Characterization of age-related changes in human brain using diffusion kurtosis imaging

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Introduction: Diffusion kurtosis imaging (DKI) is a novel technique to characterize a non-Gaussian diffusion property in biological tissues [1-5]. DKI has shown great promises to better characterize microstructural changes both in grey and white matter (GM/WM) in rodent [1, 2] and human [3, 4] while conventional diffusion tensor imaging (DTI) is limited to WM [3]. Recently, Veraart et al. reported that diffusivity measures by DKI provided more accurate estimation compared to conventional DTI [5]. In this study, we aimed to characterize age-related changes in a deep GM region using DKI at 3 Tesla clinical MRI system.

Methods: Twenty seven healthy volunteers (scoring ≥ 26 on the Mini Mental State Examination (MMSE)) were studied after signed, informed consent and divided into two groups: young (7 male, 6 females; rang = 21–38 yrs, mean age = 26.5 ± standard deviation (SD) = 4.9) and middle-aged (6 male, 8 females; rang = 44–59 yrs, mean age = 52.9 ± 5.0). All scans were performed on a Philips 3T MRI Achieva scanner (Philips Healthcare, Best, The Netherlands) with a body coil excitation and an 8-channel SENSE head coil for reception. Four averaged minimally weighted (b0) and 2 averaged 32 gradient directions with two b values (1000 and 2000 s/mm2) were acquired using single-shot EPI sequence with following parameters: TR/TE = 7000/3.2 ms, nominal resolution = 2.5x2.5x3 mm3, 44 axial slices with no interslice gap to cover the whole brain, SENSE factor = 2, 3/4 partial Fourier encoding, total scan time = 19 min. 39 s. For anatomical reference, T1-weighted images were acquired using 3D-MPRAGE sequence with the following parameters: TR/TE = 7.0/3.2 ms, TI = 800 ms, nominal/reconstruction resolution = 1x1x1 mm3, 167 slices, scan duration 10 min. 41 s. Diffusion-weighted images were first co-registered to b0 and transferred to all DTI- and DKI-derived maps for quantification. Independent samples T test and Spearman-rho analysis were performed to test group difference and the correlation between each metric and age, respectively, using SPSS (Chicago, IL, USA).

Results and Discussion: Table 1 shows that mean DTI- and DKI-derived metrics in putamen were significantly different between young and middle-aged groups. The increase of DKI-derived metrics agrees well with former DTI study on putamen [8]. Fig. 1 illustrates significant correlation between each metric and age, suggesting DKI may detect microstructural changes due to aging in putamen.

Conclusion: In the present study, we have demonstrated that age-related changes in brain can be quantitatively assessed using DKI. Further study with larger sample size may help better understanding the age-related changes in various neural tissues.


Table 1. Mean DTI- and DKI-derived metrics of putamen in young and middle-aged groups and p values of independent samples T test between the two groups. *: p<0.05; **: p<0.01.

Fig.1 Scatter plot and Spearman rho correlation coefficient of DTI- and DKI-derived metrics versus age. *: p<0.05; **: p<0.01.