

● IMAGING IN NEURAL REGENERATION

Recovery of injured fornical crura following neurosurgical operation of a brain tumor: a case report

The fornix, which is involved in transfer of episodic memory, is an important structure of the Papez circuit between the medial diencephalon and the medial temporal lobe. Many studies using DTI have reported on injury of the fornix in patients with brain injury (Nakayama et al., 2006; Sugiyama et al., 2007; Wang et al., 2008; Chang et al., 2010). However, only a few studies on recovery of an injured fornix in patients with brain injury, including traumatic brain injury and stroke, have been reported (Yeo et al., 2011; Yeo and Jang, 2013a, b). In this study, using follow up DTT images, we reported on a patient who showed recovery of injured fornical crura following a neurosurgical operation for a brain tumor.

A 48-year-old female patient underwent craniotomy and a navigator assisted removal of craniopharyngioma at the university hospital. Brain MRIs showed a cystic mass at the suprasellar space before the operation, and a lesion and hematoma in the body of the corpus callosum and the lateral ventricle 1 day after the operation (Figure 1A). According to pathology, the patient was diagnosed suffering from a craniopharyngioma. The patient had shown severe memory impairment since the operation and underwent neuropsychological evaluations at 6 weeks after onset: Memory Assessment Scale [MAS, global memory: 58 (< 1%ile), short term memory: 61 (< 1%ile), verbal memory: 58 (< 1%ile), and visual memory: 60 (< 1%ile)], Mini-Mental State Examination (MMSE: 13). She had undergone comprehensive rehabilitation, including cognitive therapy, until 20 months after onset. She showed mild improvement in memory impairment at 20 months after onset: MAS [global memory: 61 (> 1%ile),

short term memory: 101 (53%ile), verbal memory: 67 (1%ile), and visual memory: 70 (2%ile)], MMSE: 24.

DTI was performed three times (2, 6 and 20 months after onset) using a 6-channel head coil on a 1.5T Philips Gyroscan Intera. Fiber tracking was based on the fiber assignment continuous tracking (FACT) algorithm implemented within the DTI task card software. For reconstruction of the fornix, the first region of interest (ROI) was placed at the junction between the body and column of the fornix on a coronal image of the color map. The second ROIs were placed on each side of the crus of the fornix on a coronal image of the color map, respectively (Yeo and Jang, 2013b). On 2-month DTT images, discontinuities were observed in both fornical crura (Figure 1B). A collateral branch from the end of the right fornical body was observed, which ended in the right temporal lobe *via* the splenium of the corpus callosum. On 6-month DTT images, fornical crura emerged from the end of the fornical body on both sides; in contrast, the right collateral branch was shortened and a collateral branch emerged from the left fornical body. On 20-month DTT images, the fornical crura were elongated to the medial temporal lobe on both sides and the collateral branches had disappeared on both sides.

In the current study, we investigated changes in DTT findings of injured fornical crura following a neurosurgical operation in a patient with a brain tumor. After removal of the tumor, a lesion and hematoma were observed in the body of the corpus callosum and the lateral ventricle. We observed discontinuities of the bilateral fornix crura on 2-month DTT images. Based on previous studies demonstrating the vulnerability of the fornix to intraventricular hemorrhage and lesion in the corpus callosum, the fornix injury in this patient was ascribed to the intraventricular hemorrhage and neurosurgical operation through the body of the corpus callosum (Chang et al., 2010; Yeo et al., 2011). We observed two kinds of changes of injured fornical crura on three follow up DTT images: 1) recovery of discontinued fornical crura on both sides, consequently, the

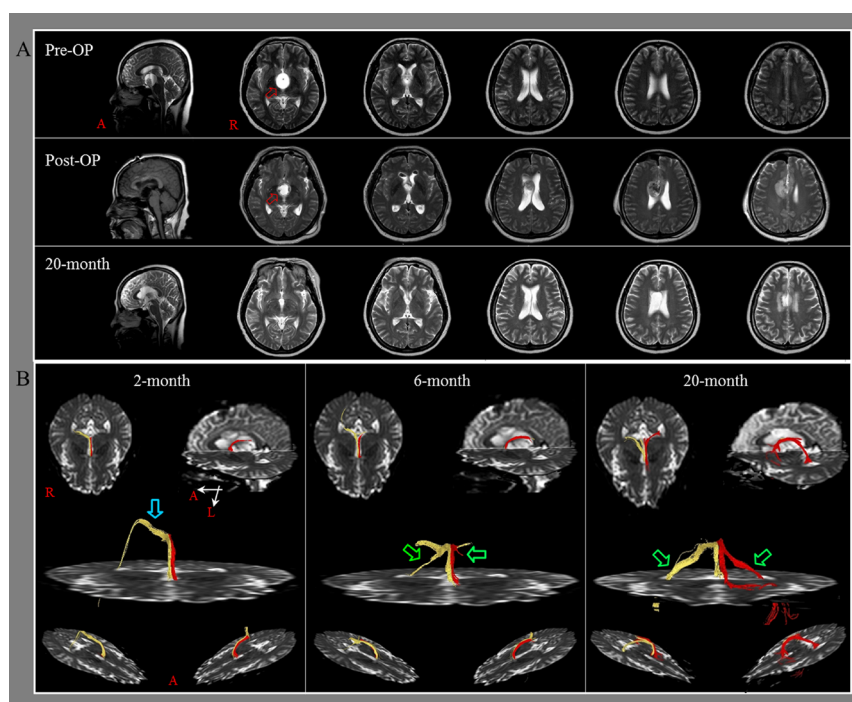


Figure 1 Brain magnetic resonance and diffusion tensor tractography (DTT) images of the fornical crura in a patient with a brain tumor after neurosurgical operation.

(A) Brain MR images show a cystic mass (red arrow) in the suprasellar space before the operation (Pre-OP), and a lesion and hematoma (red arrow) in the body of the corpus callosum and the lateral ventricle 1 day after the operation (Post-OP). A lesion in the body of the corpus callosum was observed 20 months after the operation. (B) On 2-month DTT images, discontinuities were observed in both fornical crura. A collateral branch from the end of the right fornical body (blue arrow) was observed and this right collateral branch ended in the right temporal lobe *via* the splenium of the corpus callosum. On 6-month DTT images, fornical crura (green arrows) emerged from the end of the fornical body on both sides; in contrast, the right collateral branch was shortened and a collateral branch emerged from the left fornical body. On 20-month DTT images, the fornical crura (green arrows) were elongated to the medial temporal lobe on both sides and the collateral branches had disappeared on both sides. The injury to the red nerve fiber was more severe than that to the yellow fiber. A: Anterior; R: right.

ends of injured fornical crura were connected to the medial temporal lobe on both sides on 20-month DTT images, and 2) the collateral branches *via* the splenium of the corpus callosum from the injured fornical body disappeared with the recovery of injured fornical crura. Previous studies have reported that collateral branches *via* the splenium of the corpus callosum result from development of compensatory neural tracts following injury of the fornical crus (Yeo and Jang, 2013a, b; Lee et al., 2014). Therefore, we believe that the compensatory collateral branches *via* the corpus callosum had disappeared along with the recovery of the injured fornical crura. The improvement of impaired memory in the visual and verbal observed in this patient for 20 months may be additional evidence of the recovery of injured fornical crura in this patient.

Since introduction of DTI, a few studies have reported on the recovery of an injured fornix in patients with brain injury (Yeo and Jang, 2013a, b; Lee et al., 2014). In 2013, Yeo and Jang (2013b) reported on a patient who showed compensatory neural tracts (an abnormal neural tract originating from an injured fornical crus passed through the splenium of the corpus callosum to connect to the medial temporal lobe and another abnormal neural tract originating from the fornical column was connected to the medial temporal lobe) after head trauma resulting in bilateral injury of the fornical crura. Yeo and Jang (2013a) also reported on a patient who underwent coiling for a ruptured anterior communicating cerebral artery aneurysm and conservative management for subarachnoid and intraventricular haemorrhage. They showed that the end of the discontinued fornical body was connected to the splenium of the corpus callosum and then branched to the medial temporal lobe and thalamus. Lee and Jang (2014) recently reported on the change of an injured fornix in a patient with traumatic axonal injury. One branch from the injured fornical body was connected to the medial temporal lobe *via* the splenium of the corpus callosum, and two branches from both fornical columns were connected to the medial temporal lobes respectively. As a result, to the best of our knowledge, this is the first study to demonstrate the recovery of injured fornical crura in a patient with brain injury. However, limitation of DTI should be considered (Yamada et al., 2009). DTI may underestimate or overestimate the fiber tracts. In addition, fiber complexity and crossing can prevent full reflection of the underlying fiber architecture by DTI (Yamada et al., 2009).

In conclusion, we reported on a patient who showed recovery of injured fornical crura following a neurosurgical operation for a brain tumor. This finding appears to suggest a mechanism for recovery of injured fornical crura. Because it is based on a single case report, this study is limited. Larger-scale complementary studies needed to be conducted.

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