# Region of Interest Analysis of DTI FA Histogram Differentiates Mild Traumatic Brain Injury from Controls

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**Introduction:** Over 1.2 million people sustain mild traumatic brain injury (MTBI) each year in the United States [1]. Over 90% of MTBI patients have no any evidence of abnormality in conventional neuroimaging. The neurocognitive diagnostic method suffers its subjective manner. The objective diagnosis of MTBI has been very challenging. Diffusion tensor imaging (DTI) has been reported being sensitive to MTBI. However, much more work needs to be done to further investigate the use of DTI for MTBI detection. Our previous work demonstrated that a global white matter Index can differentiate the traumatized brain from normal control patients [2]. Autopsy data revealed that, in diffuse axonal injury, the corpus callosum, internal capsule, and rostral part of brain stem are major locations subject to brain injury. It is still unknown how DTI findings are consistent with reported autopsy data on the regional locations of brain damage. This study is to investigate whether corpus callosum is a major location for DTI signal changes after brain injury.

**Materials and method:** Six MTBI patients with initial Glasgow Coma Scale (GCS) score 13-15 were recruited. Seventy (70) control subjects with their age ranging from 19-81 (SD= 19.22 years) with no history of any kind of brain injury were also recruited. All subjects were imaged with standard MRI sequences and DTI as a part of a multi-imaging protocol on a Siemens sonata 1.5 T scanner. Single shot spin-echo planar DTI was acquired in 6 directions with the following parameters FOV = 256*256, 128*128 matrix size, in plane resolution of 2*2*4, 35 slices, TR/TE = 5800/97, b values of 0 and 1000 sec/mm$^2$, NEX = 10. The conventional sequences included high resolution 3D FLASH T1, T2, Fluid Attenuation Inversion Recovery (FLAIR), Arterial Spin Labeling (ASL), Diffusion Weighted Imaging (DWI) and Susceptibility Weighted Imaging (SWI) sequence. Corresponding FA maps were generated using DTI studio software and normalized with SPM2. A white matter (WM)-only FA image for the whole brain were created after segmentation of each patient's spatially normalized FA image by using SPM2 (see details in Benson et al 2007). WM was then threshold to 100% to create a complete WM mask. Individual control's WM mask was then logically AND'ed with the regional CC masks created from the template after segmentation of the CC into 3 parts namely Genu (anterior), CC body and Splenium (posterior) using the anatomical land marks. This method ensured us of looking into the regions in the WM only. The mean values and histograms of each ROI were calculated in the similar procedure as that in Benson et al [2].

**Results:** Our whole brain WM FA histogram showed group difference between MTBI and controls in consistency with our previous published data. The means of whole brain WM FA also showed group difference (MTBI group mean 0.374, std 0.033; controls group mean 0.426, std 0.022). The region of interest (ROI) analysis of corpus callosum (CC) also showed their histogram difference between MTBI and controls (MTBI group mean of FA in CC 0.567, std 0.050; control group mean of FA in CC 0.645, std 0.027). by further breaking down of CC, the body of CC showed group difference in their means (MTBI mean 0.531, std 0.056; control mean 0.624, std 0.031); while genu and splenium parts of CC showed marginally difference between groups. All together, all FA histograms demonstrated clear difference between MTBI and control groups.

Furthermore, the group difference can be more clearly demonstrated by the integral curve of the area under histogram (ICUAH). For the whole CC, the 50% frequency threshold of pixels are 0.634 (p=0.006) for controls and 0.540 (p=0.041) for MTBI patients, respectively. For the body of CC, the 50% frequency threshold of pixels are 0.613 (p=0.007) for controls and 0.509 (p=0.048) for MTBI, respectively.

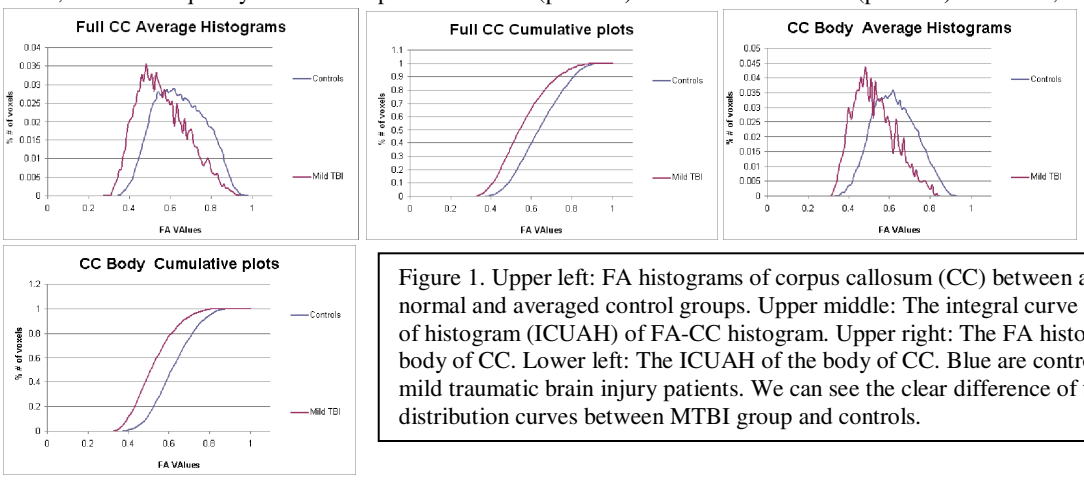


Figure 1. Upper left: FA histograms of corpus callosum (CC) between averaged normal and averaged control groups. Upper middle: The integral curve under the area of histogram (ICUAH) of FA-CC histogram. Upper right: The FA histograms of the body of CC. Lower left: The ICUAH of the body of CC. Blue are controls and red are mild traumatic brain injury patients. We can see the clear difference of their distribution curves between MTBI group and controls.

**Discussion and conclusions:** Our regional histogram of white matter FA showed being able to differentiate the MTBI patients from controls on the normal appearing corpus callosum. Particularly, the whole CC and the body of cc showed prominent group differences between MTBI and controls. This data is consistent with the published autopsy report of the hallmarker lesion on cc in DAI patients. In conclusion, our DTI ROI analysis of corpus callosum may serve as a hallmarker of mild traumatic brain injury. This will be particularly important in clinics in those brain injured patients with normal appearing brain in structural MRI.

**References:**

1. Thurman D, Guerrero J, *Trends in hospitalization associated with traumatic brain injury.* JAMA, 1999. **282**: p. 954–7.
2. Benson RR, Meda SA, Vasudevan S, Kou Z, Govindarajan KA, Hanks RA, Millis SR, Makki M, Latif Z, Coplin W, Meythaler J, Haacke EM, *Global white matter analysis of diffusion tensor images is predictive of injury severity in TBI.* J Neurotrauma, 2007. **24**(3): p. 446-459.