Assessing white matter abnormalities in HIV patients using diffusion tensor imaging statistics through elastic image registration

H. An[1], Y. Chen[1], J. Smith[1], C. Hall[2], K. Robertson[2], K. Wilber[1], W. Robertson[2], L. Kwock[1], E. Bullitt[3], W. Lin[1]

[1]Radiology, The Univ. of North Carolina at Chapel Hill, Chapel Hill, North Carolina, United States, [2]Neurology, The Univ. of North Carolina at Chapel Hill, Chapel Hill, North Carolina, United States, [3]Surgery, The Univ. of North Carolina at Chapel Hill, Chapel Hill, North Carolina, United States

Introduction

Diffusion tensor imaging (DTI) [1] reveals the physiological information related to local water diffusivity within tissue. It allows for non-invasive evaluation of micro-structural integrity and putative orientation of white matter fiber. Two major physiological parameters related to water diffusion, fractional anistropy (FA) and apparent diffusion coefficient are widely utilized for the investigation of white matter diseases [2-7]. Many investigators have demonstrated that a reduction of FA and/or increase of ADC is commonly observed in patients with neurodegenerative diseases including HIV [3, 5]. Thus, DTI may serve as a biomarker for evaluating the severity of white matter abnormality in patients with HIV. Therefore, the main purposes of the study are: to determine whether DTI is able to detect abnormalities in HIV patients as well as to determine whether statistically significant differences existed in different HIV stages.

Materials and Methods

21 normal volunteers and 29 HIV patients in three different clinical stages (12 sub-clinical, 9 MCMD and 8 HAD) were scanned using T1 and DTI sequences. All anatomical images were co-registered to a common template chosen arbitrarily, and the transformations from co-registration were used to spatially normalize DTI results. The statistical analysis were performed with three quantities: 1) the locations of the peak of spatially normalized FA histogram, 2) spatially normalized abnormal volumes of different clinical groups and 3) the voxel based whole brain group differences among the three HIV groups and the normal controls using Tukey tests.

Results

The location of the peaks of the spatially normalized anisotropy histograms appears to move towards lower values in HIV patients. HAD group had the most deviation from the normal controls (Table 1 for the locations of peaks of spatially normalized histograms). Fig. 1 demonstrated the detected abnormal regions superimposed upon the FA templates with reduced FA(top row) and elevated ADC (bottom row). The blue and red colors indicate 2 and 5 standard deviations away from the mean of the normal controls, respectively. The abnormal volumes showed a trend to increase with the advancement of disease in general (Table 2). Statistically significant differences between each HIV group with normal controls were observed in genu and splenium of the corpus callosum, and the internal capsule. Group comparison for one representative anatomical location is given in Fig. 2 with the reduced FA (top row) and elevated ADC (bottom row). The differences, however, among the three patient groups were minimal.

Tabel1	
SUBC	0.333±0.039
MCMD	0.328±0.083
HAD	0.325±0.046
Normal	0.364±0.065

Table2	↓FA(cm^3)	↑ADC(cm^3)
SUBC	13.023±10.041	35.063±21.603
MCMD	14.122±8.833	31.418±22.541
HAD	19.915±10.087	50.635±22.912

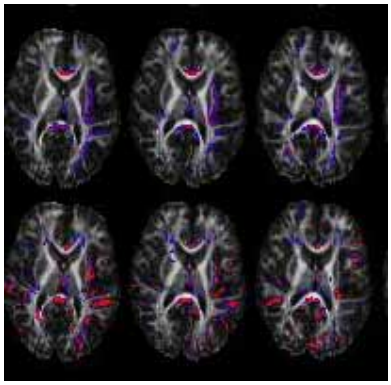

Fig. 1

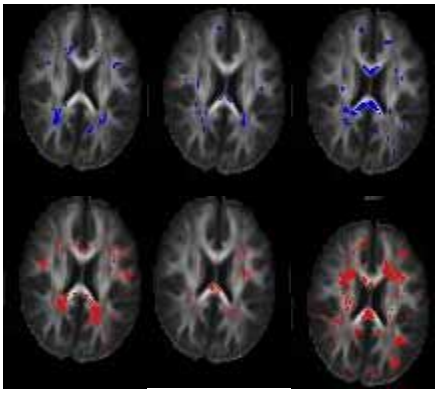

Fig. 2

Discussion

Despite the fact that only HAD and MCMD groups show clinical symptom, reduced FA and increased ADC are also observed in the sub-clinical MCMD group when compared with normal controls. This finding suggests that a whole brain diffusion tensor analysis is highly sensitive to reveal changes in white matter even before the onset of clinical symptoms in the disease. In contrast, although a tread of increasing abnormal FA volume was in observed from sub-clinical to HAD patients, statistical difference was not observed. A limited sample size may limit our ability to delineate the potential FA differences among the sub-types of HIV patients.

References

[1] Basser P. et al, Journal of Magnetic Resonance Series B 1994;103(3):247-254. [2] Bammer R, et al, Magnetic Resonance in Medicine 2000;44(4):583-591.
[3] Filippi C. et al, American Journal of Neuroradiology 2001;22(2):277-283. [4] Horsfield, NMR in Biomedicine 2002;15(7-8):570-577.
[5] Pomara N, et al. Psychiatry Research 2001;106(1):15-24. [6] Werring D. et al, Neurology 1999;52(8):1626-1632.
[7] Hanyu H, et al. Journal of the Neurological Sciences 1998;156(2):195-200.