The Utility of Sulfur Colloid Imaging to Differentiate Charcot's Neuroarthropathy from Osteomyelitis

A Case Study

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Charcot's neuroarthropathy and osteomyelitis can have similar initial presentations. The ability to differentiate between the two pathologic conditions is essential, as each requires different treatment. We present a case of a 53-year-old woman with pain, swelling, and warmth in her left first metatarsophalangeal joint and first tarsometatarsal joint. Radiographs showed comminuted fractures at the base of the first metatarsal. Osteomyelitis was suspected by the primary team based on physical findings and a history of previous first metatarsophalangeal joint arthrodesis. A triphasic bone scan and an indium white blood cell scan were positive for osteomyelitis. The podiatric medical team was suspicious for possible Charcot's neuroarthropathy based on physical findings and uncontrolled blood glucose levels at the time of her previous arthrodesis. A sulfur colloid scan was performed and compared with an indium scan, which showed no evidence of osteomyelitis. This case demonstrates the usefulness of sulfur colloid imaging compared with an indium white blood cell scan to differentiate osteomyelitis from Charcot's neuroarthropathy. This case also highlights the importance of using clinical judgment to make the correct diagnosis. (J Am Podiatr Med Assoc 114(2), 2024; doi:10.7547/21-235)

The initial clinical presentations of Charcot's neuroarthropathy and osteomyelitis can be similar, leading to difficulty in making the correct diagnosis. It has long been thought that a bone biopsy is the gold standard for diagnosing osteomyelitis. However, in a study published in 2011, Meyr et al[1] noted significant disagreement among four pathologists who were asked to confirm the presence of osteomyelitis in 39 bone biopsy specimens. There was noted to be significant disagreement among pathologists in 16 of the 39 bone biopsy specimens (41%).[1] Other things to consider when performing a bone biopsy are its invasive nature, false-negatives that can be obtained when the patient is taking antibiotics, and culture contamination.

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Imaging studies are a less invasive way of differentiating osteomyelitis from Charcot's neuroarthropathy. Magnetic resonance imaging (MRI) does have usefulness in identifying and ruling out osteomyelitis. Pugmire et al[2] quoted Lee et al[3 (p 191)] in their review article that "MRI has very high sensitivity for the detection of osteomyelitis; a normal MRI virtually excludes osteomyelitis." A triphasic bone scan may be used to confirm a diagnosis of osteomyelitis; however, Palestro and colleagues[4] recommend this be used only in the absence of complicating patient factors. A combined technetium and indium white blood cell scan can also be used for identifying the presence of osteomyelitis. The advantage to this scan compared with the triphasic bone scan is an increase in sensitivity and specificity. Schauwecker[5] found the sensitivity and specificity of a triphasic bone scan to be 95% and 33%, respectively, compared with an indium white blood cell scan at 88% and 85%, respectively. The significant disadvantage to this scan is that indium experiences uptake in noninfected acute fracture sites, as seen in Charcot's neuroarthropathy.[6]

The use of a sulfur colloid scan combined with an indium white blood cell scan has proved to increase

the specificity in differentiating osteomyelitis from Charcot's neuroarthropathy.[4,6] Sulfur colloid provides an accurate map of the body's active bone marrow, hence it can be taken up only in healthy red marrow. If bone marrow is suppressed or infected, the sulfur colloid will not experience uptake and the scan is considered "cold."[7] The most important concept in sulfur colloid imaging is the idea of spatial congruency. Uptake of both the indium and sulfur colloid in bone demonstrates spatial congruency. Because sulfur colloid can experience uptake only in healthy marrow, a spatially congruent scan is considered negative for osteomyelitis. In contrast, spatial incongruency can be described as bone that localizes the indium but not the sulfur colloid.[7] In this case, both scans can be considered positive for osteomyelitis. This case study demonstrates use of the indium white blood cell scan compared with the sulfur colloid scan and shows how the concept of spatial congruency was used to make the correct diagnosis and to select the correct surgical procedure.

Case Study

A 53-year-old woman presented to the emergency department with nausea, vomiting, and abdominal pain. During her history and physical examination, she admitted to a left first metatarsophalangeal arthrodesis at an outside facility approximately 3 months previously. Of note, the patient had a pertinent medical history of uncontrolled type 2 diabetes mellitus with peripheral neuropathy, fibromyalgia, congestive heart failure, hypertension, myocardial infarction, and depression.

Three days into her hospital admission she started complaining of pain in her left foot, specifically in the area of her first metatarsophalangeal joint and along the base of the first metatarsal. Her primary team ordered radiographs of the left foot, which showed a comminuted fracture at the base of the first metatarsal along with hardware from her first metatarsophalangeal joint arthrodesis (Fig. 1).

The primary team was concerned for possible osteomyelitis due to the patient's complaint of pain along with edema and calor noted to the left foot. A triphasic bone scan of the left foot was ordered and showed an increase in uptake at the first metatarsophalangeal joint on the blood flow, blood pool, and delayed image phases (Fig. 2). The results were read as suspicious for osteomyelitis of the first metatarsophalangeal joint at the site of her hardware.



Figure 1. Comminuted fracture of the base of the first metatarsal, along with hardware from a previous first metatarsophalangeal joint arthrodesis.

The primary team then ordered a combined technetium-99m methyl diphosphonate (MDP)–indium 111 white blood cell scan and consulted podiatric medicine. Before podiatric medicine's initial evaluation of the patient, the technetium-99m MDP–indium 111 white blood cell scan results showed acute osteomyelitis involving the distal first metatarsal and the first metatarsophalangeal joint at the site of the hardware (Fig. 3).

Physical examination demonstrated edema to the left foot, as well as pain to palpation along the first ray. An increase in temperature to the left foot was also noted compared with the contralateral side. All of the pedal pulses were readily palpable, and there was noted diminished sensation via light touch to

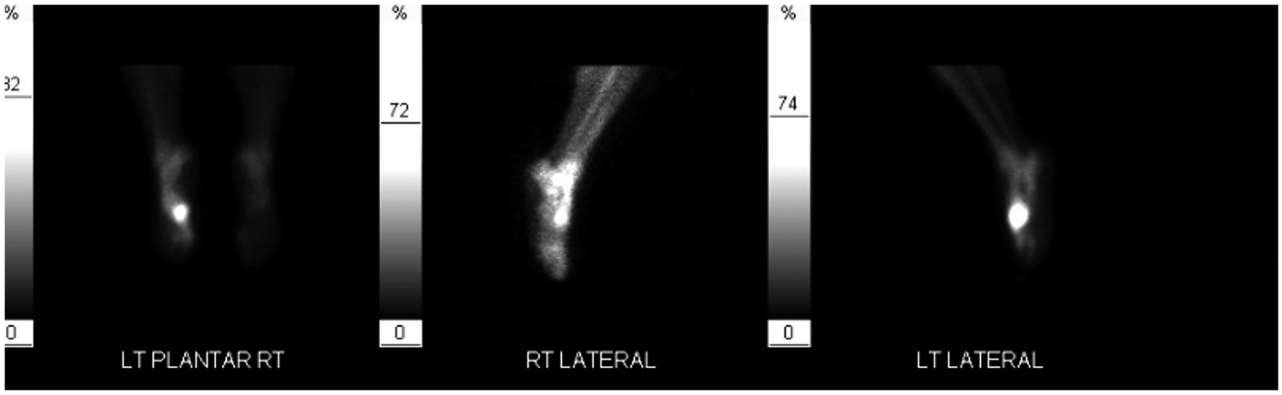


Figure 2. Increased uptake at the first metatarsophalangeal joint on blood flow (left), blood pool (center), and delayed (right) images. These findings are suspicious for osteomyelitis.

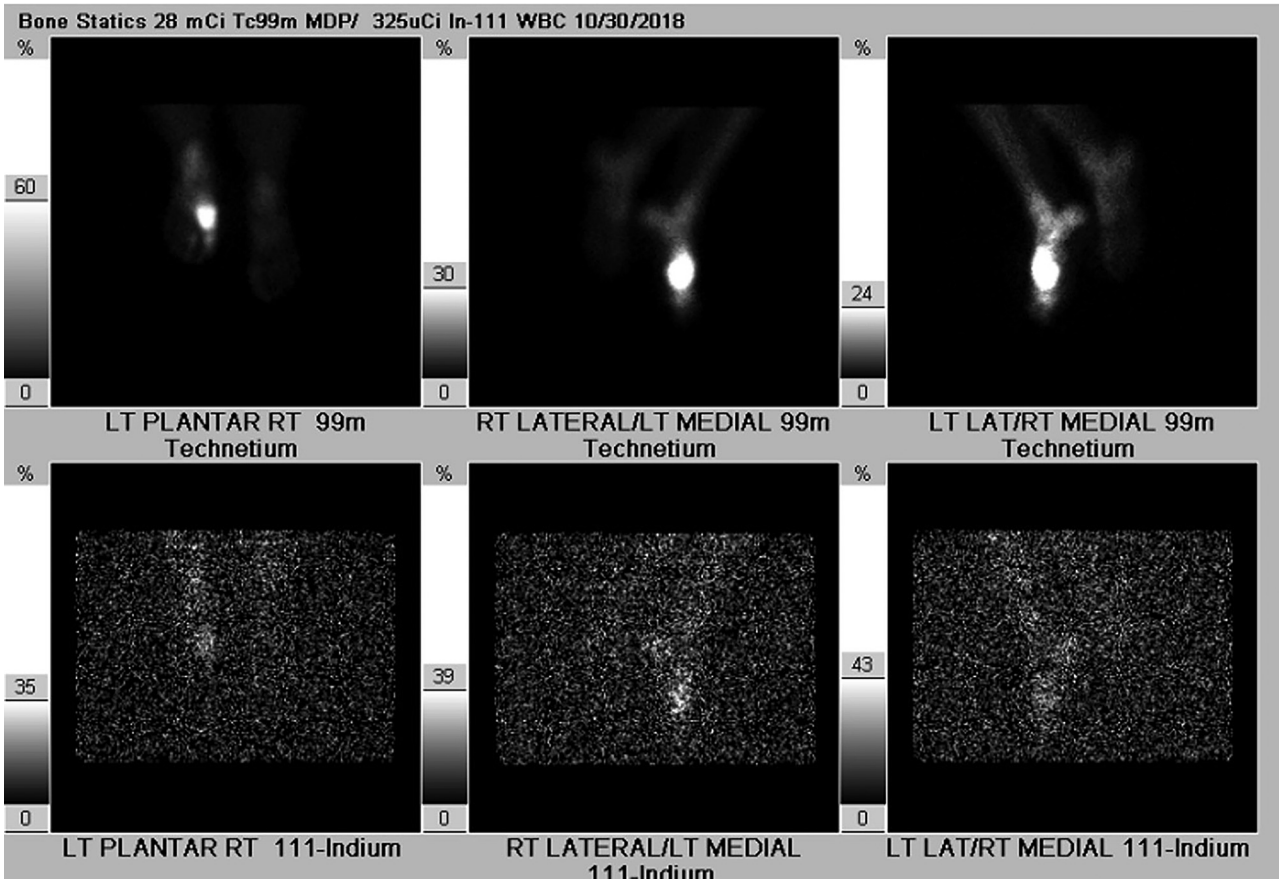


Figure 3. Technetium-99m methyl diphosphonate–indium 111 white blood cell scan. Top, Technetium-99m scan shows increased uptake in bone during all three phases. Bottom, Indium 111 scan shows similar increased radiotracer uptake in the same area as the technetium-99m scan. This further increases the suspicion for osteomyelitis.

all of the dermal levels distal to the ankle. Based on these findings as well as an elevated hemoglobin A_{1c} level of nearly 9.0% at the time of the patient's initial first metatarsophalangeal joint arthrodesis, Charcot's neuroarthropathy was strongly suspected.

The podiatric medical team discussed further imaging with nuclear medicine, who recommended a sulfur colloid scan. The sulfur colloid scan showed similar skeletal uptake at the first metatarsal and the first metatarsophalangeal joint compared with

the technetium-99m MDP–indium 111 white blood cell scan (Fig. 4). Based on the principle of spatial congruency, this was read as no evidence of osteomyelitis.

After ensuring tight glucose control and a hemoglobin A_{1c} level of 7.0%, a left first metatarsal–cuneiform arthrodesis was performed along with a bone biopsy. This created a type of mini–super construct along the first ray. The patient's last follow-up was approximately 1 year after surgery. Her follow-up appointment showed excellent consolidation of the first metatarsal–cuneiform joint, with no current signs of progressing Charcot's deformity and no clinical signs of infection.

Discussion

It can be difficult to differentiate between osteomyelitis and acute Charcot's neuroarthropathy. Comparison between an indium white blood cell scan and a sulfur colloid scan can help differentiate between the two conditions and assist in making an accurate diagnosis. The idea of spatial congruency is the key concept when comparing the two studies. If both the indium white blood cell and the sulfur colloid are taken up by the bone, the images are said to be spatially congruent and osteomyelitis can be ruled out. In this case, both the indium white blood cell and sulfur colloid experienced uptake in the first metatarsal and the first metatarsophalangeal joint. According to Palestro et al,[4] the accuracy of both scans used in comparison for diagnosis of osteomyelitis has been reported to be as high as 88% to 98%. In another study, Palestro and colleagues[6] found the accuracy of the combined imaging technique to be 95% regarding the diagnosis of osteomyelitis in the presence of Charcot's neuroarthropathy. Using the concept of spatial congruency in this case study, osteomyelitis was ruled out and Charcot's neuroarthropathy was confirmed. Not only was the correct diagnosis made, but the correct surgical procedure was selected. This led to a successful outcome of a first metatarsal–cuneiform arthrodesis with no signs of progressing Charcot's deformity (Fig. 5). This case is similar to that of Short and Zgonis,[8] who had a patient with Charcot's neuroarthropathy with concern for osteomyelitis. In their case, a triphasic bone scan showed uptake in the blood pool phase suspicious for osteomyelitis. However, a combined white blood cell scan and

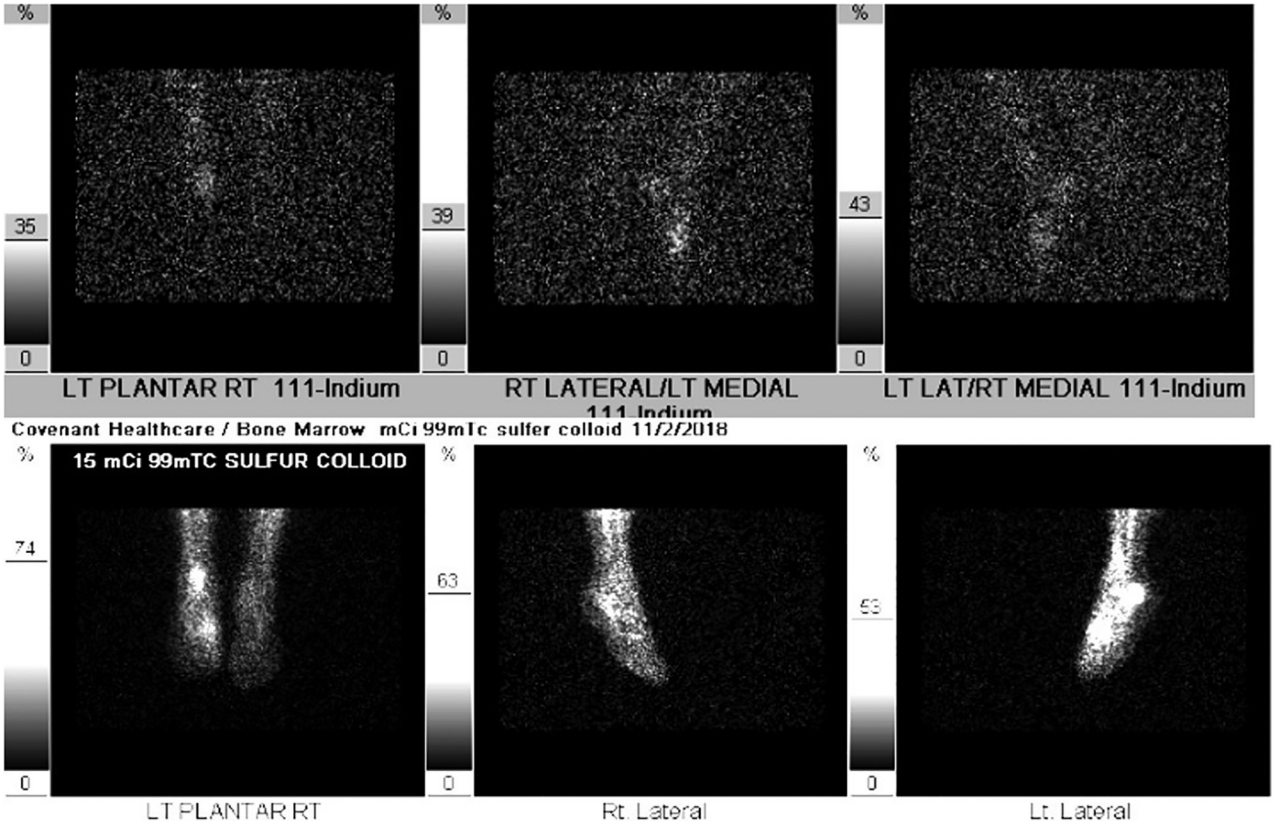


Figure 4. Spatial congruence of indium 111 scan (top) compared with sulfur colloid scan (bottom). Both images show similar radiotracer uptake in the same anatomical area, which is the definition of spatial congruence.

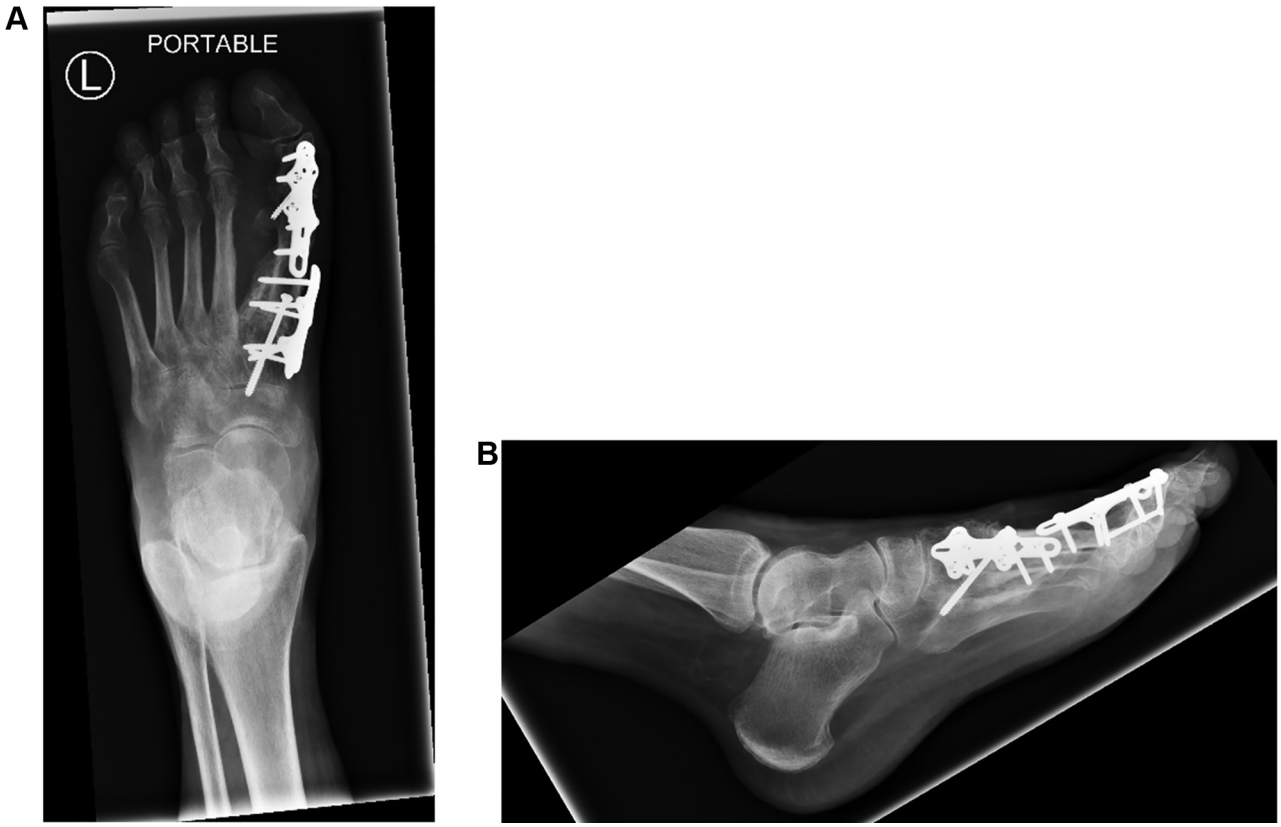


Figure 5. Anteroposterior (A) and lateral (B) views of the left foot showing the final result of a first metatarsal–cuneiform arthrodesis with no signs of progressing Charcot's deformity.

sulfur colloid scan demonstrated spatial congruence, and osteomyelitis was ruled out. This was further proved with an intraoperative bone biopsy and histopathologic analysis.[8]

Conclusions

The intent of this case study was to highlight the importance of using a sulfur colloid scan combined with an indium white blood cell scan to confirm clinical suspicion of Charcot's neuroarthropathy and choose the proper surgical procedure. This case also serves as a reminder of how critical clinical judgment is in making both the correct diagnosis and selecting the correct surgical procedure. With recent studies questioning the accuracy of the bone biopsy technique, future use of sulfur colloid scans to diagnose osteomyelitis in the setting of Charcot's neuroarthropathy may prove beneficial.

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References

1. Meyr A, Singh S, Zhang X, et al: Statistical reliability of bone biopsy for the diagnosis of diabetic foot osteomyelitis. J Foot Ankle Surg **50:** 663, 2011.
2. Pugmire BS, Shailam R, Gee MS: Role of MRI in the diagnosis and treatment of osteomyelitis in pediatric patients. World J Radiol **6:** 530, 2014.
3. Lee YJ, Sadigh S, et al: The imaging of osteomyelitis. Quant Imaging Med Surg **6:** 191, 2016.
4. Palestro CJ, Love C, Tronco GG, et al: Combined labeled leukocyte and technetium 99m sulfur colloid bone marrow imaging for diagnosing musculoskeletal infection. Radiographics **26:** 859, 2006.
5. Schauwecker DS: The scintigraphic diagnosis of osteomyelitis. AJR Am J Roentgenol **158:** 9, 1992.
6. Palestro CJ, Mehta HH, Patel M, et al: Marrow versus infection in the Charcot joint: indium-111 leukocyte and technetium-99mm sulfur colloid scintigraphy. J Nucl Med **39:** 346, 1998.
7. Baccei BJ, Raghavan M, Smith SE: Imaging techniques for evaluation of the painful joint. UpToDate Web site. Available at: https://www.uptodate.com/contents/imaging-techniques-for-evaluation-of-the-painful-joint. Accessed February 13, 2020.
8. Short DJ, Zgonis T: Medical imaging in differentiating the diabetic Charcot foot from osteomyelitis. Clin Podiatr Med Surg **34:** 9, 2017.