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Case report

Change of cingulum following shunt operation for hydrocephalus in a patient with a haemorrhagic stroke

HanDo Lee, Sung Ho Jang*

Department of Physical Medicine and Rehabilitation, College of Medicine, Yeungnam University, Republic of Korea

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1. Introduction

Hydrocephalus is a dilatation of the ventricular system of the brain, usually accompanied by an elevated intraventricular pressure. The increased pressure can cause compression of white matter adjacent to ventricles; shunt operation for hydrocephalus can be performed for decompression of the neural structures around the ventricles. Diffusion tensor imaging (DTI) is a recently introduced technique that enables evaluation of white matter by virtue of its ability to capture and represent water diffusion characteristics. Many studies have reported on DTI findings of hydrocephalus, however, only a few studies have reported on change of DTI findings following shunt operation [1–4].

The cingulum, the neural tract extending from the orbitofrontal cortex to the medial temporal lobe, plays an important role in cognitive function, including attention, learning, memory, emotion, motivation, and pain perception. In the past, demonstration of the state of the cingulum was difficult because conventional brain MRI has limitation in assessing the state of the cingulum, which is not discriminated from adjacent structures. Recently, diffusion tensor tractography (DTT), which was derived from diffusion tensor imaging (DTI), has enabled three-dimensional visualization and evaluation of the cingulum.

In the current study, using DTT, we report on a stroke patient who showed change of the cingulum concurrent with the recovery of impaired cognition following shunt operation for hydrocephalus.

2. Case report

2.1. Subjects

A 59-year-old female patient underwent CT guided stereotactic drainage for management of intracerebral hemorrhage and intraventricular hemorrhage due to rupture of an arteriovenous malformation in the right thalamus at the department of neurosurgery of a university hospital. After four weeks from onset, she was transferred to the rehabilitation department of the same hospital in order to undergo rehabilitation. Brain MRI showed dilatation of the ventricular system (Fig. 1-A). The patient exhibited impaired cognition, with a Mini-Mental State Exam (MMSE: cut-off score <25) score of 4. She underwent comprehensive rehabilitative therapy for 2 weeks, which included neurotropic drugs, and physical therapy, and occupational therapy; however she did not show significant improvement in cognition and physical function due to hydrocephalus. As a result, she underwent ventriculo-peritoneal shunt operation with a right frontal approach. After the shunt operation, her cognition showed improvement as MMSE 24 at 7 days and 27 at 4 weeks after the shunt operation, respectively. The

* Corresponding author at: Department of Physical Medicine and Rehabilitation, College of Medicine, Yeungnam University 317-1, Daemyung dong, Namku, Daegu, 705-717, Republic of Korea.
E-mail address: strokerehab@hanmail.net (S.H. Jang).

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patient provided signed, informed consent, and the study protocol was approved by our Institutional Review Board.

2.2. Diffusion tensor imaging

DTI data were acquired two times (four and seven weeks after onset) using a sensitivity-encoding head coil on a 1.5-T Philips Gyroscan Intera (Philips, Ltd, Best, The Netherlands) with single-shot echo-planar imaging and navigator echo. Sixty contiguous slices (acquisition matrix = 96 × 96; reconstruction matrix = 192 × 192 matrix; field of view = 240 × 240 mm^2; TR = 10,398 ms; TE = 72 ms, b = 1000 s/mm^2, NEX = 1, slice gap = 0 mm and thickness = 2.5 mm) were acquired for each of the 32 noncollinear diffusion-sensitizing gradients. Fiber tracking was performed using the fiber assignment continuous tracking (FACT) algorithm implemented within the DTI task card software (Philips Extended MR Work Space 2.6.3). Each of the DTI replications was intra-registered to the baseline "b0" images in order to correct for residual Eddy-current image distortions and head motion effect, using a diffusion registration package (Philips Medical Systems). For reconstruction of two neural tracts, two regions of interest (ROIs) were placed for each tract as follows: the cingulum; the seed ROI – the middle portion of the cingulum, the target ROI – posterior portion of the cingulum; the fornix, the seed ROI – the junction between the body and column of each fornix on a coronal image, the target ROI – the crus of the right and left fornix on the coronal image. Termination criteria were fractional anisotropy <0.2 and an angle change >27°.

On the pre-op DTT, discontinuations were observed between the anterior cingulum and the basal forebrain in both cingulums. The fornix also showed discontinuations in both anterior and posterior bodies. A neural connection from the left injured cingulum to the left parabigeminal nucleus (Ch8) was observed (Fig. 1-B). By contrast, on the post-op DTT, the discontinued anterior portion of both cingulums was elongated; in particular, the left cingulum was elongated to the left basal forebrain and the neural connection from the left injured cingulum to the left Ch8 had disappeared. However, significant change was not observed in the discontinued fornix compared with the pre-op DTT.

3. Discussion

In the current study, using DTT, we evaluated changes of the injured cingulums after shunt operation for hydrocephalus in a patient with intracerebral hemorrhage and intraventricular hemorrhage. On the pre-op DTT, both anterior cingulums showed discontinuations to the basal forebrain, where the cholinergic nuclei are located. Instead, a neural connection from the left injured cingulum to a left brainstem cholinergic nucleus (Ch8) was observed. By contrast, on the post-op DTT, the discontinued

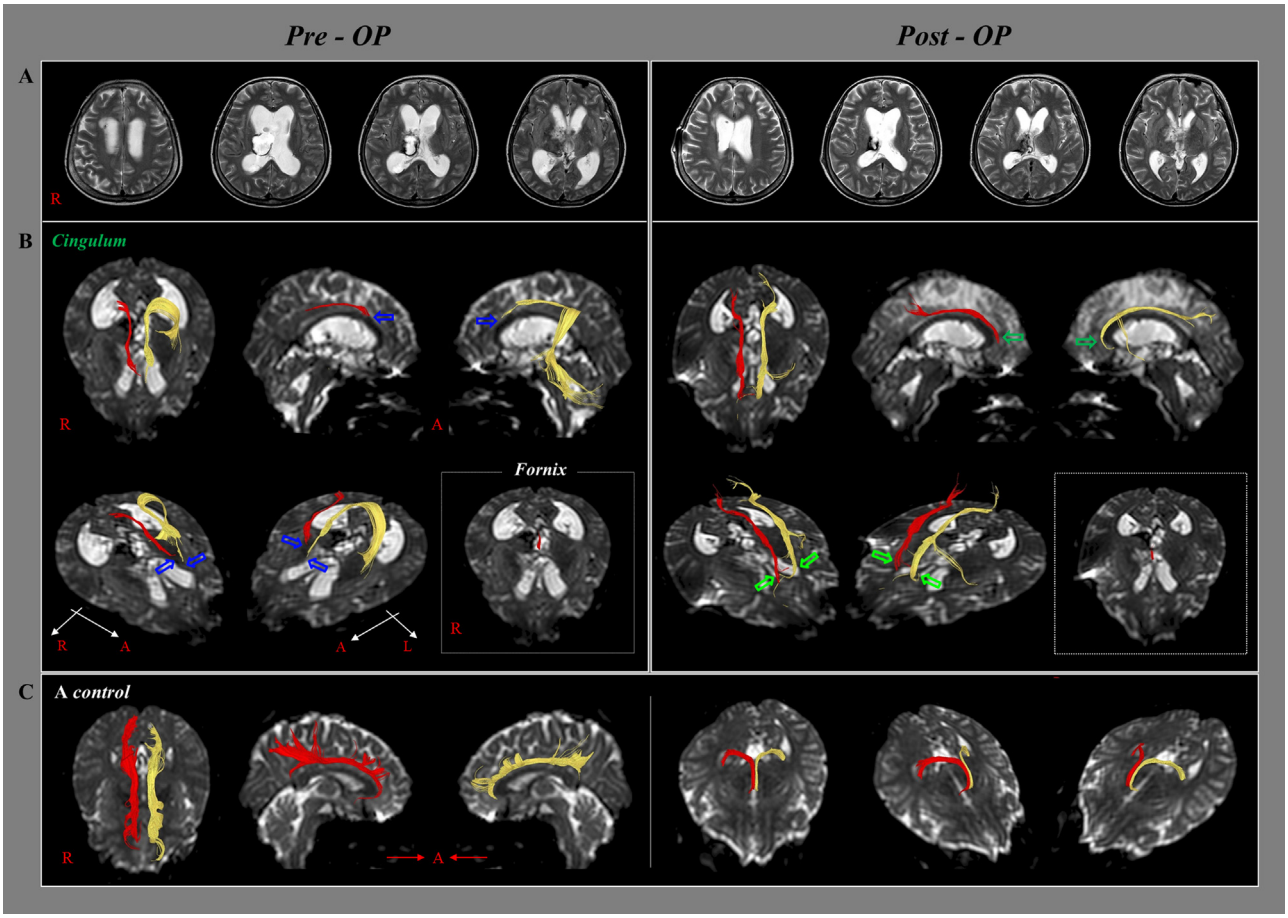

Fig. 1. (A) The pre-op T2-weighted brain MRI images show dilatation of the ventricular system and improvement of dilatation of the ventricular system after shunt operation. (B) Results of diffusion tensor tractography (DTT). On the pre-op DTT, discontinuations are observed between the anterior cingulum and the basal forebrain in both cingulums. The fornix also shows discontinuations (blue arrows) in both anterior and posterior bodies. A neural connection from the left injured cingulum to the left parabigeminal nucleus was observed. By contrast, on the post-op DTT, the discontinued anterior portions of both cingulums are elongated (green arrow); in particular, the left cingulum is elongated to the left basal forebrain and the neural connection from the left injured cingulum to the left parabigeminal nucleus has disappeared. However, significant change is not observed in the discontinued fornix compared with the pre-op DTT. (C) Results of DTT for a 56 year-old normal subject. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)