

TRAUMATIC BRAIN INJURY: ABNORMAL FRACTIONAL ANISOTROPY IN THE CORPUS CALLOSUM AND ITS ASSOCIATION WITH INJURY SEVERITY.

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Abstract Traumatic brain injury (TBI) is a severe and potentially debilitating event that affects 1.7 million people annually in the United States (4). Mild TBI accounts for approximately 75% of all reported cases (5). The physical forces that are present during TBI bear a potential impact on all anatomical structures in the brain. Research has shown that the corpus callosum (CC) is affected in TBI independent on the locus of the initial injury (1, 2). In addition, ventricular swelling is also commonly observed with diffusion tensor imaging (DTI) (3). DTI is an ideal in-vivo imaging technique to study abnormalities in the axonal microstructure not visible on macroscopic anatomical imaging protocols.

Method Eleven subjects diagnosed with mild to moderate TBI and ten age and gender-matched controls were scanned once after completing a battery of neuropsychological testing. Images were obtained on a Philips Achieva 3T X-Series Whole-body MRI. A diffusion-weighted image (TR=5682.4 ms, TE=70.0 ms, FOV=21.0 cm, matrix = 104x106, 38 slices, thickness = 2.5 mm, no skip, 32 gradient directions, max b=1200 s/mm²) was acquired using a head-dedicated SENSE 8-channel head coil for each subject. Images were eddy-current-corrected and fractional anisotropy (FA) maps were calculated using FSL (www.fmrib.ox.ac.uk/fsl). In-house software developed in Matlab 2009 was used for ROI data collection. The corpus callosum was traced on a midsagittal slice. Tracing was performed on an edge enhanced FA image using a Sobel filter (Fig 1). The average FA of the CC was calculated. In addition, rectangular ROIs were obtained from the Genu, Body and Splenium of the CC as well (Fig 2). Prior to scanning, participants were assessed using the Brain Injury Screening Questionnaire (BISQ), the Beck Depression Inventory (BDI), Beck Anxiety Inventory (BAI), Brief Health Questionnaire (BPHQ), Cognitive Failures Test (CFQ) and severity of TBI. The BISQ is a self report of cognitive, physical, and emotional symptoms, the BDI and BPHQ are indicators of depression, the BAI an index of anxiety, and the CFQ is a self-report measure of functional cognitive failures experienced in daily life. Injury severity was classified using a 7-point scale ranging from 1 (No loss of consciousness, no confusion (i.e., no TBI) to 7 (Loss of consciousness greater than 4 weeks in duration). T-tests were used to determine group differences and correlations between FA and neuropsychological measures were computed.

Results The TBI group had significantly lower FA than controls in the corpus callosum (Table 1). Furthermore, ROI FA values were also lower in TBI subjects in the body of CC and a trend of lower FA in the Genu of the CC (Table 1). Correlation analysis (aged corrected) showed that the corpus callosum FA was negatively correlated with the severity score in the TBI group ($r(11) = -0.728, p < 0.05$). The TBI group also reported significantly greater symptoms of depression, anxiety, and cognitive failures. There were no significant correlations between measures of depression (BDI, BPHQ), anxiety (BAI) or self-reported cognitive failures (CFQ) with corpus callosum FA in the TBI group.

Region of Interest	Mean Control (n=10)	Mean mTBI (n=11)	t-value	df	p
Total CC	589.37	484.11	4.02	19	0.0007
Body CC	654.55	566.68	2.48	19	0.0227
Genu CC	756.53	661.32	2.05	19	0.0567
Splenium CC	850.88	812.76	0.98	19	0.3415

Table 1. Group differences in white matter FA of the corpus callosum (CC). Total CC ROI was obtained on a midsagittal view of the sobel filtered FA image. Body CC, Genu CC and Splenium CC ROIs were performed on color map of FA image with dimensions 4x1, 3x2, 3x2 respectively.

Neuropsych Assessment	Mean Control	Mean mTBI	t-value	df	p	N Controls	N mTBI
BDI	1.60	12.67	-3.42	20	0.0027	10	12
BAI	1.64	6.5	-2.69	21	0.0137	11	12
BPHQ	12.00	16.33	-2.65	21	0.0150	11	12
CFQ	17.82	45.75	-4.28	21	0.0003	11	12

Table 2. Group differences in neuropsychological assessments. BDI = Beck Depression Inventory, BAI = Beck Anxiety Inventory, BPHQ = Brief Patient Health Questionnaire, CFQ = Cognitive Failures Questionnaire.



Figure 1. Midsagittal sobel-filtered FA image.

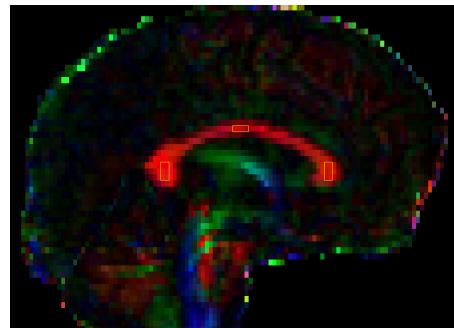


Figure 2. Rectangular ROIs on a midsagittal FA image.

Discussion

This preliminary analysis suggests that the atrophy of the CC observed in TBI can be attributed to demyelination of the axonal bundles in the CC. The apparent atrophy might be compounded by the increased ventricular size due to edema. The significant correlation of the FA with the severity score suggest that FA might be able to be used as a biomarker or outcome predictor in TBI.

References

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