Focus on Advanced Magnetic Resonance Techniques in Clinical Practice

Magnetic Resonance Neurography

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KEYWORDS

• MR imaging • Neurography • Upper extremity • Lower extremity

KEY POINTS

- Magnetic resonance neurography (MRN) provides the greatest degree of soft tissue contrast in the evaluation of peripheral nerves.
- Utilization of MRN relies on (1) peripheral nerve anatomy, (2) the spectrum of pathology, and (3) familiarity with dedicated MR imaging techniques.
- Although there remain several pitfalls in MRN imaging, awareness of these pitfalls improves imaging quality and limits misinterpretation.

INTRODUCTION

There has been significant development in the field of MRN imaging techniques since its initial description in rabbit forelimbs.[1] Expansion of this technique for human use occurred in 1993, and, to date, its utility is ever expanding.[2]

The strength of MRN rests on that in comparison with any other imaging technique, it provides the greatest degree of soft tissue contrast in the evaluation of peripheral nerves. As such, it allows for optimal evaluation of peripheral nerve morphology and alterations in nerve caliber and signal as well as location-specific detection of nerve compression due to anatomic variations or space-occupying lesions. Additionally, MRN provides exceptional assessment of regional muscle and nerve anatomy, which allows for elucidation of systemic versus local pathology. Furthermore, MRN provides radiologists with the ability to generate high-resolution, 3-D images, which have proved useful for preoperative assessment and planning.

Utilization of MRN in the evaluation of the peripheral nervous system relies on 3 facets of knowledge: (1) peripheral nerve anatomy, (2) the spectrum of pathology, and (3) familiarity with dedicated MR imaging techniques.[3]

PERIPHERAL NERVE ANATOMY

Evaluation of the peripheral nervous system through MRN allows for visualization of sub–5-mm peripheral nerves.[4] The nerves are typically symmetric in size bilaterally, gradually decrease in caliber from proximal to distal, and are similar in size relative to their adjacent arteries. In addition, delineation of peripheral nerves from adjacent vessels is essential for accurate image interpretation. Peripheral nerves generally follow a straight course, do not branch, and should not exhibit flow voids. Familiarity with the basic structure of the nerve unit is also essential for image interpretation, where an individual nerve is often likened to an insulated cable: nerves are comprised of multiple axons, which are grouped together into fascicles. At the deepest level, each axon is surrounded by endoneurium, whereas individual

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fascicles are surrounded by perineurium and groups of fascicles are surrounded by epineurium.

Understanding this compartmentalization of the nerve unit is important for imaging because it allows for detection of nerve pathology. Similar to the brain, fluid bathing each axon and fascicle allows for optimal transmission of electrical impulses and accounts for approximately 70% of peripheral nerve water content.[5,6] The flow of this fluid is regulated by the endoneurium and perineurium, which act together to form a functional, relatively impermeable barrier known as the blood-nerve interface (BNI).

Similar to the blood-brain barrier, the ability of the BNI to regulate the endoneurial microenvironment protects the peripheral nervous system. Like the brain, the endoneurial space lacks a lymphatic system and is regulated according to hydrostatic pressure mechanisms. In this way, how hydrostatic pressure within the endoneurial fluid increases after trauma can be understood, and, therefore, these changes in the microenvironment through MR imaging can be identified.

NERVE INJURY: PATHOPHYSIOLOGY AND CLASSIFICATION

Technical Considerations

The magnet

Performing MRN at 3T is preferable compared with 1.5T due to the improved signal-to-noise ratio (SNR), which allows for thinner slices, greater contrast, and overall better spatial resolution. Furthermore, there is also less magnetic field inhomogeneity at 3T, which provides for better, more uniform fat suppression and thus greater conspicuity of fluid signal. Additionally, utilization of specialized phased-array surface coils in conjunction with parallel imaging techniques allows for faster acquisition time. An exception to this general rule includes the performance of MRN in patients with metallic implants and hardware located in the field of view (FOV), where imaging at 1.5T is preferable.

Although SNR is optimized through the use of high-field, 3T imaging, the use of a 3-D acquisition is preferable to a 2-D acquisition. This is in part due to generation of a data set, which is derived from isotropic voxels, thereby allowing for high-resolution 3-D reconstructions in any desired plane. Furthermore, compared with a 2-D acquisition, a 3-D acquisition lacks interslice gaps and limits cross-talk between slices, which can further decrease SNR.[7]

Magnetic resonance protocol

Field of view Determination of the FOV relies on the physician request and the nerve being evaluated. Ideally, the FOV should be kept as small as possible to maintain high-resolution images (**Fig. 1**). Ideally, patients should also receive correlative electrodiagnostic testing prior to MRN to further narrow the anatomic location of interest.

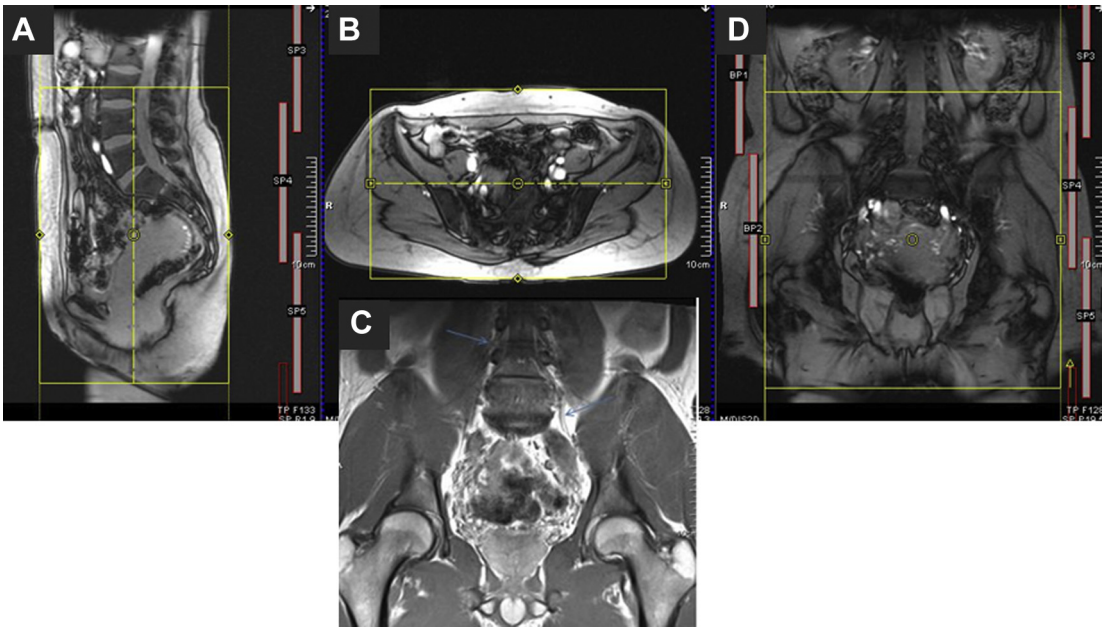

Fig. 1. FOV. Imaging planes for the lumbosacral plexus. (*A*) Sagittal STIR. (*B*) Transaxial fast spin-echo proton density. (*C*) Coronal T1, thin section (4 mm). Superior arrow points to right L3 nerve root. (*D*) Thin coronal fast spin-echo proton density.