High-Resolution Magnetic Resonance Imaging of the Lower Extremity Nerves

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KEYWORDS

• MRI • Nerves • Lower extremity • Neurography

KEY POINTS

- Magnetic resonance (MR) imaging of the peripheral nerves is accomplished by using a combination of pulse sequences allowing detection of changes in both nerve signal and architecture.
- Characteristic MR imaging findings allow differentiation of neuropathic conditions related to entrapment, trauma, iatrogenic injury, extrinsic mass effect, and tumors/tumorlike lesions of the nerves.
- In the setting of suspected neuropathy, MR imaging findings complement clinical evaluation and electrodiagnostic testing, facilitating accurate and timely diagnosis, and promoting appropriate management.

INTRODUCTION

Magnetic resonance (MR) imaging of the nerves, also known as MR neurography (MRN), is increasingly being used as a noninvasive means of diagnosing peripheral nerve disease. Patients often present with vague symptoms, including poorly defined pain and possible functional impairment, producing a complex clinical picture. In the past, patients with perceived neurologic symptoms were referred for electromyography (EMG); however, MR imaging is increasingly being selected over other imaging modalities because of its superior soft tissue contrast, its capacity to identify and describe neural injuries, and its ability to demonstrate additional causes of nerve impairment, as well as secondary findings, such as muscle edema or denervation.[1] MR imaging using high-resolution 2-dimensional (2D) fast spin-echo (FSE) techniques combined with fluid-sensitive sequences in the plane perpendicular to the long axis of the peripheral nerve can reveal traumatic or iatrogenic injuries, entrapment, inflammation, and tumorlike lesions affecting the nerves of the lower limb. Although the treatment for peripheral neuropathies varies based on the type of injury, region, and underlying disease, early diagnosis is essential to restore normal sensory and motor function. Studies have demonstrated that MRN findings can significantly influence the clinical management of patients with lower limb neuropathies, helping to determine which causes would benefit from surgical intervention.[1–3] This article focuses on MRN of the lower limb, discussing the imaging techniques, normal anatomy, and pathologic conditions affecting the major nerves in the hip, thigh, knee, ankle, and foot.

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NORMAL ANATOMY AND IMAGING TECHNIQUE

General Imaging Technique

Imaging of the peripheral nerves is best performed at 1.5 or 3.0 T field strengths, with the type of coil used, the imaging planes acquired, and the scan parameters determined by the body part being imaged. Complete evaluation requires the ability to detect alterations in both nerve signal and morphology; therefore, some combination of pulse sequences providing high-resolution morphologic depiction and sensitive detection of mobile water is necessary. At the authors' institution, general extremity imaging consists of 3-plane intermediate 2D moderate echo time FSE images plus fluid-sensitive imaging (short tau inversion recovery [STIR] or T2 with fat saturation) obtained in a single plane optimal to the structure being imaged. When specifically evaluating peripheral nerves, this general protocol is augmented by the addition of axial STIR images oriented perpendicular to the long axis of the nerve in question (**Fig. 1**). Additional oblique coronal and sagittal images may further disclose the long axis of the nerve and the transition at points of compression. The standard matrix in the frequency direction is 512 with a phase matrix of 320 to 384. Although the field of view varies based on the body part being scanned, off-set images of the affected limb are preferred to minimize pixel size and maximize in plane resolution. Thin slices without an interslice gap further improve through plane resolution.

Other authors have described dedicated neurographic imaging protocols using sequences specifically tailored to the evaluation of peripheral nerves. Chhabra and colleagues[4] advocate a protocol based on a combination of T2 and diffusion-weighted imaging (DWI) neurographic sequences, which includes T1 FSE, T2 adiabatic inversion recovery (IR), proton density (PD), 3-dimensional (3D) IR, and 3D diffusion-weighted reversed fast imaging with steady state precession (DW-PSIF) hybrid pulse sequences; the addition of 3D sequences with isotropic voxel sets allows multiplanar reformation, whereas the addition of hybrid DWI provides nerve-selective images with suppression of adjacent vascular structures.[3–5] The administration of an intravenous gadolinium-based contrast agent is rarely warranted outside of the setting of suspected enhancing soft tissue mass lesion.

More advanced imaging techniques include diffusion tensor imaging (DTI), a technique which exploits the anisotropic properties of axonal fiber

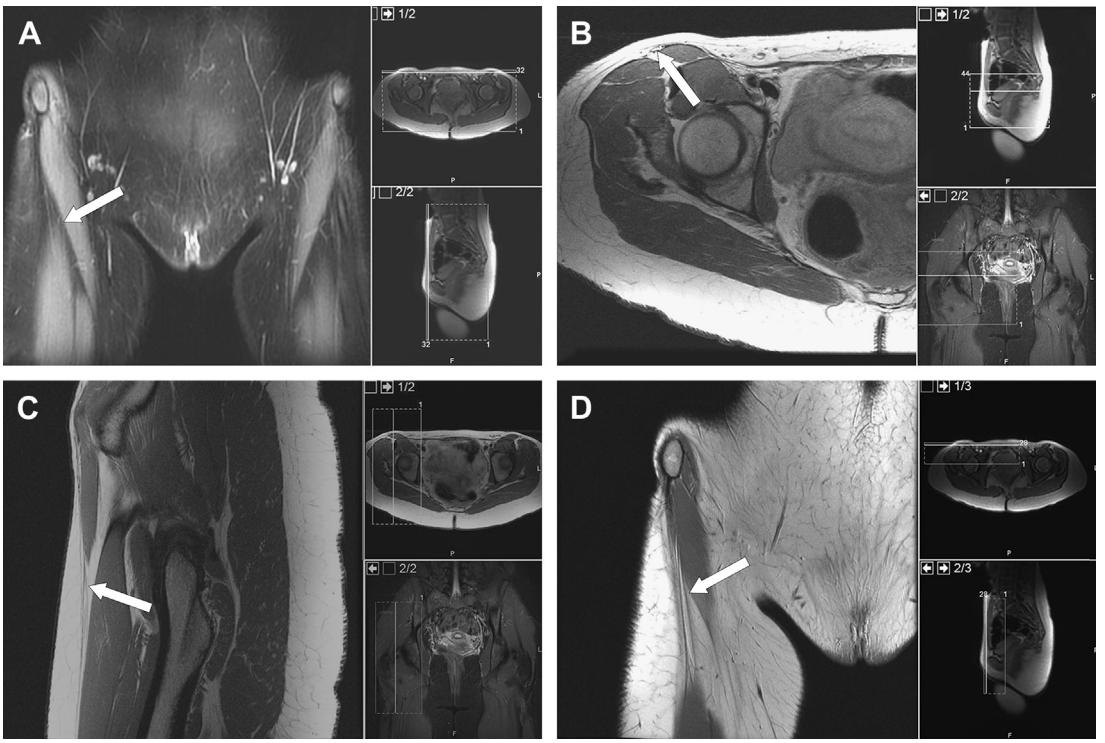

Fig. 1. Imaging planes for the lateral femoral cutaneous nerve (*white arrows*). (*A*) Coronal STIR. (*B*) Axial FSE PD. (*C*) Sagittal FSE PD. (*D*) Thin coronal FSE PD.