Improved sensitivity in the temporal lobe epilepsy by measuring the area and volume of the diffusion anisotropy tensor

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Introduction: Diffusion related MR images have shown improved lesion specificity and sensitivity compared with conventional MR images in Epilepsy[1]. A reduced Fractional Anisotropy and increase trace were often noticed as an indication of the change of the micro-structure in the lesion. Diffusion anisotropy index is the measure of the diffusion deviation tensor. To improve the CNR and sensitivity of the diffusion anisotropy index on Epilepsy studies, we performed a systematic analysis by comparing the measures of the amplitude, area and volume on the normalized diffusion deviation tensor.

Methods and Materials: The diffusion deviation tensor measured the differences of the diffusion tensor from its mean eigenvalue. For comparison, the deviation tensor was normalized by the diffusion tensor. Three indices were proposed which measured the amplitude, area and volume of the normalized deviation tensor. The amplitude measure is the same as Fractional Anisotropy, $\sqrt{\frac{3}{2}} * \frac{\sqrt{\Delta\lambda_1^2 + \Delta\lambda_2^2 + \Delta\lambda_3^2}}{\sqrt{\lambda_1^2 + \lambda_2^2 + \lambda_3^2}}$. The area dimension measures the sum of the areas defined by the x-y, x-z and y-z axes in the principal coordinate system, $\frac{|\Delta\lambda_1||\Delta\lambda_2| + |\Delta\lambda_2||\Delta\lambda_3| + |\Delta\lambda_3||\Delta\lambda_1|}{|\lambda_1||\lambda_2| + |\lambda_2||\lambda_3| + |\lambda_3||\lambda_1|}$. The volume dimension measures is the multiplication of the eigenvalues, $\frac{|\Delta\lambda_1||\Delta\lambda_2||\Delta\lambda_3|}{|\lambda_1||\lambda_2||\lambda_3|}$.

DTI from 6 patients of temporal lobe epilepsy aged from 19 to 47, confirmed by 24 hr EEG monitoring, were measured using a 1.5 T MR scanner (Vision Magnetom Siemens, Erlangen). A diffusion weighted SE-EPI sequence, applied in six non-collinear directions, was acquired within approximately 15 minutes of 25 average at TE of 105ms, flip angle of 90° and a voxel size of 3 mm * 3 mm * 5 mm covering the major part of the brain. The b factor used is 886 s/mm^2. One non-diffusion weighted image was acquired. Regions Of Interest (ROIs) analysis were performed for each subject, with ROI carefully drawn by an experienced neuro-radiologist within lesion in the hippocampus defined in the anatomy image and the contra-lateral normal side. The sensitivity was measured as the index within the ROI in the lesion side subtracted from that in the contra-lateral normal side and then normalized with the average value in both ROI.

Result & Discussion: Figure 1 showed the measure of amplitude (left) and area (right) of the diffusion anisotropy index. The area index has a better SNR and CNR than that of FA map in human brain. Figure 2 plotted the percentage of change in the diffusion anisotropy index compared with that in the contra-lateral normal side. The black, gray and white bars are the measures of amplitude (FA), area and volume respectively and the trace is plotted in red. A positive change in the diffusion anisotropy index and negative in the trace were expected. Out of the six subjects, four findings in the diffusion anisotropy index are positive, but only two in the trace. The sensitivity in the measure of area and volume are 35.2% and 68.1% respectively, generally higher than that of FA, 13.8%. The result shows that the measures of area and volume have better sensitivity than the corresponding FA. The diffusion anisotropy index is more specific to the detection of seizure compared with trace. Measures of area and volume of the index showed improved sensitivity than the amplitude (FA) and with better delineation of the lesion.

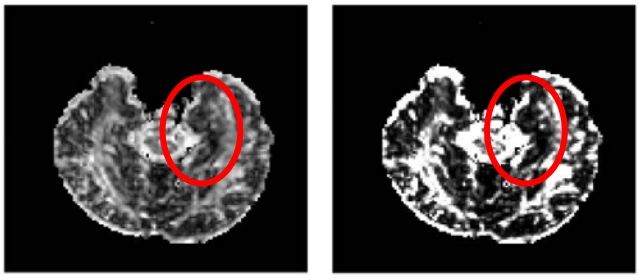

Figure 1

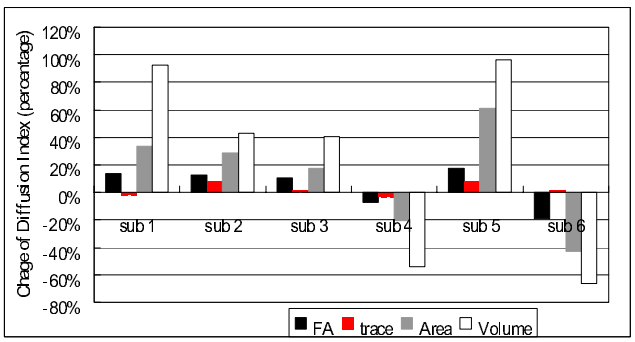

Figure 2

Reference: 1. Assaf BA et al. Journal of Neuroradiology 24(9):1857-62 (2003)

2. Arfanakis et al MRI 20(7):511-9 (2005)