Introduction:

Malformations of cortical development (MCD) are an important cause of partial epilepsy and have been described in 6-12% of adults with this form of epilepsy, however, the lesions may be difficult to detect on routine imaging. Epilepsy surgery on patients without any visible pathology on MRI is known to be associated with a less favorable outcome. MCD are a result of abnormal proliferation, migration or organization during brain development and therefore involve both the gray and the white matter. Diffusion tensor imaging (DTI) is an MRI technique, which incorporates pulsed magnetic field gradients into a standard MRI sequence, thus elucidating the differences in the diffusion of water molecules among various biologic tissues. The anisotropy of white matter and nerves is caused by tightly packed axonal membranes and, if present, the myelin in these tissues, which allow diffusion only in a direction parallel to the fibers. DTI is able to provide structural data about brain tissue and information about white matter in particular, which cannot be obtained by other imaging techniques.

Methods:

SUBJECTS:

- 3 patients: aged 21, 23, 39; 2 female, 1 male
- 11 normal controls: aged 19-46, median 29

IMAGING:

- 1.5 T Phillips Gyroscan ACS NT
- DTI acquisition: 50-60 axial slices with a slice thickness of 2.5 mm; diffusion weighting was applied along 30 independent axes; other imaging parameters: TR/TE=6453, 78T=80, acquisition matrix 256x256; reconstruction matrix 256x256; FOV 240, 3 acquisitions
- MPRAGE acquisition: TR/TE/TI of 8.1/3.7, flip angle of 8; acquisition matrix was 256 x 256, reconstruction matrix was 256 x 256 and the FOV 25.6 cm

ANALYSIS:

- Fractional anisotropy (FA) maps were calculated using software developed in-house
- Statistical parametric mapping (SPM2)
- Gray-white matter segmentation
- Normalization of study subject and normal control data onto a template
- Random-effects test of higher or lower anisotropy of each subject against the normal group
- Reported results are significant at p < 0.001 (uncorrected for multiple comparisons)

Results:

PATIENT 1:

- 39 y old male
- Temporal lobe seizure etiology (confusion, automatons)
- Marked bradykinesia, syncope during seizures
- Normal MRI, normal 18-FDG PET
- Anisotropy map identified decreased anisotropy in the white matter of the left insula
- Subdural strip recordings and depth recordings localized seizure onset to the left temporal lobe, patient did not have a resection, continues to have seizures on AEDs

PATIENT 2:

- 23 y old female
- Frontal lobe seizure etiology (head turn to left)
- MRI showed large right frontal dysplasia
- Marked bradykinesia, syncope during seizures
- Normal MRI, normal 18-FDG PET
- Anisotropy map also identified increased anisotropy all unchanged the right frontal dysplasia
- Subdural grid recordings identified right frontal dysplasia as seizure focus

PATIENT 3:

- 21 y old female
- Frontal lobe seizure etiology (head turn to right)
- Normal MRI, 18-FDG PET showed minimal hypometabolism in right temporal lobe, ictal SPECT showed increased tracer uptake in right fronto-temporal lobe
- Anisotropy map identified a cluster of decreased anisotropy in the white matter of the right frontal lobe
- Seizure monitoring with bilateral strip electrodes showed seizure discharges in several left frontal strips
- Seizure monitoring with subdural grid electrodes over left hemisphere showed seizure discharges in the left mesial frontal and the left lateral frontal cortex
- Pathology: no cortical dysplasia identified
- Patient continues to have seizures

NORMAL CONTROLS:

- 3 normal controls had small areas of statistically significant anisotropy decrease in areas of their white matter
- The identified areas of decreased anisotropy in normal controls were generally smaller than those identified in the 3 patients

Discussion:

- DTI identified areas of decreased anisotropy in the white matter of 3 patients with partial seizures
- Correlation of area of decreased fractional anisotropy (FA) in white matter with area of seizure onset

Conclusions:

- DTI is a promising, non-invasive technique for the localization of abnormalities associated with malformations of cortical development that give rise to partial epilepsy
- Further studies are needed to evaluate the potential of DTI in this area further
- Further studies are needed to define the normal range of white matter anisotropy

References:

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7. Kuzniecky RI, Sander TH. Clinical utility of diffusion tensor imaging in the evaluation of patients with seizures. Epilepsia 2002; 43(6 suppl):2-4