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(G*) A Method to Explore Tissue Microstructure on Cellular and Subcellular Spatial Scales with Diffusional Kurtosis Imaging

Monday 27 May 2024 15:00 (15 minutes)

Diffusion magnetic resonance imaging (dMRI) is a method that sensitizes the MR signal to water molecule diffusion, probing tissue on a microstructural level not attainable with traditional MRI techniques. While conventional dMRI has proven useful in many research areas, more advanced techniques are necessary to further characterize tissue microstructure at spatial scales not available with conventional dMRI. Encoding diffusion using an oscillating gradient spin echo (OGSE) sequence increases sensitivity to smaller spatial scales (<10 µm), and diffusional kurtosis imaging (DKI) provides a comprehensive representation of the dMRI signal, increasing sensitivity to microstructure. While combining these techniques may allow for probing cellular length scales with high sensitivity, generating the large b-values (strength of diffusion weighting) required for DKI is challenging when using OGSE, and DKI maps are often confounded by noise. In this work, we present a method that combines an efficient diffusion encoding scheme and a fitting algorithm utilizing spatial regularization to address these challenges and provide robust estimates of DKI parameters. DKI data was acquired in 8 mice on a 9.4 Tesla scanner using an OGSE sequence with b-value shells of 1,000 and 2,500 s/mm2 (each with a 10-direction scheme which maximizes b-value), TE/TR=35.5/15,000 ms, 4 averages. For comparison, in one mouse we acquired the same dataset but using a commonly used 40-direction scheme, TE/TR=52/15,000 ms, no averaging. We compared our implementation of spatial regularization with a commonly used denoising technique in dMRI, Gaussian smoothing on diffusion-weighted images (DWIs) prior to fitting. We show that using the efficient 10-direction scheme results in much higher signal-to-noise ratio in non-DWIs (30.6 vs 11.4) and improved DKI map quality compared to the 40-direction protocol. Spatial regularization was shown to outperform Gaussian smoothing in terms of contrast preservation both qualitatively and quantitatively. The presented method allows for DKI fitting when using OGSE sequences by addressing key challenges when combining their use, and we showed the advantages of the various elements over conventionally used methods. This pipeline will allow for investigation of normal and pathological brain microstructure at cellular and sub-cellular spatial scales with high sensitivity.

Keyword-1

Magnetic resonance imaging

Keyword-2

Diffusional kurtosis

Keyword-3

Oscillating gradient

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