Evaluation of Corpus Callosum Anisotropy in Young Adults with Fetal Alcohol Syndrome Using Diffusion Tensor Imaging

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SYNOPSIS

Diffusion tensor imaging was used to evaluate the corpus callosum diffusion anisotropy in six normal volunteers and five patients with fetal alcohol syndrome (FAS). A decreased fractional anisotropy (FA) along with an increased apparent diffusion coefficient (ADC) were observed in the corpus callosum in FAS patients compared with those in normals. Our results illustrate that DTI could be used in evaluating the integrity of corpus callosum in FAS patient. The diffusion anisotropy, represented by FA, may have the potential to be used as a clinical marker in the diagnosis of FAS and for assessing the severity of this disease.

Introduction

Fetal alcohol syndrome (FAS) and the spectrum of associated disorders that result from maternal alcohol use during gestation are among the most common developmental disorders (1). However, they are rarely diagnosed and not fully understood in terms of their behavior and neurocognitive phenotype. Prenatal exposure leads to alterations in facial morphology, growth and neurocognition (2), but the relationship between the teratogenic effects on brain and observed behavioral outcomes remains in debate due to the fact that there is no existing marker for the neurological effects of the teratogenic exposure. In this study we examined the impact of prenatal alcohol exposure on the brain in young adults who have been followed since the prenatal period using diffusion tensor imaging (DTI) (3), which may provide evidence that observed behavioral outcomes can be attributed to the effects of teratogenic exposure on white matter integrity rather than associated social and behavioral factors.

Methods

Diffusion tensor images were acquired using diffusion weighted single-shot spin echo EPI sequence. A dual spin echo technique was employed to minimize the geometric distortion induced by eddy currents. Diffusion weighting was applied in 12 directions with a b-value of 1000 s/mm². Six normal volunteers and five FAS patients, with Adolescent Pedscore: 9~27 and IQ: 44~74, participated in MRI DTI examinations. All studies were performed on a 3 T Siemens Trio system. The following parameters were used: TR=2660ms, TE=86ms, FOV=22cm×22cm, slice thickness =2.5mm, slice gap=0mm, number of slices=19 (in order to cover the whole range of corpus callosum), b=0, 1000s/mm², and 12 averages. The total imaging time was 7:27 minutes. Images (128×96 matrix size) were acquired in the axial orientation. The diffusion tensor was calculated for each voxel, and the averaged diffusion coefficient (ADC) and the fractional anisotropy (FA) maps were generated using DtiMap (Johns Hopkins Univ) (4).

Results and Discussions

ROI calculations are performed to obtain the mean value and standard derivation of ADC, and FA. The between group comparison was made in order to ascertain correlation between the changes in corpus callosum diffusion anisotropy and neuropsychological deficits. Figure 1 shows T2, ADC, FA, and color maps from a patient. The comparison of ADC and FA between normal control and patient is listed in Table 1. ROI measurements in the genu and the splenium of the corpus callosum (CCg and CCS) in FAS patients showed a lower FA value and a higher ADC value compared to those in normal volunteers. Since brain regions with dense and highly orientated fiber bundles have a high anisotropy, the decrease in FA in FAS patients suggest that there is abnormal development of white matter in CC causing degradation of corpus callosum, such that fibers are less dense or less oriented and the diffusion becomes less anisotropic. Also, the results from these subjects suggest that changes in both FA and ADC might be proportional to Pedscore as FA and ADC in the patient with a lower Pedscore and a higher IQ were found to be closer to those in normals. We anticipate that a study with a larger control and patient groups will further verify this observation as well as determine whether there is quantitative relationship between the reduction in FA of CC in FAS patients with the behavior deficits.

Table 1. Comparison of FA and ADC values between normal control and FAS patients.

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<tr>
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<th>CCg</th>
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<th>CCs</th>
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<tbody>
<tr>
<td>ADC (10⁻⁵ cm²/sec)</td>
<td>FA</td>
<td>ADC (10⁻⁵ cm²/sec)</td>
<td>FA</td>
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<tr>
<td>Normal (6)</td>
<td>1.042 ± 0.037</td>
<td>0.593 ± 0.021</td>
<td>0.957 ± 0.026</td>
<td>0.657 ± 0.117</td>
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<td>FAS Patients (5)</td>
<td>1.119 ± 0.053</td>
<td>0.496 ± 0.039</td>
<td>1.050 ± 0.068</td>
<td>0.591 ± 0.026</td>
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Conclusions

Our preliminary results illustrate that DTI could be used in evaluating the integrity of corpus callosum in FAS patient. The diffusion anisotropy, represented by FA, may have the potential to be used as a clinical marker in the diagnosis of FAS.

Acknowledgement

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References