7T DTI in Mild Traumatic Brain Injury Patients and Age Matched Controls

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Introduction:

Mild chronic traumatic brain Injury (TBI) often occurs without anatomical MRI changes despite the presence of behavioral deficits. Quantitative analysis of diffusion tensor imaging (DTI) data, such as ADC, FA [1, 2], and diffusion fiber tractography revealed subtle differences already at lower field-strengths [3] suggesting that ultra-high field MR might have additional abilities. The objective of this study was to assess the potential of 7T DTI in a defined patient population with traumatic brain injury.

Methods:

Ten mild TBI patients (ages 34-54y) and ten approximately age- matched healthy subjects (31-56y) were imaged at 7T (Philips, Achieva) after signing an IRB approved-informed consent. Images were acquired with a 16 channel receive coil (Nova medical), using SE-EPI DTI sequence with TR/TE = 5126 ms/75 ms, SENSE-factor = 5, voxel size = 1.6×1.6×3.2 mm^3, with b = 0, 1000 s/mm^2 and 6 b-directions. In addition ultra-high resolution susceptibility weighted image (SWI: TR/TE/flip = 24.5 ms/12 ms/5°, voxel size = 0.5×0.5×1.6 mm^3) and T1-weighted IR prepared turbo gradient echo images (shot interval between IR pulses TS = 4000 ms , TI = 2000 ms, TR/TE1/TE2/flip = 14 ms/2.5 ms/10.5 ms/8°, voxel size = 0.5×0.5×1.6 mm^3) were collected. Diffusion tensor images were analyzed using Philips Fiber Trak with default parameter setting (FA > 0.15, angle change < 27°, fiber length < 10 mm). Analysis included tractography from a single ROI that covered the whole corpus callosum in a mid-sagittal registered plane. Statistical analysis included resulting number of lines, voxels, fiber length, mean ADC and FA values. In addition the corpus callosum was traced on color FA maps and RGB color statistics was used to assess the alignment of fibers passing through the ROI by using DTI Studio [4] and Image J (public domain NIH Image program).

Results:

Anatomical abnormalities were not seen on T1W and SWI of the TBI patient except one case. In TBI patients the mean length of fibers through the corpus callosum was shorter, mean ADC values were larger and mean FA values were smaller compared to healthy control subjects (Table). Figure 1 shows example of DTI tractography of a TBI patient and a healthy age-matched control. Independently performed analyses by two analyzers were not significantly different. Investigation of color histogram of an ROI that covers corpus callosum in the central sagittal plane showed lower mean red color index (control vs. patient: 167/141, color index ranges 0 to 255 in RGB color space).

	TBI patients	Controls	p –value
mean fiber length [mm]	59.5	68.5	0.01
mean FA	0.59	0.56	0.03
mean ADC [10^{-3} s/mm^2]	0.99	0.89	0.03

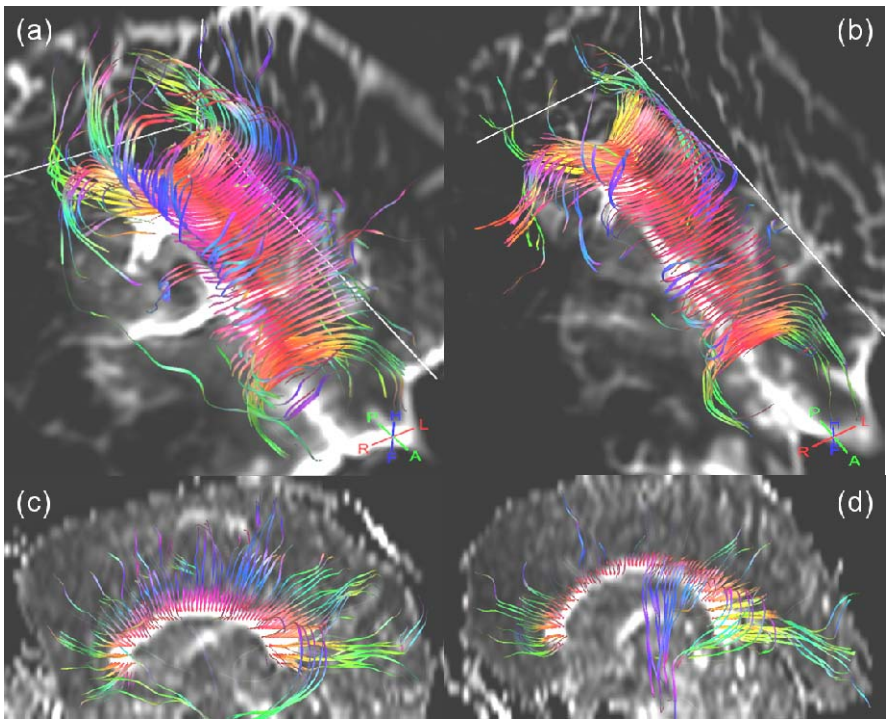

Figure1: 7T fiber tracking in the corpus callosum of a healthy subject (a, c; 49-year, female) and in a TBI patient (b, d; 50-year, female) The fiber density and the fiber length in the patient are decreased.

Discussion:

Despite magnetic field inhomogeneities at ultra high field strengths, our 7T DTI showed brain diffusion abnormalities, i.e. shorter fibers, larger ADC and smaller FA values, in TBI patients compared to healthy control subjects. This pilot data appears indicative of the improved diagnostic potential of changes in patients with TBI at 7T. Future evaluation of additional anatomic regions, e.g. fibers connecting the amygdala to the anterior cingulate and orbital frontal cortex or tracts emanating from the thalamus, may more selectively correlate the behavioral deficits in these patients.

References:

[1] Nusbaum et al., 2001 AJNR 22:136 – 142. [2] Gideon et al., 1994 JMRI 4:185 – 188. [3] Basser et al., 2000 MRM 44:625 – 632. [4] Jiang et al. Comput Methods Programs Biomed 2006 81:106 – 16.