Resolution of Tissue Microstructure via Diffusion MR: Beyond Mapping Orientations

Evren Özarslan

Section on Tissue Biophysics and Biomimetics, NICHD
National Institutes of Health, Bethesda, MD, USA

The microscopic architecture of biological tissues influences the diffusion-attenuated MR signal intensity. Consequently, it is possible to obtain a wealth of different information at the cellular level from well-controlled diffusion-weighted MR image and spectrum acquisitions. For example, numerous techniques have been developed over the years to map the orientation of local white-matter axonal bundles. However, other important characteristics of tissue microstructure can be obtained as well if reliable models are developed. The first step in such an endeavor is to solve the forward problem of quantifying the MR signal intensity in simplified geometries representing more general biological structures. The purpose of this talk is to review some of the recent techniques that could be used in extracting microstructural features such as cell size and shape, axon diameter distribution, and complexity of the medium. Some emphasis will be placed on the double pulsed field gradient (double-PFG) MR technique. Unlike the traditional two-pulse Stejskal-Tanner sequence, the double-PFG pulse sequence is capable of providing signatures for restricted diffusion even at low diffusion weighting. This phenomenon could make it an ideal experimental framework to characterize tissue microstructure in the clinical setting.