AbstractID: 8460 Title: The Benefits of Non-Uniform Gradient Direction Specification in DTI: Simulations and Phantom Data

Purpose: The goal of this project was to optimize angular precision in determining the principle diffusion eigenvector of prolate tensors in a diffusion tensor imaging (DTI) series, using prior knowledge of principle eigenvector direction and non-uniform specification of gradient directions. Additionally, the effect of non-uniform gradient distributions on fractional anisotropy (FA) was characterized.

Method and Materials: Simulations were conducted, representing diffusive behavior in tissue as manifest in a DTI image series. Diffusion-encoding gradient directions were constrained in elevation, for a prolate tensor oriented along the z-axis. Noise was added to generate multiple measurements as per a DTI ROI analysis. Tensors were calculated as well as FA. Angular precision was quantified as the dispersion in the angle between the principle eigenvector of the prolate and the z-axis. To confirm simulations, a phantom containing glass capillary arrays (FA=0.68) was imaged with DTI using a 3.0T GE HDx scanner. Gradient directions were specified to match simulation results. Eigenvalues, eigenvectors, and FA were calculated within an ROI.

Results: Simulations identify the range of elevation angles $\theta=30^o$-40^o as being most sensitive to the determination of principle eigenvector direction. This result is fairly consistent within the range of FA=0.2-0.8. Prescription of gradients within a band of elevation angles having a width of $\Delta\theta$ ~40^o-60^o and centered at θ ~30^o can improve angular precision by 30-40%, given an uncertainty in prior eigenvector direction of <30^o. FA precision using this scheme is similar to uniform gradient prescriptions, and accuracy is improved at low SNR values. Data from phantom measurements generally agree with simulation results.

Conclusion: This work suggests that prior knowledge of principle eigenvector direction can improve its final determination, using gradients prescribed non-uniformly. This technique may be useful for increasing sensitivity in these conditions (e.g., spinal lesions, determining tumor infiltration of white matter tracts).