

DTI of The Optic Nerve

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INTRODUCTION

High resolution diffusion tensor MR imaging of the optic nerve is challenging due to the low SNR and distortions [1,2,3]. We have obtained high resolution DTI based data from the optic nerve at voxel sizes of 1mm x 1mm x 3mm and derived the maps of fractional anisotropy (FA), and trace ADC. To enhance the SNR and to avoid wrap-around problems we employed surface coils with appropriate depth sensitivity to image the optic nerve. High resolution DTI of the optic nerve may be helpful in the imaging evaluation of optic neuropathy.

METHODS

For this study one healthy subject underwent MRI scanning on a Siemens 3T Trio MRI scanner (Siemens Medical Systems, Erlangen, Germany). To obtain higher SNR for eye imaging, we used a set of surface coils in the receive mode, a 3 cm diameter surface coil and a phased array surface coil composed of two 5cm diameter elements. The body coil of the scanner was used as the transmit coil. The surface coils were affixed in contact with the right eye, while the subject was asked to fixate with the left eye on a display showing a small stationary cross.

For the DTI of the optic nerve, the two-element phased array surface coil was used. Four anatomical scans (3DMPRAGE) were obtained with 1mm cubic isotropic voxels, FOV of 128mmx128mm and 88 slices. Seven EPI based DTI scans were obtained with the following imaging parameters: voxel size=1mm x 1mm x 3mm anisotropic, slices=20, slice thickness=3mm, FOV=128mm x 128mm, TE=95ms, TR=3600ms, bandwidth=1028Hz/pixel, flip angle=1.57deg, bvalue=700s/mm², acquisition time=6.45 minutes/scan and diffusion directions=60. Slices were chosen along the direction of the optic nerve. DTI data were motion corrected and registered across runs and average maps for LowB, FA, and trace ADC were computed. To show the DTI maps near the optic nerve, the LowB map was used as guide to create a mask around the optic nerve. All the masked maps are displayed as overlays on anatomical data. A final cubic resampling to 0.1mm cubic voxels was performed for display purposes. Using the LowB map, two ROI masks of cylindrical shape were created, one in the center of the optic nerve (dark in LowB) and another on annular ring around the optic nerve (bright in LowB). These two ROI masks (Fig. 3) were used to obtain the ROI averaged values of FA and trace ADC.

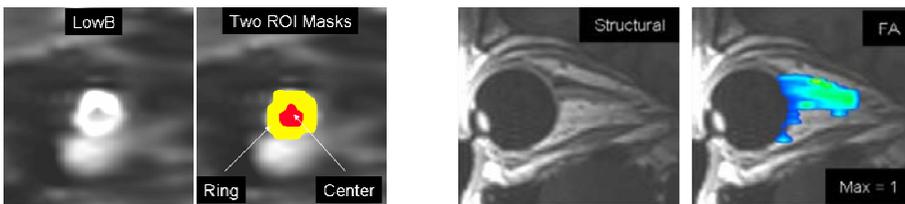
RESULTS & DISCUSSION

Figure 1 shows maps of FA, trace ADC and LowB overlaid on two coronal structural slices. Table 1 shows the values of FA and trace ADC within two ROI masks demonstrated in Fig. 3. The mean FA in the center is 0.30 with a maximum of 0.48. Mean ADC value in the center is $1.62 \times 10^{-3} \text{mm}^2/\text{s}$. Iwasawa et al. [2] had reported ADC values ranging from $0.98 \times 10^{-3} \text{mm}^2/\text{s}$ to $1.56 \times 10^{-3} \text{mm}^2/\text{s}$ in normals and upto $4.18 \times 10^{-3} \text{mm}^2/\text{s}$ in subjects with chronic neuritis. In the human brain a typical ADC value (at bvalue of 700s/mm²) is $0.8 \times 10^{-3} \text{mm}^2/\text{s}$ and FA in white matter is 0.6. In our measurements the FA values in the optic nerve are smaller than the typical brain FA, and ADC values are larger than the typical

| | FA | | Trace ADC (10 ⁻³ mm ² /s) | |
|----------|------|--------|---|--------|
| | Ring | Center | Ring | Center |
| Mean | 0.22 | 0.30 | 2.23 | 1.62 |
| Std. Dev | 0.10 | 0.12 | 0.38 | 0.30 |
| Min | 0.07 | 0.08 | 1.18 | 1.17 |
| Max | 0.47 | 0.48 | 3.95 | 2.20 |

Table 1. The values of FA, avg DWI and trace ADC from two ROI masks shown in Fig3.

FA values in the optic nerve are smaller than the typical brain FA, and ADC values are larger than the typical



brain ADC.

Fig.3 Two ROI masks drawn on LowB images. Masks span several slices and contain 101 and 22 voxels respectively.

REFERENCES:

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Fig.2 Oblique sagittal images through the orbit. Fractional anisotropy (FA) map obtained from DTI scans is overlaid on the anatomical image. The FA map is shown within a mask created on the basis of LowB images. The color scale is same as shown in Fig. 1.

ACKNOWLEDGEMENTS

This work was supported by US Public Health Services grants P01NS35611, P41RR14075 and NS035611 and the Mental Illness and Neuroscience Discovery, (MIND) Institute.

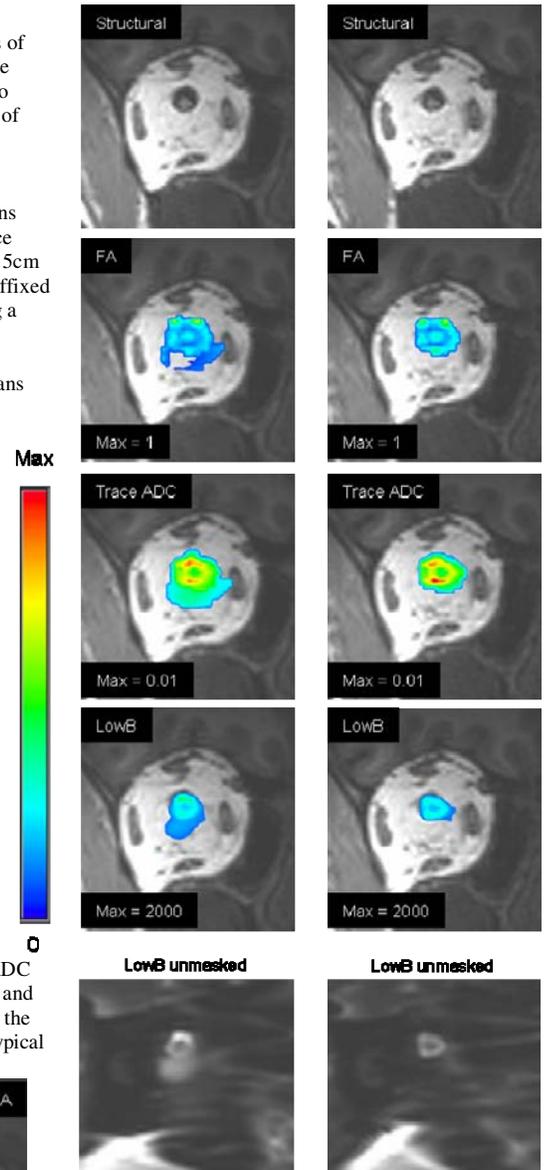


Fig.1 Two coronal slices showing DTI derived maps of Fractional Anisotropy (FA), Trace ADC (in units of 10⁻³mm²/s) and LowB overlaid on structural images. The maps are shown only within a mask based on the LowB images surrounding the optic nerve. Same color bar is employed for all the maps with different values for the maximum of the scale. FA, DWI and LowB maps were also thresholded with lower thresholds of 0.0658, 33 and 201 respectively.