Seminars in ULTRASOUND CT and MRI

Spinal Cord in Multiple Sclerosis: Magnetic Resonance Imaging Features and Differential Diagnosis

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Multiple sclerosis (MS) is an idiopathic inflammatory disorder of the central nervous system that affects not only the brain but also the spinal cord. In the diagnostic and monitoring process of MS, spinal cord magnetic resonance imaging (MRI) is not performed as commonly as brain MRI, mainly because of certain technical difficulties and the increase in total acquisition time. Nonetheless, spinal cord MRI findings are important to establish a prompt accurate diagnosis of MS, impart prognostic information, and provide valuable data for monitoring the disease course in certain cases. In this article, we discuss the technical aspects of spinal cord MRI, the typical MRI features of the spinal cord in MS, the clinical indications for this examination, and the differential diagnosis with other disorders that may produce similar clinical or MRI findings.
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Introduction

Multiple sclerosis (MS) is a progressive inflammatory, demyelinating, and neurodegenerative autoimmune disease of the central nervous system (CNS) characterized pathologically by perivascular infiltrates of mononuclear inflammatory cells, demyelination, axonal loss, and gliosis with formation of focal and diffuse abnormalities. The optic nerves, brainstem, spinal cord, and cerebellar and periventricular white matter regions are most commonly affected, although cortical and subcortical gray matter damage is also prominent. MS leads to chronic progressive disability in most individuals with this condition.[1]

MS affects more than 2.5 million people worldwide. The onset usually occurs between the age of 20 and 40 years, and women are affected 3-fold more often than men. MS is the leading cause of nontraumatic disability in young adults at the peak of their productive life, involved in building their career, social status, and family.[2] As a consequence, it is associated with a tremendous loss of health-related quality of life, work productivity, and employment, not only of the patients but also of their caregivers.

The high sensitivity of magnetic resonance imaging (MRI) in depicting brain and spinal cord demyelinating plaques has made this technique the most important paraclinical tool in current use for diagnosing MS, understanding the natural history of the disease, and monitoring and predicting the efficacy of disease-modifying treatments. Spinal cord MRI is not performed as commonly as brain MRI in MS, mainly because of certain technical difficulties and the increase in total acquisition time, but the spinal cord findings can be of value for establishing an early and accurate diagnosis of the disease, imparting prognostic information, and in some cases, providing valuable data for monitoring treatment response.

Spinal Cord MRI: Technical Features and Recommended Protocol

Imaging the spinal cord can be more difficult than imaging of the brain in MS patients. The spinal cord is a small, mobile structure and acquisition of high-quality magnetic resonance (MR) images is challenging. The evaluation is further complicated by the common presence of ghosting (breathing, vessel, and cerebrospinal fluid [CSF] pulsations) and truncation artifacts,[3] which can lead to false-negative and false-positive

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interpretations. Several technical improvements minimize these difficulties, such as spatial presaturation slabs and fast imaging sequences, which, when combined with spinal phased-array coils, allow rapid imaging of the whole spinal cord within clinically acceptable acquisition times (Fig. 1). The strategy of using conventional spin-echo sequences with cardiac gating reduces flow-related ghosting, but increases the acquisition time and risk of motion artifacts. Spinal cord MR imaging should be obtained at a minimum field strength of 1.5 T, and contrary to what has been observed in brain imaging, the use of 3T confers no additional value.[4] Selection of an appropriate T2-weighted sequence is essential to obtain diagnostic images. For sagittal imaging, which allows coverage of a large area, but is prone to partial volume and CSF pulsation artifacts, conventional or fast dual-echo (proton density-weighted and T2-weighted, acquired in combination or independently) spin-echo sequences with a spatial resolution of at least $3 \times 1 \times 1$ mm^3 should be considered the reference standard. Adequate selection of the first echo time is crucial to render the normal spinal cord isointense to CSF. This facilitates

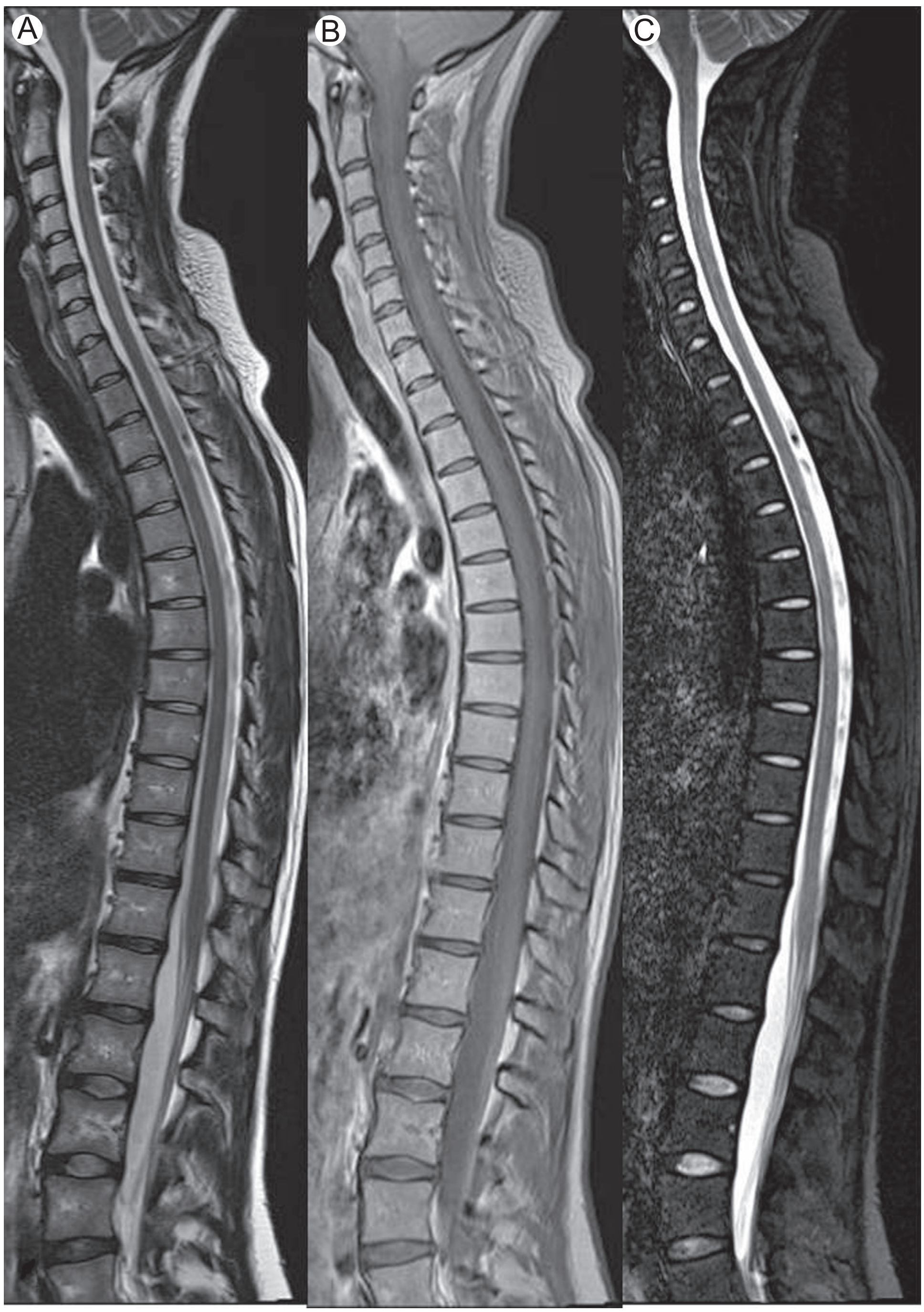

Figure 1 Whole spinal cord MRI in a normal individual. The combination of phased-array coils and fast imaging sequences allows complete coverage of the spinal cord in acceptable acquisition times. (A) T2-weighted sequence, (B) proton density-weighted sequence, and (C) short-tau inversion recovery (STIR) sequence.