NEURAL REGENERATION RESEARCH
February 2015, Volume 10, Issue 2
www.nrronline.org

IMAGING IN NEURAL REGENERATION

Is thalamocortical tract injury responsible for memory impairment in a patient with putaminal hemorrhage?

Prior to development of diffusion tensor imaging (DTI), there were many difficulties in visualization and estimation of the Papez circuit in the live human brain (Papez, 1995). Diffusion tensor tractography (DTT), derived from DTI, allows for identification and visualization of neural tracts in the Papez circuit (Concha et al., 2005; Kwon et al., 2010; Granziera et al., 2011; Jang and Yeo, 2013; Jang et al., 2014a). In the current study, using DTT, we report on a patient who showed injured thalamocortical tract between the anterior thalamic nuclei and the cingulate gyrus following a putaminal hemorrhage.

A 55-year-old male patient received conservative management for a putaminal hemorrhage in the left hemisphere (**Figure 1A**). He showed cognitive dysfunction since the onset of putaminal hemorrhage. Results of evaluation at 5 weeks after onset using the Memory Assessment Scale (MAS) which is a comprehensive standardized memory assessment battery that consists of four memory subsets: global memory, short-term memory, verbal memory, and visual memory indicate severe memory impairment (global memory: 71 (3%ile), short term memory: 75 (5%ile), verbal memory: 64 (1%ile), and visual memory: 94 (35%ile)) although Wechsler Adult Intelligence Scale (IQ) was within normal range as 94 (Williams, 1991).

DTI data was acquired at 5 weeks after onset using a 6-channel head coil on a 1.5 T Philips Gyroscan Intera (Philips, Ltd., Best, the Netherlands) with single-shot echo-planar imaging. For each of the 32 non-collinear diffusion sensitizing gradients, we acquired 70 contiguous slices parallel to the anterior commissure-posterior commissure line. Imaging parameters were as follows: acquisition matrix = 96 × 96; reconstructed to matrix = 192 × 192; field of view = 240 × 240 mm^2; repetition time (TR) = 10,398 ms; echo time (TE) = 72 ms; parallel imaging reduction factor (SENSE factor) = 2; echo planar imaging factor = 59; b = 1,000 s/mm^2; and a slice thickness of 2.5 mm. Fiber tracking was performed using a probabilistic tractography method based, and applied in the present study utilizing tractography routines implemented in Oxford Centre for Functional Magnetic Resonance Imaging of the Brain (FMRIB) Software Library (FSL; www.fmrib.ox.ac.uk/fsl). Each neural tract of the Papez circuit was determined by selection of fibers passing through seed and target regions of interest (ROIs) (Concha et al., 2005; Kwon et al., 2010; Jang and Yeo, 2013). We manually drew the ROIs as follows: thalamocortical tract: seed ROI – the cingulate gyrus, first target ROI – anterior limb of internal capsule, second target ROI – anterior thalamic nuclei; fornix: seed ROI – mammillary body, target ROI – crus of fornix; mammillothalamic tract: seed ROI – anterior thalamic nucleus, first target ROI – portion of isolated mammillothalamic tract, second target ROI – mammillary body; cingulum: seed ROI – middle portion of the cingulum, target ROI – posterior portion of the cingulum. Out of 5,000 samples generated from a seed voxel, results were visualized at the threshold of 5 streamline through each voxel for analysis.

In the right hemisphere, the whole Papez circuit including the thalamocortical tract, cingulum, fornix, and mammillothalamic tract were reconstructed. By contrast, the thalamocortical tract was not reconstructed in the left hemisphere due to the putaminal hemorrhage.

The Papez circuit, described by James Papez in 1937, is known to play important roles in control of emotion and memory (Papez, 1995). The pathway of the Papez circuit was reported as follows: hippocampal formation – fornix – mammillary bodies – anterior thalamic nuclei – cingulate gyrus – cingulum – parahippocampal gyrus – hippocampus (Papez, 1995). Previous studies using DTT have reported on injury of a portion of the Papez circuit including fornix, mammillothalamic tract and cingulum (Wang et al., 2008; Yeo and Jang, 2013; Jang et al., 2014a, b; Kwon et al., 2014). Regarding the thalamocortical tract between anterior thalamic nuclei and cingulate gyrus, a recent study reported on a patient who showed thinned thalamocortical tract and non-reconstruction of the mammillothalamic tract following anterior thalamic infarction (Jang et al., 2014a). In the current study, we investigated DTT findings of the neural tracts of the Papez circuit and found injury of the left thalamocortical tract between anterior thalamic nuclei and cingulate gyrus. We think that this patient's memory impairment was mainly the result of the injury of this tract in the Papez circuit. To the best of our knowledge, this is the first study to demonstrate neural tract injuries of the Papez circuit following an intracerebral hemorrhage. We think that further studies involving larger numbers of patients and recovery of memory function using follow up DTT are necessary.

This study was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology, No. 2012R1A1A4A01001873.

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***Accepted:** 2014-10-20*
***doi:**10.4103/1673-5374.152390* ***http**://www.nrronline.org/*
Kwon HG, Chang CH, Jang SH (2015) Is thalamocortical tract injury responsible for memory impairment in a patient with putaminal hemorrhage? Neural Regen Res 10(2):321-322.

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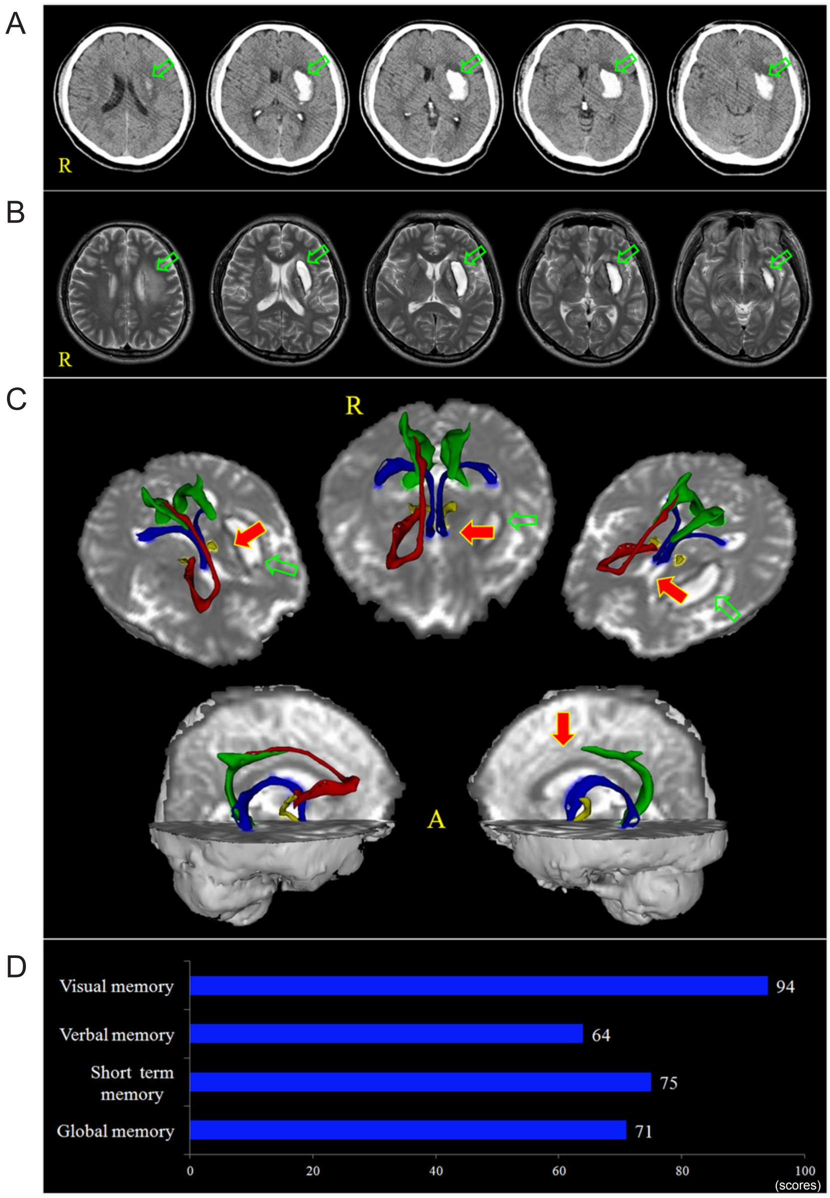

Figure 1 Brain CT, T2-weighted MR images, and diffusion tensor tractography (DTT) images of a 55-year-old male patient with a putaminal hemorrhage in the left hemisphere exhibiting cognitive dysfunction.
(A) Brain CT images at onset show a putaminal hemorrhage (green arrows) in the left hemisphere. (B) T2-weighted brain MR images at 5 weeks after onset show a leukomalactic lesion in the left basal ganglia (green arrows). (C) DTT images at 5 weeks after onset showing the whole Papez circuit including the thalamocortical tract (red), cingulum (green), fornix (blue), mammillothalamic tract (yellow) was reconstructed. By contrast, the thalamocortical tract between anterior thalamic nuclei and cingulate gyrus (red arrow) was not reconstructed in the left hemisphere due to the putaminal hemorrhage (green arrows). R: Right; A: anterior. (D) Scores of Memory Assessment Scale.

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Copyedited by Ng WH, Jiang Z, Li CH, Song LP, Zhao M