# Anisotropy and Diffusivity Changes in Corpus Callosal Subregions in Chronic Pediatric Traumatic Brain Injury

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## Introduction

Traumatic brain injury (TBI) is a major cause of disability and morbidity in school-age children and is related to diffuse axonal injury (DAI) caused by shear-strain deformation disrupting the cytoskeletal network and axonal membranes **[1].** DAI most prominently affects the subcortical white matter, corpus callosum (CC), and dorsolateral aspect of the upper brainstem**.** Following TBI, CC volumes are diminished particularly in the posterior body and splenium in both children and adults **[2].** Diffusion tensor imaging (DTI) has the potential to further localize and quantify CC injury with the ability to better characterize myelin loss and axonal damage **[3,4]**. In this preliminary report, we have used a full brain, optimally designed DT-MRI protocol in combination with conventional anatomical MRI to assess the extent of injury in different subregions of the CC as indicated by fractional anisotropy (FA) and the transverse eigenvalues ($\lambda_t=(\lambda_2+\lambda_3)/2$).

## Methods

DT-MRI was obtained in 14 TBI cases that sustained moderate to severe TBI at ages 0-15 years; the mean Glasgow Coma Scale score was 7.79 (SD=4.10). The mean age at DT-MRI was 14.3 ± 3.2 years (range 9.6 to 18.9); scans were obtained an average of 6.1± 2.7 years post injury. The control group consisted of 19 cases with a mean age of 10.2 years (range 6.6 to 15.8). Parental consent and child assent were obtained. Entire brain data was acquired using a Philips 3.0 T Intera system using a SENSE receive head coil. Conventional T1w; PD and T2w dual fast spin-echo images ($TE_1/TE_2/TR$=10/85/7000 ms) were obtained in addition to a matching prescription of diffusion tensor MRI data. The DT-MRI data were acquired using a single shot spin echo diffusion sensitized EPI sequence with the balanced Icosa21 encoding scheme [3], b=1000 $smm^{-2}$, TR=6.1 s, TE= 84 ms. The slice thickness is 3mm with 44 slices, fov=24 cm, a matrix of 256x256. The number of b~0 was 8; in addition each encoding was repeated twice and magnitude averaged to enhance the signal-to-noise ratio. The total DTI acquisition time was approximately 7 minutes and resulted in SNR independent ($SNR_0$~60, SNR (DW) ~ 20) and reproducible results. Diffusion weighted data was distortion corrected and processed as described elsewhere **[5].** To increase the accuracy and specificity of the ROI methodology, we implemented and adopted a DT-MRI guided subregional CC division of Witelson **[6,7]**. To assess tissue integrity, the FA and $\lambda_t$ value of a contiguous 9 pixel region was calculated within each of the 7 CC subdivisions (CC1-rostrum, CC2-genu, CC3-anterior midbody, CC4-middle body, CC5-posterior-body, CC6-isthmus and CC7 - splenium) were compared using two-tailed t-test (ANOVA) for unequal samples.

## Results

Figure 1 depicts the volume of the DTI-segmented midsagittal callosal regions for the TBI and control groups. In the TBI group, the volume of the entire CC, as well as the genu and isthmus, were significantly reduced. Figure 2 compares the FA and $\lambda_t$ values obtained for each of the CC subregions for the TBI and control groups. The FA values were smallest in the genu and largest in the splenium**.** FA values were significantly lower in the genu, anterior midbody, and isthmus in the TBI group, indicating reduced anisotropy. The $\lambda_t$ was significantly larger in the TBI than control in the rostrum, genu, posterior body, and isthmus compatible with increased diffusivity.

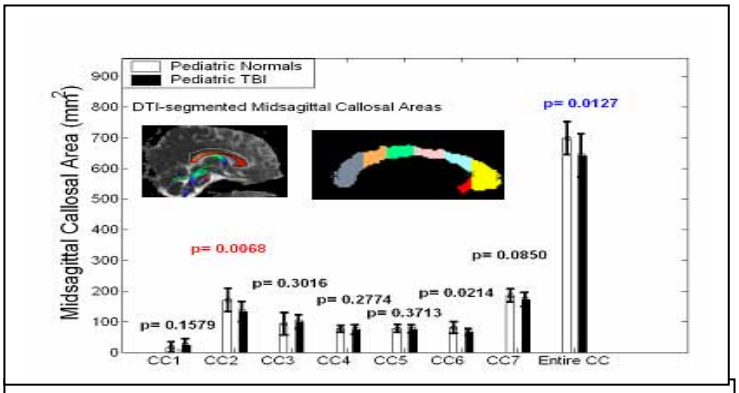


**Figure 1**. Volume of DTI-segmented callosal regions is significantly reduced in CC-genu and CC-6-isthmus in TBI group compare to controls.

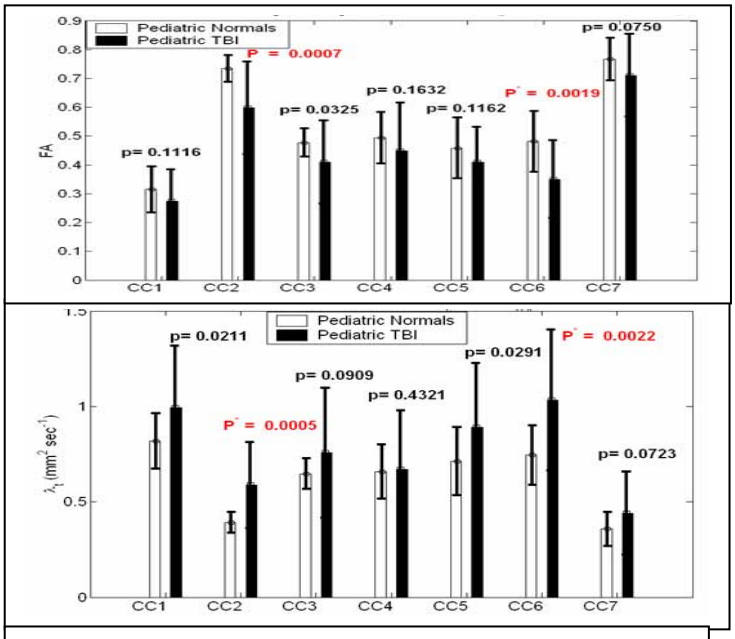


**Figure 2**. FA and $\lambda_t$ values for 7 callosal regions for TBI and control groups. Note decreased anisotropy and increased transverse diffusivity in the TBI group. $\lambda_t$ may indicate demyelination in the rostrum, genu, posterior body and isthmus after TBI.

## Discussion and Conclusions

FA and $\lambda_t$ varied across specific CC regions, reflecting morphological differences in caliber and myelination of axons. $\lambda_t$ was more sensitive than FA to chronic traumatic axonal damage as indicated by more significant differences in diffusivity across CC regions. Decreased diffusion anisotropy is not specific to either axonal or myelin pathology; therefore, examination of the directional diffusivities may provide additional diagnostic advantages. Changes in $\lambda_t$ have been interpreted as indicating disruption in CNS myelination **[4]** and may permit a more precise marker of disruption of specific neuronal elements. Our findings are also consistent with volumetric studies showing marked post-traumatic atrophy in the genu, rostrum, anterior body, and the splenium **[8].** DT-MRI shows great promise for serving as an index of chronic TBI and in elucidating specific pathological mechanisms.

## References

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