A DTI-Based Assessment of the Changes in the White Matter in Opioid Addict Patients: A Parcellation Based Approach

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Introduction: Changes in white matter have been previously reported in patients having taken an overdose of heroin [1,2] and buprenorphine [3]. In this study structural MRI (sMRI) and diffusion tensor imaging (DTI) were employed to evaluate potential white matter abnormality in a cohort of prescription opioid dependent subjects vs. demographically matched comparison subjects.

Methods: Ten prescription opioid-dependent subjects (age: 29.4 ± 8.9 yrs; selected from a cohort of 84 subjects entering into a NIDA study on prescription opioid addiction) and 10 matched mentally healthy individuals (age: 29.9 ± 7.9 yrs) were recruited for this study. All data were collected on a 3 Tesla Siemens Trio scanner with an 8-channel phased array head coil (Erlangen, Germany). Two high resolution, T_1-weighted (sMRI) datasets were collected from each patient and control subject using a 3-D MPRAGE pulse sequence (TR/TE/TI=2100/2.74/1100ms, FA=12, 128 sagittal slices, Resolution = 1.33 x 1.0 x 1.0 mm^3). DTI data were collected using a single shot-twice refocused echo planar imaging (EPI) pulse sequence. A single non-diffusion weighted (b = 0 sec/mm^2) and 72 distinct diffusion-weighted volumes were collected at b = 1000 sec/mm^2. DTI-EPI Parameters: TR/TE=7900/92 ms, 5/8 partial Fourier, 3-fold SENSE acceleration, 50 axial slices, Resolution = 1.75 x 1.75 x 2.5 mm^3 (~10 mins).

Fig1. a. WM segmentation, b.Erosion by 1 pixel, c.WM matter and cortex parcellation

DTI analysis was carried out using FMRIB Software Library (FSL) (www.fmrib.ax.ac.uk/fsl), version 4.1.3 following skull stripping and eddy current distortion and head motion correction. A diffusion tensor for each voxel was calculated using a least squares fit of the tensor model to the DTI data. From the diffusion tensors, the eigenvalues and fractional anisotropy (FA) values were calculated for each voxel. A minimum FA threshold of 0.2 was used to threshold the data. The FA maps were subsequently registered to each subject's anatomical volume. White matter parcellation for each subject was performed using Freesurfer tools (http://surfer.nmr.mgh.harvard.edu/). For this purpose first the cortex was reconstructed and parcellated. The white matter volume underneath (5mm) each cortical parcellation was labeled as the wm parcellation corresponding to the cortical parcellation. To avoid partial volume effects at the border of gray and white matter, all of the wm parcellations were eroded by one voxel (Figure 1).
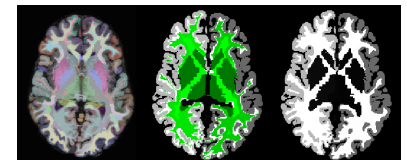
Results: The present results suggest that regional FA is affected by the prescription opioid usage and there is an overall reduction of the mean FA in the affected brain areas as assessed by the parcellation based approach (Figure 2). The results of the proposed approach were in agreement with the results of a tract-based analysis (Figure 3).

Conclusion: There is a significant damage to the white matter caused in the patient group, which presents itself in the form of reduced fractional anisotropy in various white matter areas. The approach used in this study to evaluate the white matter has the major advantage that errors due to imperfect inter-subject registration in the presence of significant anatomical differences is avoided by remaining in each subjects anatomical space for FA assessment.
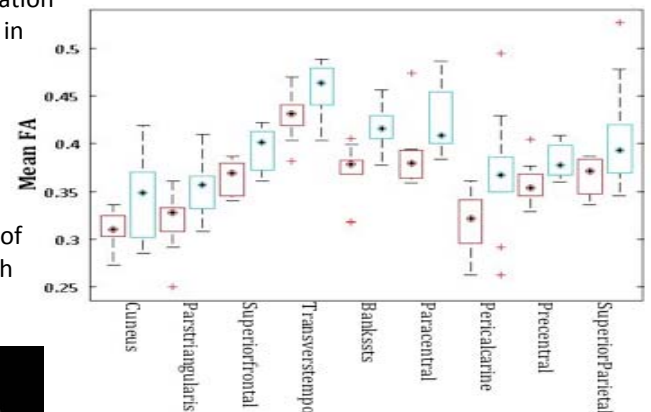

Figure 2. Mean FA in patients (red) and healthy subjects (blue). Dark circles indicate medians (P<0.05).
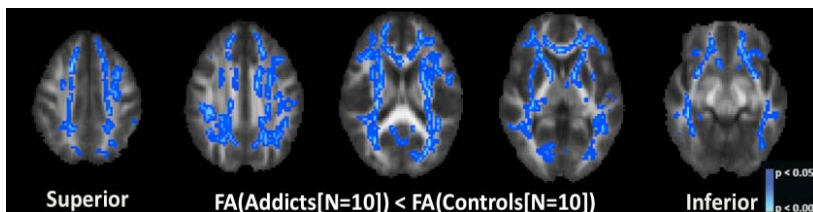

Figure 3. Tract-based spatial statistics (TBSS) analysis results

References: [1] Ryan, A., et al., *J Neurol Neurosurg Psychiatry* 76:1014-1016., [2] Offiah, C., and Hall, E. 2008., *Clin Radiol* 63:146-152., [3] Seet, R.C., 2005. *J Neurol Neurosurg Psychiatry* 76:890-891.