

## Spatial Resolution Requirements for Diffusion Tensor Imaging of Fornix

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**TARGET AUDIENCE:** Researchers interpreting or designing studies of diffusion tensor imaging (DTI) of small white matter pathways such as fornix.

**PURPOSE:** To present an approach for determining adequate spatial resolution for small white matter pathways.

**BACKGROUND:** DTI of fornix is a potential biomarker for memory-related cognitive decline. As commonly-used spatial resolution for DTI risks partial volume averaging with surrounding CSF spaces, increases in diffusivity associated with disease that simply result from atrophy may be misinterpreted as change in tissue integrity. Metzler-Baddeley et al. have recognized this problem<sup>1</sup> and used the free water fraction (FWF) model<sup>2</sup>. Here, we examine the adequacy of high spatial resolution DTI for direct determination of integrity of fornix.

**METHODS:** Ten multiple sclerosis (MS) patients and 10 healthy age- and sex-matched controls were studied under an internal review board-approved study. All imaging was performed on a Siemens TIM Trio (Siemens Medical Systems, Erlangen, Germany) with a standard 12-channel head coil. A high spatial resolution DTI scan was developed, featuring 1mm isotropic voxels (192x192 mm FOV, 192x192 matrix, 53 slices 1mm thick, TE = 90 msec, TR = 7700 msec, 6/8 partial fourier factor, GRAPPA with acceleration factor of 2 and 32 reference lines). Multiple diffusion gradient directions and diffusion weightings were acquired (8, 32, 72 non-collinear gradients with b = 83, 333, 750 sec/mm<sup>2</sup> and 9 b=0 acquisitions) with two averages. Iterative motion correction was applied<sup>3</sup>. The diffusion tensor and measures of tissue integrity (fractional anisotropy (FA), mean diffusivity (MD), longitudinal diffusivity (LD) and transverse diffusivity (TD)) were calculated with and without the FWF correction using DiVa (<http://www.cs.tau.ac.il/~oferpas/DiVa>). Regions of interest (ROI) were drawn on anatomical T1MPRAGE images, coregistered to DTI space with FLIRT<sup>4</sup> and checked against FA images.

**RESULTS:** Distributions of tissue integrity values within most ROIs were not from normal distributions, as per Lilliefors tests. However, after taking the median within each ROI, the distributions among each group were. The student t-test was then used to compare values between groups. As illustrated in figure 1, no significant difference was found between values determined with and without the FWF correction when high spatial resolution was used. Furthermore, the values found at high spatial resolution are comparable to corrected values from standard resolution data<sup>1</sup>. As illustrated in figure 2, significant differences were found between patients and controls in TD and MD (p < 0.05 corrected for multiple comparisons) only after the FWF correction.

**DISCUSSION:** At standard resolution there is significant partial volume averaging between CSF and tissue in fornix, and the FWF correction reduces the magnitude and variance of diffusivity values<sup>1</sup>. With 1mm isotropic voxels, the correction does not lead to significant changes in the magnitude of diffusivity among patients or controls, suggesting that this spatial resolution is sufficient for resolving fornix. Alignment between literature values taken at standard resolution and the high spatial resolution values also support the validity of the FWF model, which has not been validated with high spatial resolution data. However, the reduction of variance due to the correction improves sensitivity to differences, as shown if fig 1b, suggesting that the FWF correction may compensate for the low signal to noise ratio (SNR) of small voxels.

**CONCLUSION:** Partial volume averaging can have a serious impact on the interpretation of DTI results, particularly for small pathways such as fornix. This study provides evidence that 1mm voxels are adequate to avoid the problem in this region.

### REFERENCES

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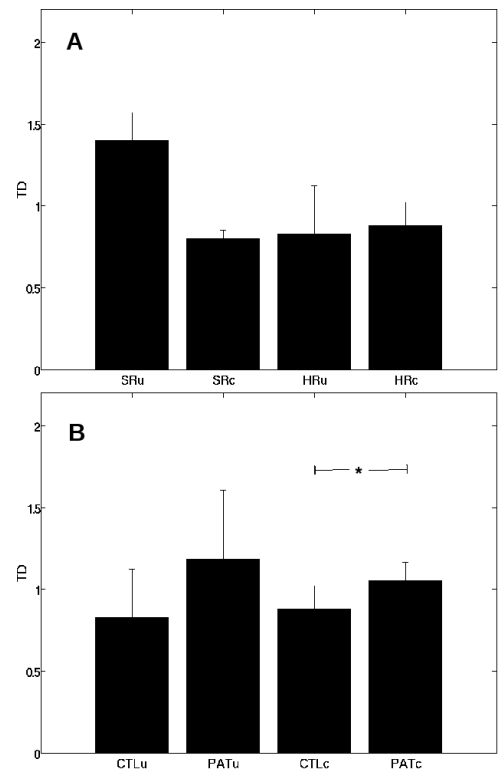


Figure 1. A) TD at standard resolution (SR) and high resolution (HR) with (SRc, HRc) and without (SRu, HRu) FWF correction. FA, MD, LD and TD do not show significant differences between values from corrected and uncorrected values at HR. SR from literature<sup>1</sup>. B) Comparisons between patients (PAT) and controls (CTL) with (PATc, CTLc) and without (PATu, CTLu) FWF correction. Significant differences are only found after correction for MD and TD. Only results for TD are shown.