Development of an automated MR-DTI-based fiber-tracking method towards identification of neural circuits associated with neuropsychiatric disorders

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Background: The fiber-tracking based on magnetic resonance diffusion tensor imaging (MR-DTI) is one of the brain mapping methods to obtain structural information about the cerebral white matter in vivo. The goal of this study is to propose a useful method to analyze and evaluate cerebral white matter integrity in neuropsychiatric disorders, such as schizophrenia and Alzheimer’s disease, quantitatively. In order to clarify physical fiber connections associated with disease specific neural circuits for various neuropsychiatric disorders, we developed an automated MR-DTI-based fiber-tracking method combined with a parcellation map separating 54 regions of the white matter.

Methods: In this study, a parcellation map with 159 parcellations (54 parcellations in the white matter), called JHU white-matter tractography atlas, made in Johns Hopkins University, was used. The method could automatically set starting plane of fiber-tracking in each parcellation and could rotate along the running direction of fibers as well. In previous studies, setting of the starting plane was carried out by visual observation, whereas the developed method made it possible to set the plane automatically, so that it enables to obtain objective and reproducible results. MR-DTI data were obtained using a 3 T Achieva (Philips Electronics). The imagery conditions were a 242-mm field of view, an image matrix of 256 × 256, a slice thickness of 3.0 mm, no gap, 50 slices, 33 non-collinear directions of MPG, and a b value of 1000 s mm⁻².

Results: The method was verified with simulation data created referred to MR-DTI of 18 healthy controls and streamlines of fiber-tracking were confirmed to run along the first component of eigenvectors of simulation data. Subsequently, the method was applied to MR-DTIs of schizophrenia. We set 6 parameters (the number of fibers, the number of steps of fibers, the mean and standard deviation of FA, the mean and standard deviation of MD) obtained along streamlines of nerve fibers in each parcellation for comparison between age-/IQ- matched 18 patients with schizophrenia and 18 healthy controls. As a result, multiple white matter percellations were detected as the possible candidates involving in schizophrenia.

Conclusions: These results demonstrate that the proposed automated MR-DTI-based fiber-tracking method is feasible and may quantitatively evaluate white matter disruptions to identify neural circuits associated with neuropsychiatric disorders.

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