ROI Based Analysis of Diffusion Tensor Imaging in Traumatic Brain Injury.

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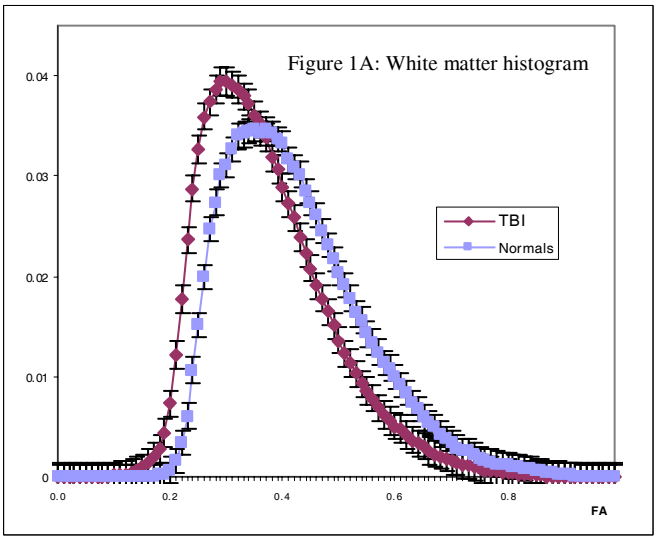
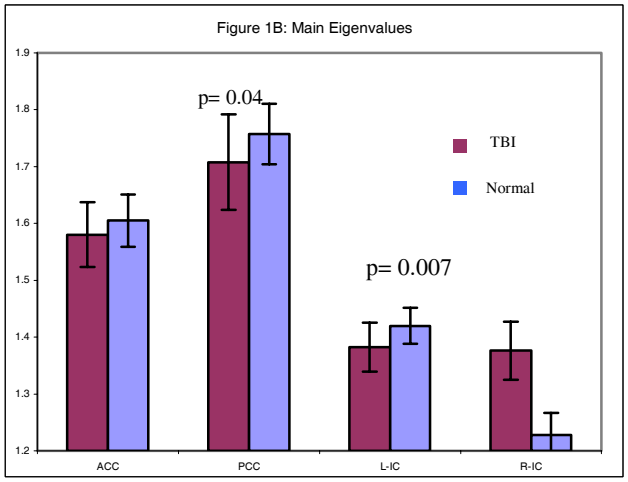
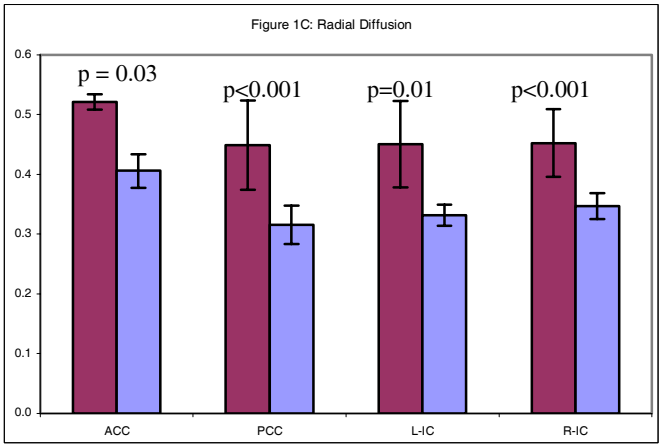
Introduction: Diffusion-tensor imaging (DTI) is extremely sensitive to alterations in water diffusion, thus it is capable of visualizing, for example, demyelinating lesions and their anatomical sites of involvement. The increased T_1 and T_2 relaxation times seen on MR images with traumatic-brain injury (TBI) in comparison with normal white matter probably relates to gliosis, loss of axons, and tissue destruction that occurs in chronic diffuse axonal injury (DAI) lesions (1,2). In this study we used whole-brain DTI and a white/gray matter segmentation technique, to compare TBI patients with healthy volunteers on a ROI-based analysis of anterior and posterior corpus callosum (ACC, PCC), and left/right internal capsule (L-IC, R-IC) hypothesizing that DTI will reveal altered diffusion in normal appearing tissue.

Materials and Methods: DTI was acquired in 6 non-colinear directions with 10 averages. Nineteen patients, (age range = 11-57 years, mean 35.5) and fourteen age-matched healthy volunteers (range 23-45 years, mean 27.5) without history of neurological or psychiatric disease were included in this study. Severity ranged from mild to severe TBI with Glascow Coma Scores (GCS) on admission 3-15. The DTI scans were repeated three times for each control subject, to assess test-retest reliability. FA maps were segmented to give gray matter, white matter and whole brain compartments. To achieve optimal tissue segmentation, FA maps were initially spatially normalized to an FA template image (affine only) in standard space, and all individual eigenvalue and ADC maps were also spatially normalized. Normalized FA images were segmented creating white matter-only FA maps, from which WM-only masks were applied to the eigenvalues, ADC, and FA maps to create WM-only image. Mean FA, ADC and eigenvalues were measured for the whole brain, ACC, PCC, L-IC, and P-IC.

Results: WM-only FA histograms revealed a shift to lower FA of the entire distribution of FA values for the entire white matter compartment for the TBI patients compared with controls with virtually no overlap between groups (Figure 1A). In addition, the histograms were more peaked and this change was associated with other shape changes such as (positive) kurtosis and (positive) skew for the TBI patients compared to the controls. The ACC and R-IC of TBI patients did not show any significant change in parallel diffusivity when compared to normal subjects (Figure 1B). However, radial diffusivity in these structures is significantly higher, hence a noticeable significant decrease of FA. In the PCC and L-IC there is significant decrease of parallel diffusivity and significant increase in radial diffusivity values (Figure 1C), hence a decrease in FA. Of the DTI metrics (FA, and ADC) the FA mean was by far the most discriminating.







Conclusions: A decrease in parallel diffusivity would be caused by impairment in axonal transport while an increase in perpendicular diffusivity would be caused by myelin or axolemma disruption (4). Only radial diffusion was altered and was significantly increased. This finding suggests that, dysmyelination, axonal swelling and membrane permeability change were the important mechanisms.

References: (1) Arfanakis et al., Neuroradiology 23(2002) ; (2) Rugg-Gunn et al., J Neurol Neuros 70(2001) ; (3)Inglese et al. Neurosurgery 103(2005) **;** (4)Song et al., Neuroimage 17(2002).