Spinal Cord MRI in Multiple Sclerosis

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KEYWORDS

• Spinal cord • MRI • Multiple sclerosis • Clinical usefulness • Prediction
• Quantitative techniques

KEY POINTS

- The spinal cord (SC) is an important structure to image for clinical and research purposes in MS.
- Conventional MRI techniques are useful in detecting lesions in the SC, and a variety of sequences can be used for this purpose.
- Conventional MRI techniques have diagnostic and prognostic usefulness in the clinical management of patients with MS, clinically isolated syndrome, and radiologically isolated syndrome.
- A number of advanced, quantitative SC measures have demonstrated usefulness in investigational settings.
- Among quantitative SC MRI measures, SC atrophy and magnetization transfer imaging have been most extensively studied; with further validation, these quantitative techniques may become useful clinically.

INTRODUCTION

The last few decades have seen extraordinary advances in the field of multiple sclerosis (MS), with notable developments in neuroimaging. The increased availability of MRI and continuous advances in MRI techniques have enabled earlier diagnosis of MS and the routine use of MRI in clinical practice to monitor MS disease activity. Moreover, advanced MRI techniques have been an important contributor to our evolving understanding of the complex inflammatory and neurodegenerative processes involved in MS disease mechanisms.

Although the brain has long been the focus of MRI use in clinical practice and research in MS, in recent years, the importance of assessing the spinal cord (SC) has become apparent. This article outlines the usefulness of assessing the SC using

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both conventional and advanced MRI techniques as a promising tool with clinical diagnostic and predictive usefulness, to gain insight into MS disease pathogenesis, and as a potential outcome measure in clinical trial settings.

SPINAL CORD MRI IN MULTIPLE SCLEROSIS: CONSIDERATIONS

The SC is a compact tubular structure with tightly packed and highly organized functional columns of gray and white matter. Its small size and precise organization of motor and sensory tracts make the SC an ideal target to study the structural and functional impact of the pathology of MS.

Imaging the SC using MRI can be challenging owing to significant technical limitations. The SC is susceptible to artifacts from partial volume averaging owing to the surrounding cerebrospinal fluid (CSF), bone, and epidural fat. In addition, owing to the proximity of the SC to other vital organs in the thoracic cavity, motion-induced artifacts resulting from respiration, heartbeat, CSF flow, and swallowing can contribute to diminished signal-to-noise ratio.[1]

Efforts have been made in the last decade to optimize the signal-to-noise ratio, thus improving image quality and minimizing unwanted interference. Improved coil technology, higher field strengths, image acquisition with cardiac and respiratory "gating," as well as newer sequences that better delineate intrinsic SC anatomy and MS lesions, are among the technical developments that have led to improved detection of demyelinating and degenerative changes in the SC.

CONVENTIONAL SPINAL CORD MRI: LESION DETECTION

T2-Weighted Sequences for Spinal Cord Lesion Detection

T2-weighted sequences of the SC are relatively sensitive in detecting MS-related disease activity. In the brain, MRI has been shown to identify new lesions up to 10 times more frequently than clinical relapses occur.[2–5] T2-hyperintense lesions on MRI, however, are not specific for acute demyelination and can represent a variety of heterogeneous histopathologic changes.[6–9]

Initially, focal T2-hyperintense lesions in the brain and SC were visualized on sagittal dual spin echo sequences.[10] The advent of fluid attenuated inversion recovery (FLAIR) sequences, which are T2-weighted images with CSF suppression and consequent reduction in CSF-related artifacts, led to improved sensitivity in detecting MS lesions in the brain.[11,12] Unfortunately, FLAIR sequences in the SC were found to be insensitive at detecting MS lesions.[13,14] Further technical advances led to the development of fast spin echo (FSE) sequences with improved resolution and signal-to-noise ratio in comparison with FLAIR and dual spin echo sequences.[15,16] The increased sensitivity and shorter acquisition time of FSE in comparison with FLAIR and dual spin echo sequences, respectively, has made this sequence the current reference standard to image SC lesions in MS (**Fig. 1**).[13,15–18]

Additional MRI Sequences for Spinal Cord Lesion Detection

Several modified T1- and T2-weighted sequences have been evaluated as complementary additions to standard T2-weighted FSE sequences with the goal of improving SC lesion detection. Short tau inversion recovery (STIR) is a fat suppression technique that has demonstrated usefulness in detecting SC lesions in MS.[15,19] Several studies have compared cervical SC imaging with STIR and FSE, and observed improved signal-to-noise ratio and increased sensitivity to SC lesions with STIR over FSE sequences.[15,20–22] In contrast, contradictory results were observed in a few studies, where an increase in signal artifact, lower image quality, and more interobserver