Diffusion Tensor Imaging in Lateralising and Localising Epileptogenic Focus in Temporal Lobe Epilepsy with and without Hippocampal Sclerosis

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Purpose

Successful surgery for TLE depends on the precise localization and lateralization of the epileptogenic zone. However, up to 30% of TLE patients with clinically EEG well-lateralized temporal lobe seizures do not have any potentially structural epileptogenic lesion detected with current MRI techniques (HS-ve TLE patients). The majority of TLE patients have hippocampal sclerosis (HS; i.e. HS+veTLE) on a structural MRI and studies on these patients have reported increased ADC but conflicting FA results (decreased or no change) in the hippocampus and temporal lobe. No direct comparisons has been made between these two subtypes of TLE. The isotropic portion of diffusion tensor (p), the anisotropic portion (q) and the Euclidean magnitude of the tensor (L) have been recently quantified which allows a more precise dissection of the tensor. FA is shown to be a ratio-metric measurement of q/L. The application of DTI may better select for HS-ve patients who will have their seizure successfully controlled by surgery.

Aims

1) To determine whether the DTI changes can lateralise and localise the epileptogenic focus in unilateral TLE patients, particularly the HS-ve patients, by comparing the DTI changes between the ipsilateral versus contralateral hippocampus and the anterior temporal pole white matter and gray matter.
2) To determine whether the DTI changes primarily reflect the presence of Hippocampal Sclerosis, or the epileptogenic substrate independent of the underlying pathology by comparing the DTI variables between HS+veTLE versus HS-veTLE patients.
3) To explore the usefulness of the newly derived DTI variables, in particularly q, in quantifying anisotropic changes in TLE.

Methods and Materials

3D FSPGR and DTI scans were performed on eighteen HS+ve and ten HS-ve patients with medically refractory unilateral TLE diagnosed by EEG. Volumetric ROIs were performed for the Hippocampus and Anterior Temporal Pole (ATP) on the FSPGR scans. Both FSPGR and DTI scans were segmented in FSL FAST into tissue compartments as partial volume (pve) maps. ATP white matter and gray matter ROIs were derived from the FSPGR pve maps. The ROIs were realigned to the DTI space. The tissue pve maps were further thresholded to limit the ROIs to voxels with minimal partial voluming effects. Volumetric and DTI measurements (ADC, FA, p, q, L) were calculated and compared between the ipsilateral and contralateral ROIs, and ipsilateral/contralateral ratios were compared between groups. Volumetric and DTI measurements were correlated. Non-parametric tests were used.

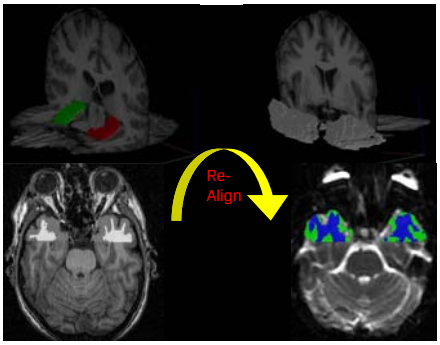


Figure 1: 3D volumetric ROI of Hippocampus and Anterior Temporal Pole. ROIs of ATP white and gray matter realigned to DTI space.

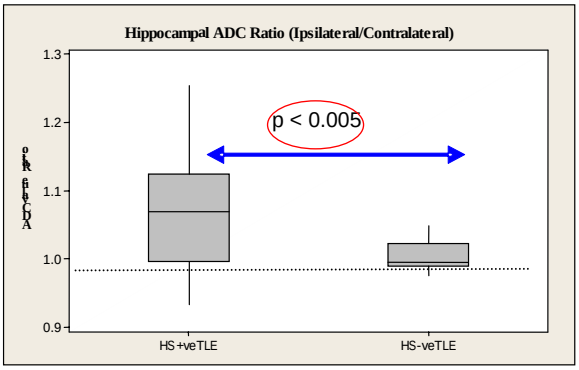
Results

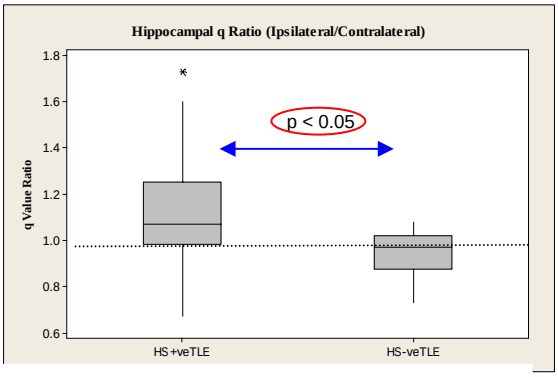
The results demonstrated that hippocampal ADC, p and L were increased on the epileptogenic side in HS+veTLE (ADC 1031 mm^2/s vs 972 mm^2/s p<0. 005) but not in HS-veTLE (ADC $963x10^{-6}$ vs $960x10^{-6}$ mm^2/s, p=0.72) and the hippocampal ADC, p and L ratios were higher in HS+ve TLE (ADC 1.06 vs 1.00 p<0.05). The q ratio was higher in the HS+ve TLE group compared to the HS-ve TLE group (1.14 vs 0.94 p<0.05) but not in the FA ratio (0.31 vs 0.2 p=0.076). In the ATP white matter, the ipsilateral ADC, p and L were higher than the contralateral side (ADC 869 mm^2/s vs 836 mm^2/s p<0.05) in the whole patient cohort with a trend in each group. However, the HS-ve TLE patients have a lower FA ratio (0.88 vs 1.04 p<0.05) and q ratio (0.91 vs 1.04 p<0.05) in the ATP white matter compared to HS+ve TLE group. HS-ve patients have a smaller ipsilateral ATP white matter volume compared to the contralateral side (3535 vs 4314 mm^3 p<0.05) and a smaller volume ratio correlated significantly with a higher ADC ratio (R=-0.73, p<0.05).

Discussion

Distinctive DTI profiles in the hippocampus and anterior temporal pole in HS+ve and HS-ve TLE patients suggest different clinicopathological basis in these two subtypes of TLE. Increased Diffusivity in ATP white matter in the whole TLE patient cohort suggests it can reflect primary or secondary epileptogenesis in this region. Decreased Anisotropy and volume in the ipsilateral ATP white matter in HS-veTLE suggests the epileptogenic region is in the neocortical ATP rather than the hippocampus. A novel finding was made demonstrating increased hippocampal anisotropy in patients with hippocampal sclerosis, using the q parameter

1. DTI may provide further localisation and lateralisation information in the ATP white matter region in HS-veTLE patients
2. Increased hippocampal diffusivity and anisotropy in chronic TLE likely reflect the structural changes of HS rather than epilepsy per se
3. The q parameter would be potentially useful in quantifying anisotropy changes in TLE compared to FA





Boxplots showing higher hippocampal ADC and q ratio in HS+ve TLE group compared to HS-veTLE group.