

Importance of CSF suppression in diffusion tensor measurements

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Introduction

Arguably the main challenge of multiple sclerosis (MS) magnetic resonance imaging is to find a tool that will allow the characterization and quantification of disease progression. While the presence of lesions is indicative of disease, the lesion load does not provide a satisfactory signpost of disease progression as it merely speaks of small regions of the brain whereas there is a growing consensus that MS is a disease of the whole brain.

We have been investigating the usefulness of diffusion as a diagnostic tool for MS. As cerebral spinal fluid (CSF) is highly diffusive, any partial voluming with it will lead to misleading diffusion parameter values, and we therefore use a flair pulse to suppress its contribution. As the importance of the effect of CSF on the apparent diffusion coefficient (ADC) has already been shown (Falconer & Ponnada 1997, Kwong et al. 1991, Liu et al. 1996), we focus on the anisotropy and eigenvalues.

Methods

All the scans discussed here were run on a 1.5T GE signa instrument with a standard RF quadrature head coil. An EPI-SE diffusion tensor pulse sequence was acquired with a 128x64 matrix covering a 400x200 mm² field-of-view, and the slice thickness was 3 mm. The TR was 10s, the echo time was 100 ms, and the inversion time was 2200 ms; the b value was 1000 s/mm².

A region centred on the corpus callosum and covering a thickness of 33 mm (11 axial slices) was defined and used for the analysis. The diffusion tensor was calculated for each pixel and diagonalized, resulting in a mapping of the diffusion eigenvalues. The relative anisotropy was calculated as defined by

$$RA = \sqrt{\frac{i}{b\bar{\lambda}^2} (\bar{\lambda} - \lambda_i)^2}$$

where $\bar{\lambda}$ is the average of the eigenvalues. The region with very high CSF content were removed using a mask based on the T2-weighted image without diffusion weighting. This mask was applied to both flair and non-flair diffusion maps.

Results

The figure shows the anisotropy and eigenvalues for both the non-flair (dashed line) and flair (solid line) cases for a normal control.

The effect of the CSF suppression is to tighten the distribution for the three eigenvalues and decrease their median values. Concomitantly, the anisotropy is increased though its variance is unaffected. The trends were the same for all normal controls (5) and MS patients (12 RRMS) considered.

Conclusions

As CSF is an isotropically diffusing fluid, it is not surprising that the anisotropy should increase when it is suppressed. As well, partial voluming with this isotropic component results in a greater spread for measured diffusion eigenvalues. Therefore if one wishes to characterize the diffusion in white matter for MS patients and compare with controls, it is essential to suppress the CSF signal in order to obtain both more accurate and more precise values.

References

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