Imaging of Nerve Entrapment in the Foot and Ankle

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KEYWORDS

• Nerve entrapment • Foot • Ankle • Imaging

Neuropathies can be a cause of chronic foot and ankle pain. The diagnosis can be elusive given the sometimes nonspecific clinical presentation. Although electrodiagnostic studies are primarily relied on for the diagnosis of nerve impairment, imaging is sometimes helpful in helping define the exact site of the entrapment and whether any masses are present. It is critical for the imager to understand the complex anatomy of these nerves and their adjacent structures, to know the most common locations for their entrapments or injury, and to select the proper imaging modality to improve detection of these difficult-to-diagnose clinical conditions.

Cross-sectional imaging of the peripheral nerves of the foot and ankle is primarily accomplished with ultrasound (US) and magnetic resonance imaging (MRI). Interpretation and performance of these studies can be challenging because of the small caliber of these nerves as well as their variable courses. However, improvements in imaging technologies for both US and MRI have increased diagnostic confidence in the imaging of peripheral nerves in the extremities. Specifically, the availability of high-frequency linear US transducers in ranges of 10 MHz and greater, as well as the development of improved MRI coils and the use of 3 Tesla (T) magnets with their increased signal/noise ratios, have made a large difference in small body part imaging.

The selection of either modality depends on the training and confidence of the imager with each, but, in many cases, they are complementary and it behooves the imager to become confident and adept at both modalities. MRI is unsurpassed in the breadth of the spectrum it can provide by imaging not only the soft tissues but also the osseous components. US is limited to the soft tissues and dependent on the operator's knowledge of anatomy and technical expertise with the transducer. In addition, its spatial resolution can be as much as an order of magnitude greater than MRI with currently available imaging coils.

MRI of the foot and ankle can directly visualize small nerves if careful attention is given to technique for increasing spatial resolution. The use of an increased number of excitations (NEX) or higher field magnets, such as 3 T systems, and dedicated

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foot and ankle phased array MRI coils, increases available signal and allows for larger matrix sizes and decreased pixel size, with consequent decrease in volume averaging.[1] Entrapped nerves show characteristic findings, including increased T2 signal, loss of fascicular pattern, diffuse enlargement, as well as focal swelling.[2–5]

MRI denervation changes in the muscles (increased muscle signal or edema on T2 initially, followed by fatty infiltration and volume loss, best seen on T1 images, with more chronicity of denervation) enervated by a specific nerve, are a sensitive indirect finding of nerve impairment (**Figs. 1** and **2**). This finding of initially increased T2 signal is considered to be secondary to enlargement of the intramuscular capillary bed, which leads to an increase in intramuscular blood volume and extracellular fluid.[6] The anatomic pattern of muscle edema distribution should be specific to those supplied by the affected nerve.

However, in the foot, this may not be as useful, because most of the distal nerves in the foot are predominantly sensory. Also, muscle edema on MRI has an extensive differential diagnosis, including infection, inflammatory myositis, and sequelae of trauma. Because distal nerve branching variations are common in the feet, attempting to determine specific patterns of nerve involvement by distribution of muscle denervation patterns may also prove difficult. Distinguishing small sensory nerves from adjacent vessels can also be difficult with non–contrast-enhanced MRI.[7]

Compared with standard 1.5-T MRI with commercially available receiver coils used most frequently in routine clinical practice, US has improved spatial resolution, allowing for greater detail of the nerve fascicles.[8] Focal swelling of the nerve can be easily detected, and, given the nature of US, direct visualization of the nerve with correlation with symptoms, and with overlying transducer pressure, is helpful in identifying the sites of abnormality. Superficial nerves can be followed easily in cross section through their courses through the ankle and foot by using high-resolution linear transducers, preferably with frequencies greater than 10 MHz (**Fig. 3**), which is in contrast with MRI: the fixed prescribed imaging planes in MRI lead to artifacts of some of these small nerves as they traverse in and out of the imaging plane. However, visualization with US can sometimes be difficult in the plantar aspect of the foot because the nerves dive deep into the plantar intrinsic foot muscles, or if the patient has marked keratosis of the soles of the foot.[7]

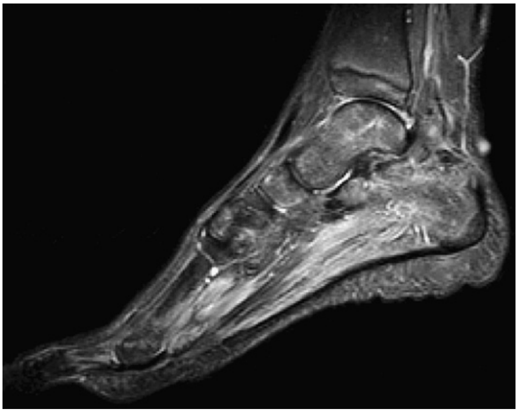

Fig. 1. Sagittal T2-weighted image of the foot in a 12-year-old patient who underwent prior resection of a synovial sarcoma with secondary posterior tibial nerve dysfunction. There is increased T2 signal in the intrinsic plantar muscles of the foot from denervation (muscle edema).