White Matter Abnormalities in Alcohol Dependents using Diffusion Tensor Imaging at 3T

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Introduction

Chronic alcoholics show significant volume loss in brain structures that includes both gray and white matter shrinkage [1]. Previous neuroimaging studies have shown that white matter damage accompanies excessive alcohol use, but the mechanisms of alcohol-related white matter damage remain unknown [2]. Recently, diffusion tensor imaging (DTI) studies have explored the relationship between alcohol use and white matter integrity in adolescents [3]. They suggest that alcohol use is associated with reduced white matter integrity, particularly in the superior/inferior longitudinal fasciculus, the anterior limb of the internal capsule, and the corpus callosum [4]. More studies are still needed to confirm those observations. We applied quantitative DTI to investigate the association between alcohol use and white matter integrity in adults. The purpose of this study was to examine the reproducibility of the DTI by evaluating measures of anisotropy and diffusivity in brain regions such as the fornix, cingulum, and the corpus callosum.

Materials and Methods

This study included 45 subjects, 22 male alcohol dependents (mean±SD, 51±8.3 years) and 23 healthy control subjects (mean±SD, 52±8.4 years). MRI scans were performed on a 3T (e.g., Philips Achieva 3.0 TX). DTI scans were acquired using single-shot spin-echo echo-planar imaging (3 mm thick slices, TR=6000ms, TE=70ms, 128x128 zerofilled to a 256x256 acquisition metrix, FOV=24cm, 50 slices). A 32-channel receive-only array head coil was used, with SENSE (x2), 32 gradient directions, and b=80 sec/mm2, and the b=0 experiment was repeated five times. Image postprocessing was performed to generate apparent diffusion coefficient (ADC) and fractional anisotropy (FA) maps with vendor-provided software (e.g., Philips Fiber Tracking tool). The regions of interest were determined from the FA MR images. White matter regions (e.g., cingulum, corpus callosum, and fornix (not shown here)) were selected, and FA values for the skelectonized voxels were averaged to obtain single value per tract to be used in correlations with clinical data. For multivariate analysis, partial least squares regression discriminant analysis (PLS-DA) was performed to distinguish between the two groups. To identify which variables were responsible for the separation, the variable influence on the projection (VIP) parameter was used (SIMCA-P 13.0 software).

Results

Figure 1 shows representative FA maps from a healthy control (Left) and alcohol dependent patient (Right). In the FA map of alcoholic, the white matter in the area of cingulum and corpus callosum shows a decrease in fractional anisotropy. As shown in Figure 2, the main observation in this work was the significant reduction of FA and increase of ADC value in the corpus callosum of alcohol-dependent patients compared to healthy controls ($p<0.05$ and $p<0.01$). Significantly decreased FA value was found in the left cingulum of the alcoholics as compared to the controls ($p<0.01$), but not significant in the right cingulum ($p>0.05$). In addition, there was significant difference in both FA and ADC values in fornix between the two groups ($p<0.0001$ and $p<0.0001$, not shown in Figure 2). Using 2 DTI measures (e.g., ADC of corpus callosum and FA of cingulum) with VIP>1, an optimal PLA-DA model did not show a significant separation between the two groups (Figure 3).

Discussion

We demonstrated that alcohol use is associated with reduced white matter integrity in fornix, cingulum, and the corpus callosum in adults. In this study, alcohol-dependent subjects differed from controls in the three regions studied, with lower FA and higher ADC. The higher diffusivity reflects more unconstrained diffusion typically indicative of worse integrity. The result suggests that alcohol may damage white matter integrity in these regions. Recently, Konrad *et. al*., [5] found evidence of more widespread reductions in white matter integrity in the sample of 24 alcohol-dependent patients. Relative to controls, the alcohol-dependent group showed significantly lower white matter integrity in 8 different brain regions including the internal capsule, the cerebellum, and corpus callosum. Thus, DTI can provide useful information for quantification of white matter integrity in vivo.

References

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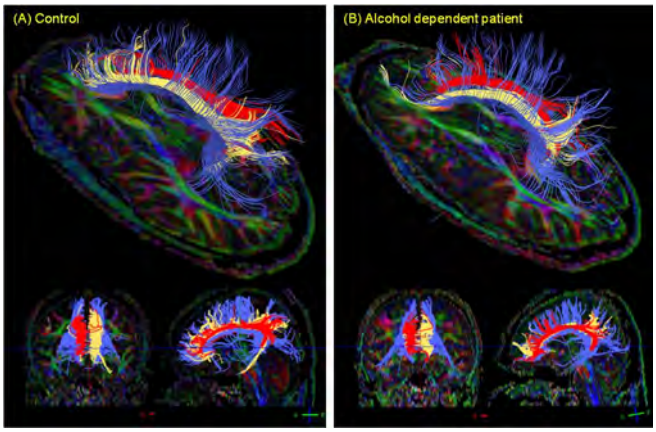

Figure 1. Fractional anisotropy (FA) map imaging from a healthy control (Left) and alcohol-dependent patient (Right) with a DTI technique. Highly directional white matter structures (e.g., cingulum and corpus callosum) are observed on FA maps in healthy control.

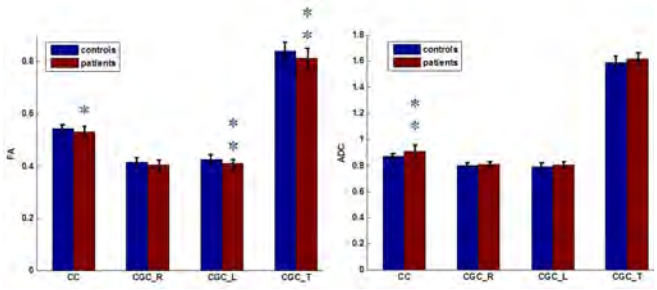

Figure 2. FA and ADC values quantified in the corpus callosum (CC) and cingulum (CGC) of alcohol-dependent patients and healthy controls. Data shows mean±SD for each group using a two tailed *t*-test with significance threshold of *p<0.05 and **p<0.01. Note that L=left, R=right, and T=total.

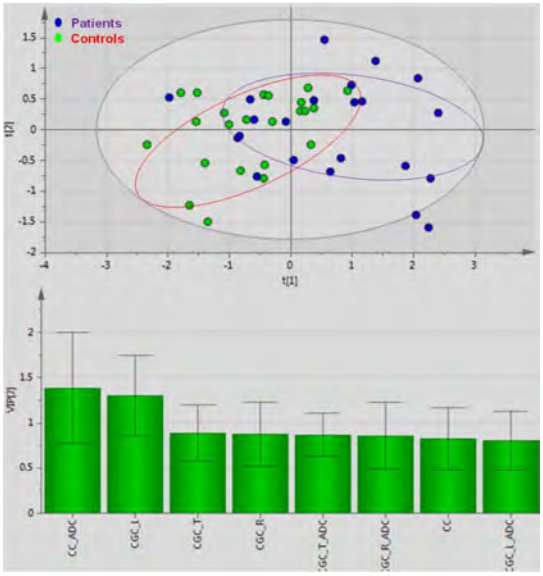

Figure 3. The variables with VIP values in PLS-DA model (bottom) and PLS-DA scores plot (top). The model did not allow a good separation of the two groups (e.g., alcohol-dependent patients vs. healthy controls).