Assessments of diffusion sensitivity in identifying brain lesions in clinically isolated syndrome subjects

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Introduction

Diffusion tensor imaging (DTI) is unique in its non-invasive capability to reveal physiological information related to water diffusion, such as fractional anisotropy (FA) and apparent diffusion coefficient (ADC). Direct statistical comparisons of these physiological parameters between normal volunteers and patients can be invaluable in detecting abnormalities in patients who have suspected white matter abnormalities [1,2,3]. Voxel based whole brain DTI statistical analysis [4,5] was developed in an attempt to better determine the extent of lesions throughout the entire brain. In this work, we first derived the mean and standard deviation maps of FA and ADC from 28 age-matched normal volunteers, and these statistics were subsequently employed for statistical comparison with DTI images from 8 CIS/MS patients. In addition, lesions identified in T2-weighted images were used as the gold standard so that the sensitivity of diffusion in delineating MS lesions can be assessed.

Materials and Methods

28 normal volunteers (aged from 25 to 45) and 8 CIS/MS patients were recruited with written consents. T1 weighted (1mm^3 in voxel size) and DTI images (6 different encoding directions and 2mm^3 in voxel size) were collected for all the subjects on a Siemens 3T head only scanner. T2 weighted images (1mm^3 in voxel size) were also collected for all the patients. A board certified neuroradiologist reviewed all T2-weighted images and manually outlined each lesions based on clinical assessments. These lesions were then used as the ground truth of lesions in each patient.

Two registrations were used for spatial normalization of DTI results, the elastic registration with T1-weighted images for across subject alignment and the rigid registration for the transformation between the same subject's DTI and T1 images. For each patient, another rigid registration to map the DTI results towards T2 weighted images were also computed so that the sensitivity (true positive/(true positive+false negative)) of DTI can be obtained.

Results

One slice of the mean and standard deviation maps of FA and ADC were given in Fig. 1A and 1B, respectively. One slice of T2 weighted image (left) and the corresponding abnormal regions identified with the reduction of FA (middle, >2SD from normal) and elevation of ADC (right, >2SD) were presented in Fig. 2. Sensitivity curves for FA and ADC for all the 8 patients were given in Fig. 3 and Fig.4, respectively. It is apparent that with an increase of the threshold for detection, the sensitivity of FA statistics decayed more rapidly than that of ADC.

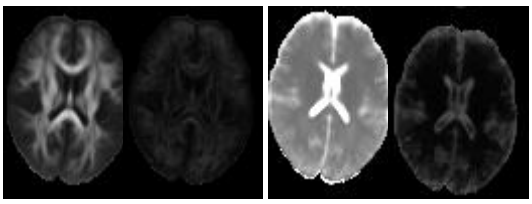

Fig. 1A

Fig. 1B

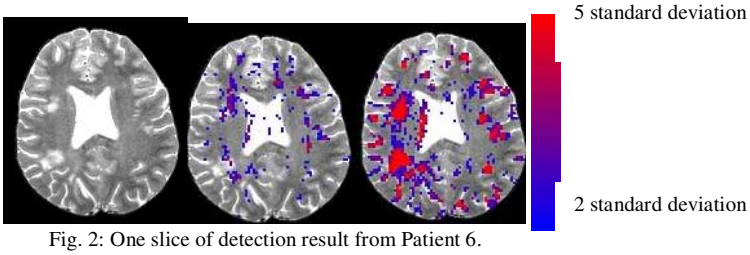

Fig. 2: One slice of detection result from Patient 6.

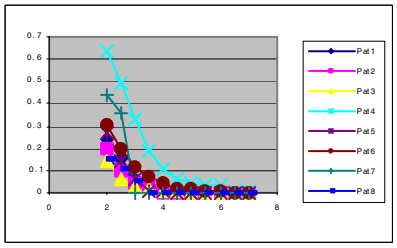

Fig. 3

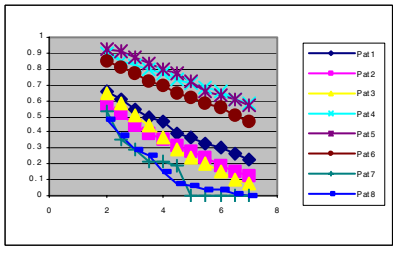

Fig. 4.

Discussion

While it has been demonstrated that DTI images are capable of delineating white matter abnormalities prior to other imaging sequences, the lack of "gold standard" makes it difficult to experimentally determine the sensitivity of this approach in delineating white matter lesions. To this end, we used the commonly employed T2 lesions as the gold standard so as to determine how sensitivity of DTI in delineating T2 lesions. Interestingly, the ADC appears to have a high sensitivity than that of FA. This finding may suggest that ADC maps may be more sensitive in delineating T2 lesions than that of FA.

References

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