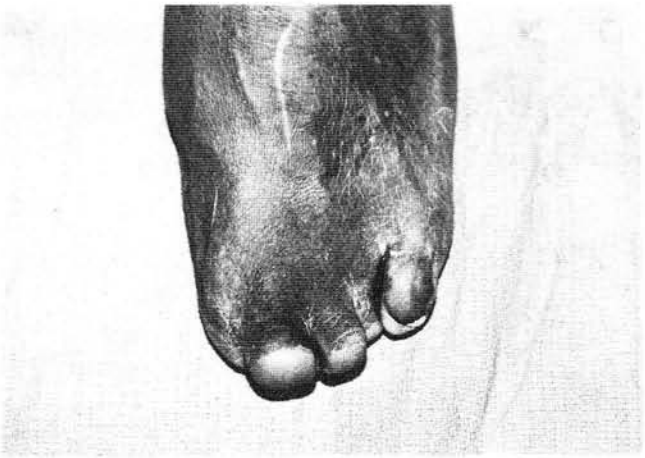

Fig. 3. Patient two years postop after bone biopsies were negative for osteomyelitis.

third and fourth phases and an abnormal MRI. Figure 3 shows the same patient two years after negative bone biopsies with a functional lower extremity.

Gallium

Gallium, an iron analog, relies on binding to plasma proteins but suffers from poor spatial relation in the foot and ankle and specificity as well. Sequential technetium and gallium scanning has seen use in differentiating soft tissue from bone infection but suffers from low specificity as well.

Indium-111

When clinical symptomatology mandates ruling out bone infection, Indium-111 was thought to be the optimal study for imaging soft tissue with increased sensitivity and specificity due to labeling white blood cells directly. However, the labeling of leukocytes needed for this modality can be a cumbersome and an impractical process in the local hospital or office setting. Blood must be drawn and usually sent elsewhere for labeling before scanning can be completed adding to the length of the study. Furthermore, research indicates, if white blood cells are outside the body for greater than three hours their viability is sharply decreased. McAfee empathetically states there is "no agent worse than dead labeled leukocytes for imaging these foci." Recent reports of the false positives for Indium-111 interestingly parallel a general differential diagnosis for the bone infection in question. (Table 1) The false negatives for Indium-111 are similarly clinical signs commonly seen in the podiatric practice consistent with the diabetic foot and peripheral vascular disease. (Table 2) Clearly, isolated Indium scanning is not the answer to the diagnosis of osteomyelitis.

TABLE 1

INDIUM-111

FALSE POSITIVES

- Aseptic soft tissue/bone inflammation
- Hyperemia/hypervascularity (without inflammation)
- Inflammatory arthritis
- Adjacent cellulitis
- Neuroma

TABLE 2

INDIUM-111

FALSE NEGATIVES

- Tissue necrosis
- Poor blood supply

Computed Tomography Scanning (CT-Scans)

Computed tomography scanning (CT-Scans) offers cross-sectional and multiplanar imaging but has limited applicability in pedal infections with the advent of magnetic resonance.

Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is unmatched in providing detailed anatomic information. It utilizes non-ionizing magnetic field and radio waves instead and offers imaging in all planes as well. Expense and availability may limit its usage in some settings. Research is promising in attempts to delineate postoperative/fracture healing from the intramedullary changes of osteomyelitis on MRI. This is especially pertinent when a postoperative infection presents and osseous procedures were performed.

The questionably infected foot is certainly a diagnostic dilemma. Scanning of some type is usually undertaken to rule out the worst possible scenario of acute bone infection. Our most common differential diagnosis for acute osteomyelitis includes, again, soft tissue infection, postoperative/fracture states, diabetic charcot disease and acute inflammatory changes. The multiple imaging techniques provide varied information concerning each of these. (Tables 3, 4 and 5) Magnetic resonance imaging has proven to be the most accurate in all cases due to its ability to differentiate subtle bone marrow changes and fluid collections from surrounding soft tissue pathology. If one is attempting to diagnose acute osteomyelitis, postoperative and fracture states in general are poor indications for scanning due to obvious active bone involvement. Bone scans ordered in this context will undoubtedly be

TABLE 3

SOFT TISSUE

Tc-99	(+) Phase 3 indicative of osteo (-) Phase 3 excludes osteo
Ga-67	Diffuse uptake - soft tissue "Focal" uptake - osteo
In-111	Difficult to differentiate (+) Tc-99

** MRI definitive for soft tissue vs. bone marrow

TABLE 4

POSTSURGICAL/FRACTURES

Tc-99	- Osseous - identical presentation - Soft tissue procedures
Ga-67	- "No help"
In-111	- questionable advantage
MRI	- Subtle bone marrow changes

TABLE 5

DIABETIC NEUROARTHROPATHY

Tc-99	- "Static vs.dynamic" - High false positives
Ga-67	- In conjunction with Tc-99
In-111	- With or without Tc-99 - Accuracy?
MRI	- "Fluid collections same" FUTURE?

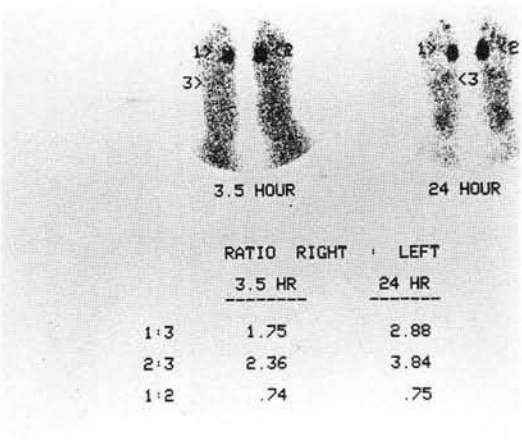

Fig. 4. As expected, bone scan status post bilateral bunionectomies to rule out osteomyelitis is intensely hot.

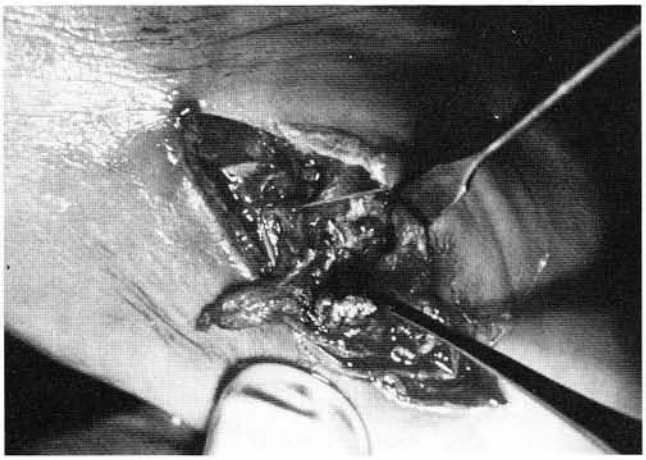

Fig. 5. Incision and drainage of this suspected postop infection with positive radionuclide studies revealed an acute gout attack.

extremely hot and indeterminate. (Fig. 4) Charcot foot deformity or diabetic neuroarthropathy in the patient with plantar ulcerations presents probably the biggest challenge diagnostically. The hyperemia of the Charcot and diabetic state and the osseous changes secondary to infection and neuropathy account for the wide ranges of sensitivities and specificities of most imaging modalities. Recent work with MRI in detecting Charcot changes from those of bone infection is promising but unrefined presently.

Magnetic resonance imaging appears to be the most accurate noninvasive, nonoperative modality for the diagnosis of osseous infection. In light of the many clinical presentations that can lead to positive scanning and the lack of specificity of these studies, surgical bone biopsy remains the gold standard for the definitive diagnosis of osteomyelitis. (Fig. 5) Gupta states succinctly in Seminars in Nuclear Medicine, 1988, "none of the imaging procedures are entirely specific for osteomyelitis."

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