Whole-Brain Correlation between Microstructural Alterations and Cognitive Performance of Alzheimer Disease Studied by Diffusion Kurtosis Imaging

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PURPOSE: Alzheimer's disease (AD) is a complex neurodegenerative disease of both white matter (WM) and gray matter (GM). The WM microstructural changes of AD have long been studied by diffusion tensor imaging (DTI). However, DTI assumes Gaussian distribution of water molecule motion and is inadequate to describe the actual diffusion process, which is restricted by its interactions with other compartments and cell membranes in biological tissues. Diffusion kurtosis imaging (DKI) is a high-order diffusion model that can solve these problems and provide additional microstructure information in WM, and especially in GM [1, 2]. In this study, we evaluate the correlation between non-Gaussian diffusion property and cognitive performance in AD patients using DKI. In addition, voxel-based whole-brain correlation is calculated instead of region-of-interests (ROI)-based methods.

METHODS: 26 AD patients underwent detailed neuropsychological assessments and the MRI examination. Images were acquired on a 3T MAGNETOM Trio Tim (Siemens AG, Erlangen, Germany) with a 32-channel head coil. Diffusion sequence was performed using a single-shot SE EPI sequence with 30 different diffusion encoding directions and 3 b values (b = 0, 1000, 2000 s/mm^2). Other imaging parameters were: TR/TE = 10500 ms/103 ms; FOV = 230×230 mm^2; matrix = 128×128; voxel = 1.8 × 1.8 × 1.8 mm^3; 73 axial slices. Maps of 3 DKI indices were calculated, including mean diffusivity (MD), fractional anisotropy (FA) and mean kurtosis (MK). Voxel-wise multiple-regression analyses were performed between the 3 DKI indices and the Mini-Mental Status Examination (MMSE) scores, respectively. Age and gender were considered as nuisance covariates, and the statistical threshold was $p < 0.001$ and clusters > 50 contiguous voxels.

RESULTS: As shown in the Fig. 1, MK values in the genu of CC, bilateral temporal and frontal lobe were positively correlated with the MMSE scores. We also found that the FA value was positively correlated to the MMSE in the genu of CC and bilateral frontal lobe, and MD was negatively correlated to the MMSE in the genu of CC, left temporal and bilateral frontal lobe. MK detected more correlated regions than FA and MD.

DISCUSSIONS: A recent study found that decreased kurtosis in the anterior corona radiata and prefrontal WM was linked to the combination of demyelination and axonal loss using DKI [3]. The significant correlation between the DKI indices in the genu of CC, bilateral temporal and frontal lobe in this study further indicated a lower degree of diffusion restriction in these regions of AD. Moreover, MK index showed higher correlation of MMSE scores than the other indices, which indicates that MK is more sensitive to microstructure changes and may be a better biomarker reflecting AD severity.

CONCLUSION: This study based on DKI found that the scores of cognitive performance were correlated to the severity of microstructural changes in some regions. Combined with various indices that DKI provided, DKI may be a powerful complementary technique in diagnosing and monitoring the AD progression, better suitable than conventional DTI.

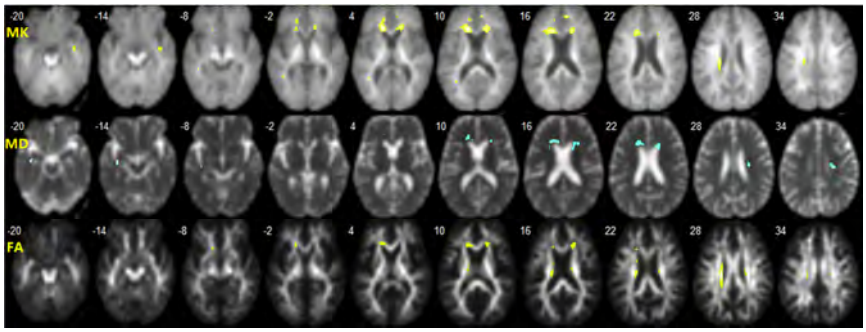

Fig.1 Representative axial images showing regions that correlated ($P < 0.001$) between the DKI indices (MK, MD, and FA) and the MMSE score in AD patients. Blue represents the clusters that correlated negatively between the index and the MMSE score; Yellow represents the clusters correlated positively between the index and the MMSE score.

REFERENCES:

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