AbstractID: 6767 Title: Use of Novel Gradient Directions to Synthesize Complex Diffusion Geometries: When A Hot Dog is a Pancake

Purpose: The goal of this project is to demonstrate that usage of different gradient directions during the acquisition and reconstruction phases of a DTI scan can produce images exhibiting complex diffusion characteristics. In this manner, a simple anisotropic phantom (e.g., “hot dog” geometry) could be employed to infer the quality of data for more clinically-realistic tissue structures (e.g., oblate, or “pancake” structures, and two prolate structures that intersect).

Method and Materials: A water-filled phantom containing glass capillary arrays was constructed. Three DTI series of images from a 3.0T GE HDx scanner were acquired by specifying sets of acquisition directions to produce synthetic oblate diffusion distributions and two diffusion distributions where prolate distributions intersect, using standard gradient directions for reconstruction. Acquisition directions were calculated so that diffusion was most restricted in the y-direction. The three desired diffusion distributions were first simulated using MATLAB, and acquisition directions appropriate for each were computed. Eigenvalues, eigenvectors, and fractional anisotropy of the oblate tensor were calculated within an ROI. RMS differences between generated and measured ADCs were determined.

Results: The simulated oblate data produced a tensor with reasonable symmetry in the x-z plane, restricted in the y direction. Eigenvalue magnitudes were consistent with those measured for the capillary array, albeit with the values associated with different eigenvectors. ADC distributions for intersecting prolate distributions qualitatively resemble the simulated distributions, and quantitatively match the simulated distributions more closely than a spherical distribution.

Conclusion: This work suggests that one could use simple phantoms to monitor scanner performance for measuring diffusion distributions with more similarity to tissue. Gradient duty cycle is similar to an ordinary diffusion protocol; the effect of noise, originating from sources other than the gradients, on complicated diffusion distributions could be characterized empirically.