A study on patients with Temporal Lobe Epilepsy showed a relationship of a circle in a plane defined by FA and trace jointly

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Introduction

Interictal diffusion imaging studies in patients with medial temporal lobe epilepsy have shown an increased diffusivity in the epileptogenic hippocampus. Increased diffusivity was detected in the epileptic hippocampus and the ipsilateral temporal structures associated with a decreased anisotropy along the temporal lobe[(1)(2)(3)]. However, from such observations it is difficult to determine the status of water diffusion in the biological environment because the information reported as the change in mean diffusivity and anisotropy is not directly related and therefore segmented. This study showed a simple relationship existed in Fractional Anisotropy (FA) and trace, which defined a circle in a coordinate system of FA and normalized trace. The combined informations from the mean diffusivity and diffusion anisotropy described a clear scenario as the change in the microenvironment in water diffusion in epileptic patients.

Methods and Materials

Fractional Anisotropy was defined as the amplitude of the diffusion deviation tensor normalized with the amplitude of the diffusion tensor. The amplitude of the diffusion tensor can be defined as in Eq. 1, where $\lambda_1, \lambda_2, \lambda_3$ are the eigenvalues. If we defined the normalized trace as trace divided by the amplitude of the diffusion tensor, then a relationship existed between FA and the normalized trace as in Eq. 2. In a coordinate system of FA and $Trace_n$, this defined an arc with a radius of $\sqrt{3/2}$ in the first domain. It is clear that a decrease in FA must be accompanied by an increase in $Trace_n$. The angle for each point in the circle can be calculated, which reflected the extent of diffusion anisotropy per unit mean diffusivity.

$$Amplitude = \sqrt{\lambda_1^2 + \lambda_2^2 + \lambda_3^2} \qquad (1)$$

$$FA^2 + \frac{1}{2} Trace_N^2 = 1.5 \qquad (2)$$

DTI from 6 seizure patients of temporal lobe epilepsy, aged between 23 and 47, confirmed by 24 hr EEG monitoring, were acquired using a 1.5 T MR scanner (Vision Magnetom Siemens, Erlangen). The diffusion tensor was acquired with the following parameters: FOV=192 mm, flip angle =90°, b=886 s/mm^2, a voxel size of 3 mm * 3 mm * 3 mm. 25 averages were acquired within 15 minutes scan time, which covered the majority of the brain. Conevntional T1, T2 and proton density weighted images were acquired from the same subject as well. ROIs were carefully drawn by an experienced neuro-radiologist from the anatomical images. Two ROIs were selected, located in the hippocampus in the lesion side and the contra-lateral normal side. FA, trace and the amplitude of the diffusion tensor were calculated for each pixel within the ROI.

Result & Discussion

Fig.1 plotted the pixels from the lesion side (red) and normal side (black) in a coordinate system of FA and $Trace_n$. The solid line plotted the arc defined in Eq. (1). The average lesion FA, 0.25±0.10, is not significantly lower than the normal FA of 0.26±0.13. Fig 1 showed that a reduction in diffusion anisotropy is accompanied by an increase of mean diffusivity. However, pixels from both groups have a significant overlap. Fig. 2 plotted the angle for each pixels in Fig 1 against the amplitude of the diffusion tensor, which is a reflection of the absolute diffusion. The seizure pixels (red) have an average angle of 78.2±4.9 degree and amplitude of 1.57±0.29 × 10^{-3} mm^2/s. The contralateral normal pixels (black) have an average angle of 77.65±6.63 and amplitude of 1.72±0.41 × 10^{-3} mm^2/s. The circles in Fig 2 covered 95% of the pixels within the group. Fig 2 showed that the decrease in diffusion anisotropy can be attributed to a change in distributions of lesion pixels compared with the contralateral normal ones. The increase in the mean diffusivity is apparent but less dominant. This relationship specified in Eq. 2 therefore provided an insight into the balance of water diffusion and anisotropy than merely the averaged FA and trace values.

Reference

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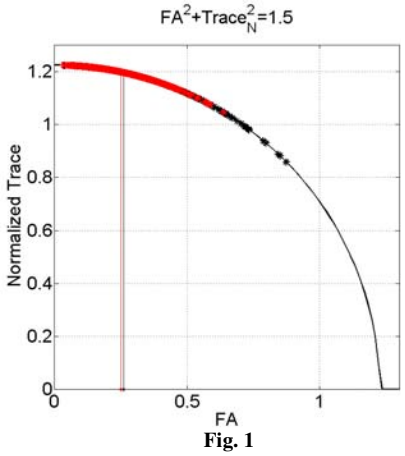

Fig. 1

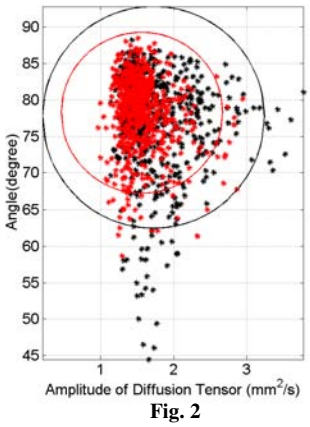

Fig. 2