

## Clinical Spinal Cord Imaging: Connecting Emerging MRI Technologies to Unmet Clinical Needs

**Session:** Advanced Neuroimaging 1: Brain and Spinal Cord

**Speaker:** Jonathan A.D. Farrell, Ph.D.  
Geisel School of Medicine at Dartmouth  
jonathan.a.d.farrell@gmail.com

### Highlights:

- Non-Gaussian water diffusion is caused by cellular compartments and tissue microstructure.
- DKI and QSI can measure and quantify non-Gaussian water diffusion in biological tissues.
- DKI and QSI are feasible *in vivo* in humans in a clinical setting and are showing improved sensitivity and specificity for myelin and axon damage in the brain and spinal cord.
- Diffusion weighted MRI is also emerging as a tool to study cartilage and bone pathology.

**Target audience:** Physicians and scientists with an interest in diffusion imaging and spinal cord MRI.

**Background:** The challenge of clinical imaging is to discern the extent, severity, and prognosis of injury. Imaging the spinal cord is technically difficult due to its small size and the wide variety of pathology that can occur as a consequence of disease or trauma including: demyelination, axon loss, ischemic injury, gliosis, or injury to surrounding structures including ligaments, cartilage or bone. In the last decade diffusion weighted MRI has been used to investigate tissue microstructure in more detail and diffusion tensor imaging (DTI) is now routinely used in a variety of settings. Capitalizing on the benefits of higher field strength and improved gradient hardware, diffusion weighted MRI data is now being acquired at multiple and higher b-values and is thus not suited to DTI analysis. This has necessitated the development of advanced analysis techniques such as q-space imaging (QSI) and diffusion kurtosis imaging (DKI). DKI and QSI offer distinct advantages over DTI and have been applied to study demyelinating disease, ischemic injury, malignancy and trauma in a wide variety of animal models and *in vivo* in humans [1, 2].

### PURPOSE and METHODS

- 1) Briefly explain the theoretical basis of QSI and DKI.
- 2) Survey recent literature that has used QSI and DKI to study spinal cord pathology with a focus on the advantages of these techniques in assessing axon and myelin damage.
- 3) Discuss some of the signal to noise, motion correction, and data processing demands of diffusion weighted MRI data and strategies to overcome them.

**OUTCOME and CONCLUSION:** DKI and QSI are newly emerging diffusion MRI techniques that aim to elucidate the complexity of tissue damage. They build upon the success of DTI and offer significant advantages from a biophysical and methodological perspective. At the conclusion of the talk, participants will be able to appreciate the differences between DTI, DKI and QSI and will be more familiar with the advantages and disadvantages of each technique in the research and clinical settings.

### REFERENCES:

- [1] Cohen Y., Assaf Y. *High b-value q-space analyzed diffusion-weighted MRS and MRI in neuronal tissues - a technical review.* NMR Biomed. 2002 Nov-Dec;15(7-8):516-42
- [2] Hori M., et al. Visualizing Non-Gaussian Diffusion: *Clinical Applications of q-Space Imaging and Diffusional Kurtosis Imaging of the Brain and Spinal Cord.* Magn Reson Med Sci, 11(4):p221-233, 2012.