Evaluation of tractography-based parcellation with human thalamus

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Introduction Fiber tracking, using diffusion tensor imaging, has been widely used as *in vivo* method to reconstruct the white matter bundles within human or animal brain. In recent study, successful parcellation of the thalamic nuclei using probabilistic tractography was reported [1]. However, despite its remarkable findings, the processing time for probabilistic approach has limited the use of probabilistic approach to the clinical applications. The purpose of this study is to evaluate whether the traditional streamline tractography in comparison with probabilistic approach can be used as a tool of anatomical parcellation of the human thalamus.

Methods Thalamus was drawn manually as a seed region of fiber tracking and eight cerebral cortices were delineated as target regions (Fig. 1) on 22 normal volunteers' T1-weighted images using an automated software, Freesurfer(MGH, Harvard). The whole fiber tracts from thalamus were generated using 4th-order Runge-Kutta (RK) streamline method using DoDTI (http://neuroimage.yonsei.ac.kr/dodti) [2] and markov-chain monte-carlo (MCMC) probabilistic approach [1]. Each voxel of thalamus was assigned with the label of the target cortical lobe having the highest connection probability. Utilizing the probabilistic segmentation results, the volume, FA and ADC of the segmented nuclei of thalamus were calculated for each target regions.

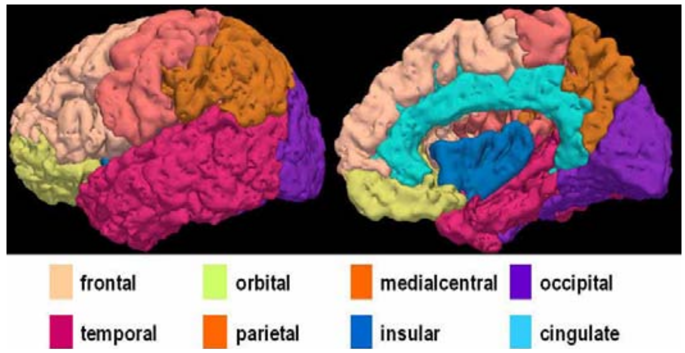

Fig. 1. Eight cerebral cortices as the tractography targets for thalamus parcellation. Right lateral (left) and mid-sagittal (right) views are displayed.

Results Fig. 2 shows the thalamic parcellation maps with RK streamline method and MCMC approach. Probability maps generated by MCMC appeared to have more focused distribution than RK approach. Especially in cingulate and insular, probability maps by RK approach are distributed through the entire thalamus while the maps by MCMC shows no connection. In Fig. 3, there is no difference in nuclei connecting the parietal and occipital regions in terms of volume, FA and ADC. However the decrease of volume and ADC, and the increase of FA were found throughout the cortices, which can be seen in the nuclei of the temporal parts significantly.

Discussion Tract-based parcellation has advantages for functional studies. Though both approaches do not completely parcel the nuclei of the entire cortices, streamline method has the more problems due to its difficulties for non-dominant tracts in terms of parceled volume, FA, and ADC. This study demonstrated that, in addition to smaller volume for RK results, the increase of FA and the decrease of ADC should be considered to the streamline-based parcellation studies.

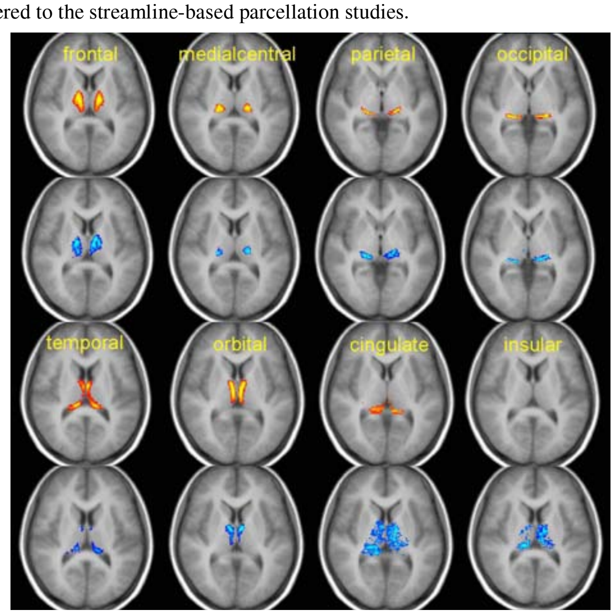

Fig. 2. Thalamus probability maps. Voxels higher than 25% probability of connection are overlaid onto mean axial T1 image. The color for MCMC approach is red-yellow (Yellow is high.), and that for Runge-Kutta method is blue-right blue (Right blue is high.).

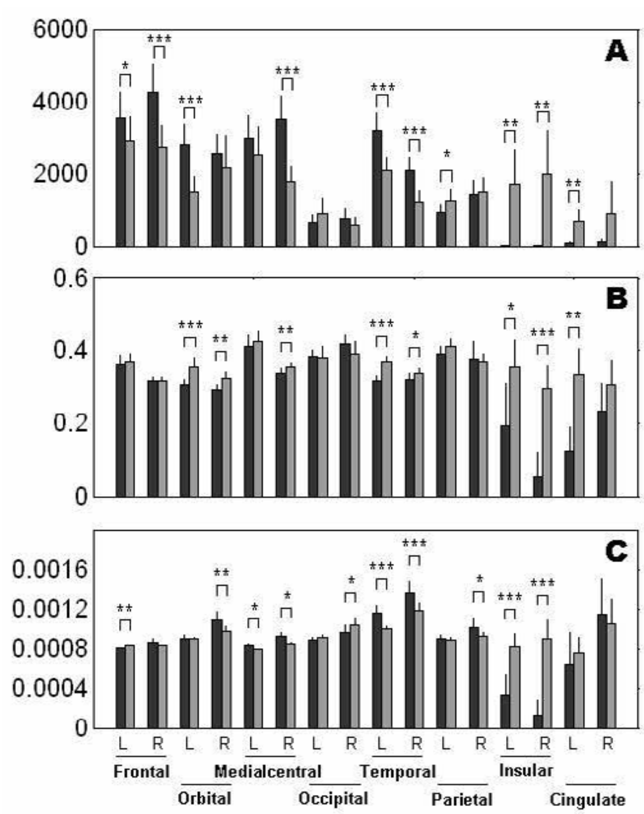

Fig. 3. Mean and standard deviation of Volume (mm^3) (A), FA (B) and ADC ($*10^{-3}$) (C) for MCMC (dark gray) and Runge-Kutta (light gray) of left- and right-target regions (*: p<.05, **: p<.005, ***: p<.0005).

References [1] Behrens, T.E.J. et. al., Non-invasive mapping of connections between human thalamus and cortex using diffusion imaging, Nat. Neurosci. 6. 750-757, 2003. [2] Park H-J. et. al., Evaluation of Spatial Normalization Schemes for Diffusion Tensor MRI Using Tractography, NeuroImage, 20(4), 1995-2009, 2003.