ELUCIDATING TISSUE MICROSTRUCTURE WITH DIFFUSION MRI

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ABSTRACT
Measuring clinically or biologically useful microstructural features of tissues is challenging in vivo. Yet determining these properties is critically important in following normal and abnormal development, diagnosing diseases and disorders, and even guiding therapeutic procedures. Tissue is optically turbid, constantly in motion, and hierarchically organized. One approach that has proven successful in elucidating tissue microstructure is diffusion MRI. It entails measuring the distribution of net displacements of water molecules in tissue on a voxel-by-voxel basis. Using these distributions, along with mathematical models of water migration in different tissue compartments, one can estimate or infer gross anatomical characteristics, such as muscle or nerve orientation, and even microscopic anatomical features, such as the axon diameter distribution in nerve bundles. The basic diffusion MRI experiment will be described, and then some models of diffusion in idealized tissue compartments will be presented. The relationship between microstructure and the measured MRI signal will be presented, and the general strategy for measuring or characterizing microstructural features of tissue from these MR displacement distribution measurements will be explained.