Alterations in white matter tracts in alcohol dependence: A Tract-Based Spatial Statistics (TBSS) based DTI study

Mukesh Kumar[1], Shilpi Modi[1], Pawan Kumar[1], and Subash Khushu[1]
[1]*NMR Research Centre, Institute of Nuclear Medicine and Allied Sciences (INMAS), New Delhi, Delhi, India*

Target audience: Researchers working in the field of alcoholism and neuroimaging**.**

Purpose: Diffusion tensor imaging is a quantitative non invasive method for measuring changes in white matter fibres tracts. The previous neuroimaging studies in alcohol dependence demonstrate white matter volume loss and neurocognitive impairments[1,2]. In present study, we used Tract-Based Spatial Statistics (TBSS) of DTI measures as well as probabilistic tractography to investigate micro-structural disruption of white matter tracts in alcohol dependence.

Materials and Methods: Twenty-nine control subjects (mean age ± SD =34.23±6.25) and twenty-eight alcoholic patients (mean age ± SD =36.93±5.95) participated in the study. The informed consent was obtained from all the subjects prior to DTI study. All the alcoholic patients were recruited from an army rehabilitation centre, and met Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria for alcohol substance dependence, and had abstained from alcohol drinking (17±4.5 days). None of the subject had any history of neurological or psychiatric disorders. The study was approved by the institutional ethics committee.
Imaging was performed on a 3-Tesla MRI scanner (Magnetom, Skyra, Siemens) with a 20 channel head and neck coil and 25 mT/m actively shielded gradient system. The conventional MR imaging was done prior to DTI to rule out any structural abnormality using routine T2-weighted turbo spin-echo sequence. DTI data were acquired using a single-shot echo-planar dual SE sequence in 30 directions with ramp sampling. Diffusion-weighted acquisition parameters were: b-factor= 0 and 1000 s/mm^2, slice thickness=3 mm with no inter-slice space, number of slices=45, FOV=230 mm×230 mm, matrix size = 128 × 128, spatial resolution = 1.797 mm X 1.797 mm X 3mm, flip angle 90°, TR = 8800 ms, TE = 95 ms and NEX=2.
Pre and post-processing of the diffusion tensor images was performed using software tools from the FMRIB software library (FSL, http://www.fmrib.ox.ac.uk/fsl)[3].

Results: In our study, significantly decreased FA values were observed in the anterior thalamic radiation, inferior fronto-occipital fasiculus, superior longitudinal fasciculus, inferior longitudinal fasciculus, forceps minor, corticospinal tract, cingulum, uncinate fasciculus in alcohol dependant subjects as compared to controls.

Discussion: The TBSS analysis of DTI data from alcohol dependant individuals showed widespread injury to white matter regions including major fibre tracts in the fronto-occipital lobe and cortico-strial regions. In alcohol dependence, reduced FA in regions of major commissural fibres and superior longitudinal fasciculus might be associated with visuospatial memory deficits earlier reported in alcohol dependent subjects[4,5]. Similarly, reduced FA in corticospinal tract, uncinate fasciculus, cingulum and anterior thalamic radiation might be associated with deficits in executive and motor function, emotional and memory impairment and other alcoholism related neuropathology[2,5].

Conclusion: Our findings suggest that alcohol dependence demonstrated widespread reduction of FA in major white matter pathways and such abnormal white matter structure may be linked to some cognitive and behavioural impairment. However, correlation between white matter fibre strength and neuropsychological scores of subjects is needed to establish its functional consequence.

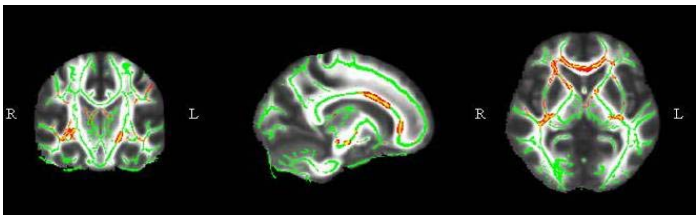

Figure 1- show mean horizontal FA skeleton from 28 alcoholics dependents and 29 controls yellow voxels show the regions where FA was reduced in alcohol dependence as compared with controls ($p < 0.05$)

Table 1- Areas of decreased fractional anisotropy in alcohol dependents (n= 28) compared with controls (n= 29) age use as covariates

Anatomic location	Cluster size(voxels)
Anterior thalamic radiation	1366
Corticospinal tract	413
Cingulum	84
Forceps minor	4945
Inferior fronto-occipital fasciculus	2344
Inferior longitudinal fasciculus	337
Superior longitudinal fasciculus	2101
Uncinate fasciculus	405

Reference:

1. Reagan R., et al. Frontoparietal connectivity in substance-naive youth with and without a family history of alcoholism. Brain Res. 2012;1432:66-73.
2. Trivedi R., et al. White matter damage is associated with memory decline in chronic alcoholics: A quantitative diffusion tensor tractography study. Behav. Brain Res. 2013;250:192-198.
3.Smith SM., et al. Tract-based spatial statistics: voxelwise analysis of multi-subject diffusion data. Neuroimage 2006;31(4):1487-505.
4. Hill SY., et al. White matter microstructure, alcohol exposure, and familial risk for alcohol dependence. Psychiatry Res. 2013;212(1):43-53.
5. Yeh PH., et al. Tract-based spatial statistics (TBSS) of diffusion tensor imaging data in alcohol dependence: abnormalities of the motivational neurocircuitry. Psychiatry Res. 2009;173(1):22-30.