Spinal Cord Imaging in MS
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Highlights
- Current MRI methods for assessing spinal cord health in MS
- Challenges (and solutions) facing advanced MRI methods
- Assembling a toolbox of quantitative MR methods to characterize the spinal cord in MS

Target Audience
The target audience is the neuroimaging research scientist who wants to learn about basic and advanced MRI methods that can be applied to the spinal cord in health and disease. The goal is to develop an understanding of the challenges facing MRI of the spinal cord, strategies to overcome these limitations and ultimate to provide quantitative MRI tools that can assess spinal cord MS pathology in, potentially, a more specific manner. We will provide an overview of multiple methods and how they relate to MS rather than an in-depth look at one single method.

Spinal Cord MRI. What's the big deal?
From a practical standpoint, the big deal of spinal cord MRI is actually the small deal. The cervical spinal cord is on the order of 10 times smaller than the brain (~1.5cm), is surrounded by bones and soft tissue, and is constantly moving due to respiration, and cardiac pulsation. Therefore, even straightforward analyses such as motion correction, when applied to the spinal cord need to be rethought in some cases. However, the spinal cord has been implied in a number of diseases and it is hypothesized that a significant fraction of day-to-day neurological impairment in MS may be derived from lesions in the spinal cord. Therefore, it is important to develop tools that can assess the spinal cord in health and disease to gain a greater understanding of disease processes, and to monitor treatment efficacy.

Clinical, diagnostic MRI of the spinal cord has significantly improved over the past two decades and can provide information about the presence and evolution of MS with little difficulty. Yet, correlation studies relating aspects of spinal cord health to neurological impairment has resulted in inconsistent agreement (perhaps depending on patient populations, treatment routine, comorbidities, etc). Recently, many groups have focused on developing spinal cord MRI strategies, which may provide quantitative biomarkers for more specific aspects of the MS pathology, such as Magnetization Transfer, Diffusion Tensor Imaging, and quantitative relaxometry. However, in general, quantitative MRI methods require high SNR, long acquisition times, and resistance to motion. In spite of the apparent discordance between the requirements for quantitative MRI of the SC (high SNR, insensitivity to motion), and the challenges in spinal cord MRI (small structure, moves all the time), a great deal of headway has been made recently.

We will explore these advancements to provide a glimpse into what quantitative MRI can provide a student of spinal cord MRI as it pertains to MS.

Overview
This lecture will cover aspects of the following:
- Spinal Cord Anatomy and Morphology
- Diagnostic MRI of MS in the spinal cord
- Correlations studies relating anatomical findings to neurological dysfunction
- Transition from anatomical MRI to quantitative MRI
- Sensitivity vs. Specificity
- Examples – Quantitative MRI in the spinal cord of patients with MS

What will we learn?
Listeners will develop an understanding of the tools that may be available to study the spinal cord in vivo and hopefully will gain a greater intuition for the pro's and cons of each method, including but not limited to, sensitivity, specificity, ease of application, and readiness for clinical studies.

In particular, they will be able to:
- Discuss methods to characterize spinal cord damage in MS
- Discuss alternative strategies for SC MRI: DTI, MTR, etc
- Understand the challenges of SC MRI
- Be able to outline potential solutions to challenges of SC MRI
- Philosophically, what can SC MRI offer for understanding, studying, following, or monitoring MS as a central nervous system disease?