Brain Adaptations in Normal Aging Evaluated with Diffusion Tensor Imaging

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Introduction

Human brain aging is a complicated process, involving changes in cognition, anatomy and physiology. Older adults often have more difficulty with attention, executive function and memory compared to young adults. One possible cause of these difficulties is the alteration of neural fiber connectivity. Diffusion tensor imaging (DTI) (1, 2), through the derived parameters such as fractional anisotropy (FA), can directly assess the white matter fiber tracts which possibly degenerate with Alzheimer's disease and mild cognitive impairment (3) and probably to some degree with normal aging. In this study comparing FA of young and older adult brains, we found altered FA with aging, at regions such as the genu of the corpus callosum, the putamen and the insula.

Methods

Twenty-one young (11 males, age 20 ± 3 yrs) and twenty-one older (9 males, age 74 ± 7 yrs) healthy adults participated in this study. Subjects who were diagnosed to be neurological abnormal or whose brain anatomical structures were visually observed quite abnormal were not included in this study. The T_2 and diffusion-weighted images for DTI were acquired with a spin echo EPI sequence on a GE 3T Signa EXCITE scanner (GE Healthcare, Waukesha, WI) with an 8-channel head coil with the following parameters: 32 contiguous 3-mm axial slices, TR = 8500 ms, TE = 76 ms, matrix size =128×128, field of view (FOV) = 22 cm × 22 cm, number of excitation = 2, parallel imaging acceleration factor = 2, b = 1000 s/mm2, and scan time = 7 min 39 s. High-resolution volumetric T_1-weighted spoiled gradient-recalled (SPGR) images with cerebrospinal fluid suppressed were also obtained to cover the whole brain with 120 1.5-mm sagittal slices, 500 ms time of inversion, 8° flip angle and 24 cm FOV.

All data processing was conducted with AFNI software (4). The T_1-weighted volumetric images were transformed to the Talairach coordinate. The FA maps for each subject were first estimated with the "3dDWItoDT" software in AFNI (4, 5). The FA maps were then transformed to the Talairach coordinate for group analysis. An ANOVA analysis was performed on the data set to compare the young and older groups with a mixed-effect two-factor model, with age category as the first factor and was modeled to have a fixed effect and the subject modeled as the second factor and was modeled to have a random effect. The T_1-weighted volumetric images were averaged for each group.

Results and Discussion

The ANOVA analysis shows an higher FA for younger adults at the genu of the corpus callosum and other regions around the border of the lateral ventricle (Figure. 1). Howerver, this appearant difference of FA can be due to the enlargement of lateral ventricles with older adults. This can be seen from the averaged T_1-weighted volumetirc images underlaid. A higher FA for younger adults (with small clusters) is also see at the white matter next to the left medial frontal gryus (MFG)/anterior cingulate cortex (ACC) and at the white matter next to the right cingulate/ACC. This might suggest some degeneration of the neural fiber integrity at these regions with aging. However, at both the left and right putamens and at the white matter next to both the left and right insula regions, the older adults have higher FA values than younger adults. Since FA suggests the integrity of the neural fibers, which in turn facilitat the information transmission between brain regions. Then the higher FA in older adults at these regions might suggest a compensation process to improve specific neural functions which might be declining with aging. At some regoins, an alternative explanation also applies: some neural fibers are damaged with aging at the border of the lateral ventricles due to the ventricle enlargement; this damage is compensented by the nearby neural fibers.

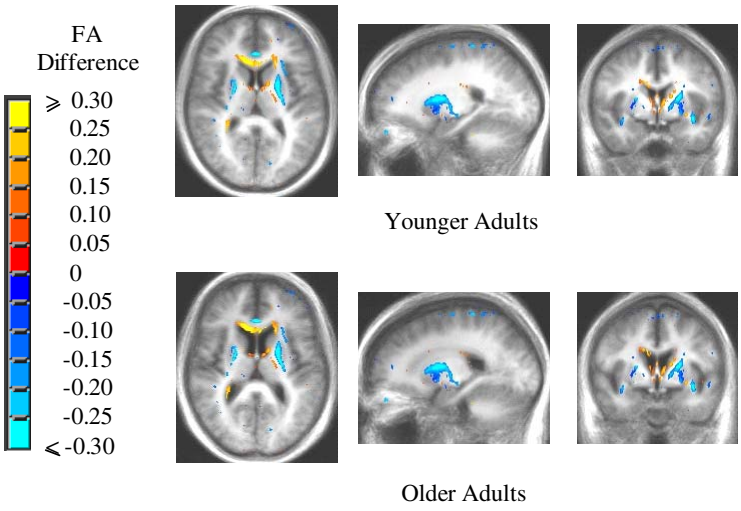

Figure 1. ANOVA analysis between the young and older populations on FA. The group averaged T_1-weighted volumetric images for the young and older adults are overlaid with FA difference of young vs. older adults, thresholded at voxel based $p \leqslant 0.001$.

References

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