In-vivo detection of diffusive water transport in human eye using high-resolution diffusion weight imaging

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Introduction The diffusion–weighted imaging with MRI can be important tool for characterizing fluid dynamics in the human eye in normal or disease states. MRI is not impeded by the iris or optical distortions and has the unique ability to visualize the entire eye in any desired plane [1]. However, most of the existing diffusion MRI studies on human eyes were performed ex vivo and relied on special customer coils. In vivo imaging of the water diffusion in human eyes with a typical MRI scanner remains a major challenge. A technique of readout-segmented echo-planar imaging combined with parallel imaging and a two-dimensional navigator-based reacquisition can provide high-resolution diffusion-weighted imaging on a regular MRI scanner [2]. In this study, we present a high resolution diffusion weight imaging on in-vivo human eyes using this readout-segmented echo-planar imaging technique.

Materials and Methods Diffusion-weighted images were acquired from four healthy subjects. They were scanned on a Siemens 3T Trio/Tim system using a readout-segmented echo-planar imaging sequence combined with parallel imaging and a two-dimensional navigator-based reacquisition [2]. Acquisition parameters were: field of view (FOV) = 197 mm, matrix = 512 × 512, in-plane resolution = 0.38mm × 0.38mm, three oblique axial slices (2.2 mm thick without gap), TR = 640 ms, TE = 89 ms, GRAPPA factor = 3, number of shots = 31, scan time = 2 minute 50 second, b = 900 s/mm^2 and 6 diffusion gradient directions. Subjects were instructed to maintain fixation during the scan on a cross, presented 91 cm from the subject. In the post-processing, the diffusion-weighted images were corrected for motion artifacts and eddy current distortions. Thereafter, diffusion tensor at each voxel was reconstructed form data with our Matlab program. The maximum eigenvector was obtained from tensor at each voxel and was used to construct the water transport direction by FACT (fiber assignment by continuous tracking) algorithm, similar to the one used in the regular tractography for brain. Furthermore, the FA (fractional anisotropy) value was calculated from tensor and displayed at each voxel.

Results and Discussion The water transport direction map is represented by the orientation of maximum eigenvector calculated from diffusion tensor, and shows the difference between eye structures (Figure 1). The results show that the water in the anterior chamber diffuses either perpendicular or parallel to lens surface. In the posterior chamber, the water transportation is mostly parallel to the surface of lens and Ciliary body. There is little constant orientation of water movement in the Vitreous chamber. The FA values in these areas also indicate the similar results: the FA in posterior chamber is the highest, the FA in anterior chamber is intermediate, and the FA in Vitreous chamber is the lowest (Table 1). Our study demonstrates the feasibility of in-vivo detection of water transport in human eye using a high-resolution diffusion weight imaging on a typical clinic scanner. The use of readout-segmented echo-planar imaging sequence combined with parallel imaging and a 2D navigator-based reacquisition can be improved further to gain higher signal noise ratio and less image distortion in the future studies.

Reference [1] Strenk, et al., *Investigative Ophthalmology & Visual Science*: 4728-D786, 2011. [2] Porter, et al., *Magnetic Resonance in Medicine* 62: 468, 2009.

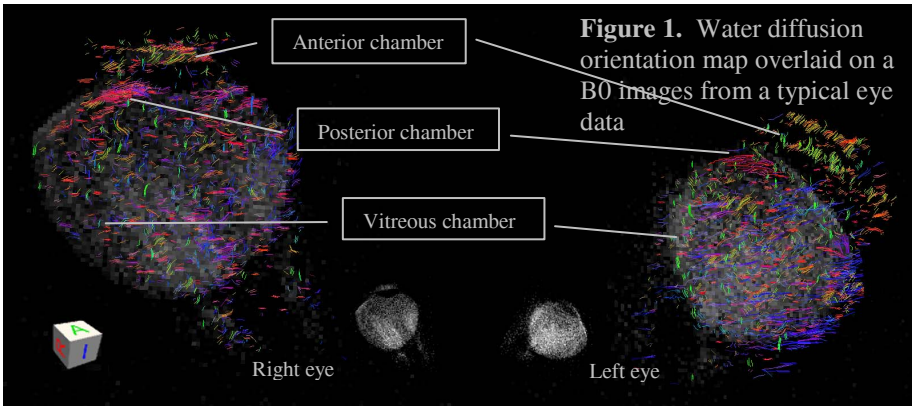

Figure 1. Water diffusion orientation map overlaid on a B0 images from a typical eye data

ROI	FA
Anterior chamber	0.276 (0.063)
Posterior chamber	0.302 (0.094)
Vitreous chamber	0.117 (0.081)

Table 1. The average of FA values (and its standard deviation) of different structures in human eyes