FRACTIONAL ANISOTROPY IN VARIOUS WHITE AND GRAY MATTER REGIONS IN ADULTHOOD. DEPENDENCE ON AGE AND COMPARISON OF TWO DTI SEQUENCES

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Introduction

Quantitative MRI is able to monitor the process of normal aging. Volumetric studies of gray and white matter have recently been amended with quantified scalar values of brain diffusion, such as fractional anisotropy (FA). The dependence of white matter FA values on age has been attributed to regions such as the corpus callosum, while other regions, i.e., projection fibers, have not previously demonstrated significant changes (1). In addition, age-associated FA differences in frontal white matter regions were consistent with the anterior-posterior gradient of FA changes in white matter, and may reflect cognitive decline in aging (2). A shortcoming of a number of published DTI studies is that they report FA values measured with a varying number of diffusion directions using a single DTI sequence. Furthermore, reported FA values differ in various studies. We elected to measure FA in a number of white and gray matter regions using two different DTI sequences in a group of healthy adult volunteers.

Methods

Twenty-three healthy volunteers (15 men, 7 women, mean age 52.4 years STD 17.6 years) in whom a neurological examination excluded the presence of dementia and other neurological diseases were included. Diffusion data were acquired using a Siemens echo planar DWI sequences at 1.5 Tesla with a b factor of 1100, including b0 image and 12/30 directional DWI images. Transverse slices covering the whole brain were measured for each b factor (TE= 8839/8800 ms, ET = 95/98 ms, slice thickness 2.2 mm, in-plane resolution 2.2 x 2.2 mm). Diffusion data were processed using FSL. After eddy-current correction and brain extraction using the brain extraction tool (BET), standard scalar invariants including fractional anisotropy were calculated using dtifit. Statistical analysis was performed using the paired Wilcoxon test and the correlation test implemented in R-project. Expected iron content in the basal ganglia was taken from the ref. 3.

The following white and gray matter regions were selected: rostrum and splenium of corpus callosum, frontal gray matter (BA10), frontal white matter, precentral gyrus (BA4), four anterior-posterior regions of internal capsule, head of caudate, putamen, pallidum, thalamus, pyramidal tracts (coronal and transverse planes), and middle cerebellar peduncles.

Results and Discussion

We detected a significant correlation between age and FA for both DTI sequences in the rostrum of the corpus callosum. FA values of the anterior part of the internal capsule and the pyramidal tract (measured in the coronal reconstruction plane by free-hand ROI placement) correlated with age for both sequences on the right side, and on the left side a correlation with the 12 direction DTI sequence was found. No correlation with age was detected for the splenium of the corpus callosum, middle cerebellar peduncules and other white matter regions, as well as in all measured gray matter areas.

We observed significant age dependence not only in the callosal fibers (rostrum of the corpus callosum), but also in the projection fibers (anterior part of the internal capsule) (Fig.1) that connect other brain regions (e.g., thalamus) with the frontal cortex. The decrease of FA in these regions with increasing age may be explained by the role of the (pre)frontal cortex in cognitive functions, which decline as a result of normal aging.

Furthermore, a significant difference in FA values between two DTI sequences (12 vs. 30 directions) was detected in the basal ganglia (head of caudate, putamen and pallidum). In addition to that an increase in the fractional anisotropy was detected in these gray matter regions compared to the prefrontal cortex. This increase correlates with expected iron content (Fig. 2) for individual brain areas. This can be explained by the introduction of a more inhomogeneous environment in the metalloprotein iron-rich areas, such as the globus pallidus, that may increase FA.

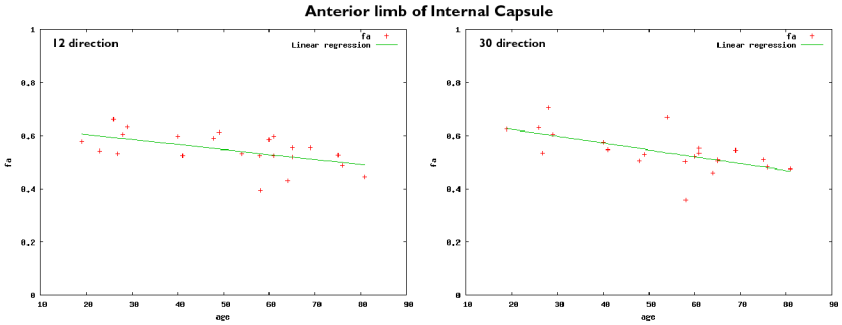

Fig. 1. Dependence FA on age for the anterior part of the left internal capsule a) DTI sequence with 12 diffusion directions b) DTI sequence with 30 diffusion directions

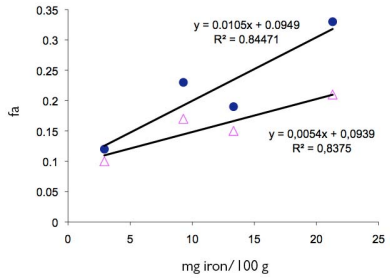

Fig. 2. Correlation between the expected iron concentration and FA for DTI sequences with 12 diffusion directions (closed circles), and 30 diffusion directions (open triangles). The data represent brain areas with increasing iron concentration in the order as follows: cortex, caudate, putamen, pallidum

References

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