

SESSION Advanced Neuroimaging 1: Brain & Spinal Cord

TITLE Spinal Cord Imaging: Diffusion & Ultra-High Field

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HIGHLIGHTS

- Diffusion tensor imaging and tractography in the spinal cord
- Acquisition and preprocessing strategies to reduce susceptibility distortions
- Clinical applications of ultra-high field (7T) spinal cord MRI

TARGET AUDIENCE – Clinicians, radiologists, researchers interested in the spinal cord.

LEARNING OBJECTIVES – (i) Know the theoretical basis for diffusion MRI; (ii) Learn step-by-step methods to perform spinal cord diffusion MRI experiments, (iii) Discuss clinical benefits of ultra-high field (7T) MRI of the spinal cord.

PURPOSE – The goal in using quantitative MRI techniques such as diffusion imaging are to obtain biomarkers of spinal pathways integrity in order to improve the diagnosis/prognosis in spinal pathologies as well as in understanding various aspects of the spinal cord within the central nervous system. However, spinal cord diffusion MRI is challenging due to: (i) the small cross-sectional size of the cord, which requires small voxel and therefore imposing low signal-to-noise ratio, (ii) physiological-related motion of the surrounding structures (heart, cerebrospinal fluid, chest) and the cord itself and (iii) susceptibility artifacts, which are caused by inhomogeneous magnetic field, inducing image distortions when echo planar imaging¹ sequence is used. This session will address the later point: susceptibility artifacts. Acquisition and processing strategies will be presented and compared. Step-by-step pipeline will be described for the learner to be able to reproduce the techniques. Lastly, the benefits of ultra-high field MRI system will be discussed in light of recent clinical results.

METHODS – Acquisition strategies for reducing image distortions include: appropriate slice orientation and positioning, improved shimming (adjusting shim volume or using z-shimming approaches), reduced field of view techniques (2D RF selective excitation [1], outer volume suppression [2], parallel reconstruction). Processing strategies to correct for susceptibility-distortions include: phase field map correction, reversed-gradient technique correction and point spread function mapping. The availability, implementation and easiness of use will be discussed for each technique. Lastly, ultra-high field (7T) MRI of the spinal cord will be applied to patients with spinal cord injury [3] and amyotrophic lateral sclerosis.

RESULTS – Amongst the most successful and available methods for optimizing spinal cord diffusion images with regards to susceptibility artifacts, we can cite: Optimize shim within a reduced box encompassing the spinal cord, reduced field of view technique using outer volume suppression (saturation bands) and parallel imaging reconstruction. Acquisition of phase field map and/or image with reversed phase encoding gradient for post-processing correction. The use of ultra-high field MRI demonstrated the benefits of high spatial resolution (300 microns) for delineating spinal cord injury and detecting corticospinal abnormality in amyotrophic lateral sclerosis.

CONCLUSION – Despite the importance of finding quantitative markers for the pathological spinal cord, advanced MRI techniques mainly developed for the brain remain challenging at the spinal level. Notably, acquisition and processing are the decisive steps that can make the difference in the interpretation of images.

REFERENCES – [1] Finsterbusch. *JMRI* 2009; 29(4):987-93 [2] Dowell *et al.* *JMRI* 2009; 29(2):454-60 [3] Cohen-Adad *et al.* *Neurology* 2012; 79(22):2217.

¹ Echo Planar Imaging (EPI) is a ultra-fast imaging sequence often used in diffusion MRI.