Abnormal gyrification of the cerebral cortex in mesial temporal lobe epilepsy

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Aim: The aim of this study was to examine magnetic resonance (MR) image-based lobar gyrification in patients with mesial temporal lobe epilepsy (TLE).

Background:

The field of quantitative MR-based epilepsy research has primarily focused on volumetric analysis of the brain, with special attention given to a few known key internal structures such as the hippocampus (Salempera 2001, Bernasconi 1999), volumetric changes of which are linked to the site of seizure focus. Other metrics such as surface area and cortical folding have received far less attention although they are acknowledged as more sensitive measures of the degree of cortico-cortical connectivity, an abnormal index of which may be implicated in the generation and propagation of seizures.

The developmental process of cortical folding is called gyrification, and produces the familiar peaks and valleys on the cortical surface. Any disruption of this process, whether by genetic or environmental factors, may result in malformations of cortical development (MCDs), which are increasingly recognised as a cause of epilepsy (Raymond, 1995). A measure of cortical gyrification may be used as a surrogate marker of cortical connectivity, and may provide further insight into the impact of brain morphology on seizure generation.

In this study we examine the MR-based gyrification index of a group of TLE patients and control subjects.

Methods:

10 mesial temporal lobe epilepsy (MTLE) patients (5 male, 5 female; 5 left seizure onset, 5 right seizure onset) were included. In each case mesial TLE (MTLE) was confirmed by EEG, qualitative MRI and post-surgical pathological examination. High-resolution pre-surgical T1-weighted volume scans were obtained for each subject. An automated cortical surface-based reconstruction technique, *FreeSurfer* (Fischl 2004), was used to model each subject's brain. Average cortical segmentation maps were applied to each model to generate lobar regions of interest (ROI's), namely, frontal, temporal, parietal and occipital lobes as defined by Desikan et. al. (Desikan 2006). Measurements of cortical surface area and volume were generated for each lobe.

A measure of cortical gyrification was generated, namely the isoperimetric ratio (IPR), which is defined as surface area corrected for volume;

$$\text{IPR} = \text{Surface Area} / \text{Volume}^{2/3}$$

The process was repeated for 10 sex-matched controls. Group differences between patients and controls were analysed using multivariate analysis of variance (MANOVA) for each lobar ROI.

Results: The patient group displayed significantly reduced cortical folding in the left and right temporal lobes when compared with the control group (Left $p = 0.023$, Right $p = 0.016$, see Figure 1). Frontal, parietal and occipital lobe gyrification displayed no change.

Conclusion: The use of quantitative methods for analysis of MR image data may help identify subtle abnormalities not readily appreciated through routine visual inspection. In this study automated methods of cortical surface reconstruction were used to identify subtle abnormalities of temporal lobe cortical gyrification in medial temporal lobe epilepsy. The identification of brain morphological abnormalities in TLE may help to further elucidate the pathogenesis of the disease.

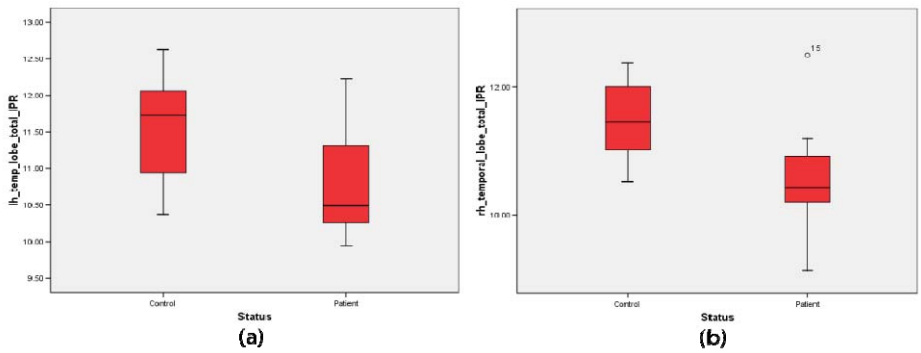

Figure 1 Box plots indicating IPR of MTLE patients and controls for (a) Left temporal lobe and (b) Right temporal lobe