Diffusion Tensor Imaging in Mild and Moderate Pediatric Traumatic Brain Injury

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Background: This study investigates the sensitivity of Diffusion Tensor Imaging (DTI) to microstructural white matter (WM) damage in mild and moderate pediatric Traumatic Brain Injury (TBI). TBI is the most common neurological condition in children. Most TBIs (75%) are classified as "mild" and, by definition, are not accompanied by neurological abnormalities on conventional MRI. Moderate TBI are often accompanied by diffuse axonal injury (DAI), but conventional MRI only identifies DAI in a small proportion of cases. The existing research on cognitive consequences of TBI indicates that moderate TBI results in neurocognitive deficits, some of which are likely related to WM injury. The literature is less clear for mild TBI. This study addresses two questions: 1) Is DTI sensitive to WM injury in mild and moderate cases of TBI? and 2) What are the neurocognitive correlates of microstructural WM changes following TBI?

Hypothesis: We hypothesized that WM microstructural integrity would be compromised in children with mild and moderate TBI compared to age-matched control subjects. We also hypothesized that damage at the microstructural level would be correlated with neurocognitive deficits, including deficits in attention, executive function, and processing speed as well as specific behavioral abnormalities including disinhibition and disorganization.

Methods: The participants were 27 children, ages 11 to 18. Thirteen had TBI and 14 were control subjects. Patients were seen 6-12 months post-injury (mean 8 months). Mean initial Glasgow Coma Scale (GCS) score for the patients was 12.5. Participants had MRI scans including the following sequences: T1-weighted anatomical, FLAIR, T2*, and DTI. DTI data were collected axially, 2mm cubic voxels, FOV = 256x256, TR=8300ms, TE=86ms, 12 directions, b=1000. ROIs were defined in the corpus callosum and cerebral WM. Subjects also completed a neurocognitive battery assessing IQ, attention, executive functioning, memory, processing speed, and motor functioning. Parents completed two rating scales, the Behavior Rating Inventory of Executive Function (BRIEF) and the Behavior Assessment System for Children, Second Edition (BASC-2).

Results: No group differences in fractional anisotropy (FA) were seen in corpus callosum, but the TBI group had lower FA in cerebral WM above the corpus callosum (p=.005). There was a trend toward lower FA in frontal WM (p=. 06) (Fig. 1). Dividing the sample, the moderate TBI group had lower FA in WM above the callosum than controls, but the mild TBI group did not differ from either. However, FA for mild TBI fell between controls and moderate TBI. As a group, TBI subjects showed slow processing speed, working memory deficits, and behavioral dysregulation compared to controls. Correlations between processing speed / motor speed and FA in WM above the corpus callosum and in frontal regions were significant (.40 to .49, p <.05). Voxelwise analyses revealed lower FA in TBI subjects compared to controls in expected regions including genu and splenium, brainstem, and central WM tracts (Figs. 2-4).

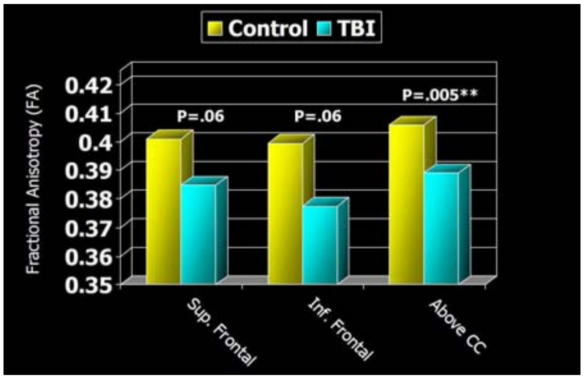

Figure 1. FA results for three cerebral regions

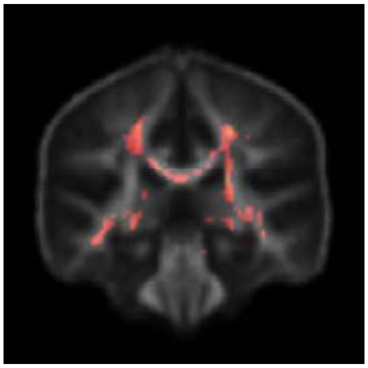

Figure 2 Voxel-wise group differences in FA

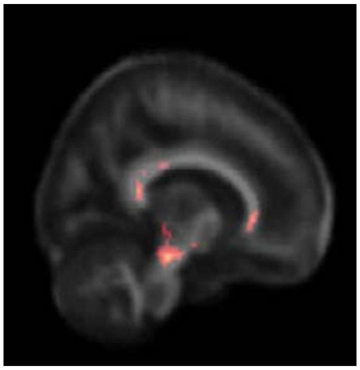

Figure 3 Voxel-wise differences

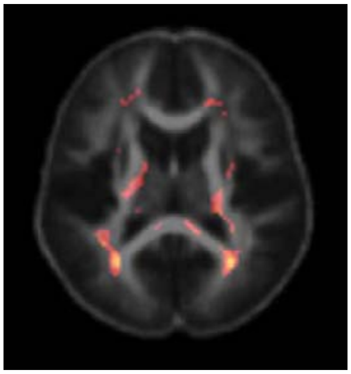

Figure 4 Voxel-wise differences

Discussion: The results suggest that moderate pediatric TBI is associated with long-term WM microstructural change, especially in superior, frontal, and specific corpus callosum regions. The data for mild TBI subjects were in the expected direction, but not statistically significant. Low FA was associated with slower processing speed / motor speed. No significant relationships with behavior were observed. Future studies of mild TBI with larger samples may yield evidence of long-term changes in WM microstructure.