Clinical Case Report

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Delayed degeneration of the left fornical crus with verbal memory impairment in a patient with mild traumatic brain injury

A case report

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Abstract

Rationale: We report on a patient who showed delayed degeneration of the left fornical crus with verbal memory impairment following mild traumatic brain injury (TBI), which was demonstrated by diffusion tensor tractography (DTT).

Patient concerns: fter flexion and hyperextension of her head to the opposite side, the patient experienced a dazed feeling for a while at the time of head trauma. The patient's Glasgow Coma Scale score was 15, and mini-mental state examination score was 30.

Diagnoses: A 50-year-old right-handed female with 12 years of education suffered from head trauma resulting from a car accident.

Interventions: A The patient showed normal memory function at one year after onset: the Memory Assessment Scale (global memory: 124 (95 percentile (%ile)), verbal memory: 111 (77%ile), and visual memory: 132 (98%ile) (A percentile is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall). However, the patient began to experience decline of memory function such as forgetfulness at approximately 1.5 years after onset. On the 2-year evaluation, she showed decrement of memory function (global memory: 108 (70%ile), verbal memory: 86 (18%ile), and visual memory: 129 (97%ile).

Outcomes: On 1-year DTT, the integrity of the fornix was well preserved between the fornical column and fornical crus. However, on 2-year DTT, a discontinuation was observed in the left fornical crus.

Lessons: Delayed degeneration of the left fornical crus was demonstrated in a patient who showed delayed onset of verbal memory impairment following mild TBI.

Abbreviations: DTI = diffusion tensor imaging, DTT = diffusion tensor tractography, TBI = traumatic brain injury.

Keywords: diffusion tensor tractography, fornical crus, mild traumatic brain injury, verbal memory

1. Introduction

The connections of prefrontal cortex, medial diencephalon, and medial temporal lobe are involved in various cognitive functions including working memory, attention, decision making, execution, behavior inhibition, and motivation.[1–3] The fornix, which connects the medial temporal lobe and the medial diencephalon, is an important part of the Papez circuit for episodic memory. The introduction of diffusion tensor tractography (DTT), derived from diffusion tensor imaging (DTI), has enabled three-dimensional reconstruction and estimation of the fornix.[1] Many studies have reported on injury of the fornix and the recovery mechanisms of an injured fornix in patients with traumatic brain injury (TBI).[2–7] Although a few studies using DTI or DTT have reported on degeneration of the fornix following TBI, no study on delayed degeneration in the patient with mild TBI has been reported.[8,9]

In this study, using follow-up DTT, we report on a patient who showed delayed degeneration of the left fornical crus with verbal memory impairment following mild TBI.

2. Case report

A 50-year-old right-handed female with 12 years of education, who had no family history of a dementia, suffered from head trauma resulting from a car accident. While driving a sedan, a taxi collided with her car from the side. After flexion and hyperextension of her head to the opposite side, the patient experienced a dazed feeling for a while at the time of head trauma, but she mentioned that she did not experience loss of consciousness and post-traumatic amnesia. The patient's Glasgow Coma Scale score was 15, and Mini-Mental State Examination score was 30. She visited our hospital for evaluation of dizziness and headache at 1 year after onset. No specific lesion was observed on brain MRI (T1-weighted, T2-weighted, and fluid attenuated inversion recovery [FLAIR] images). Before she

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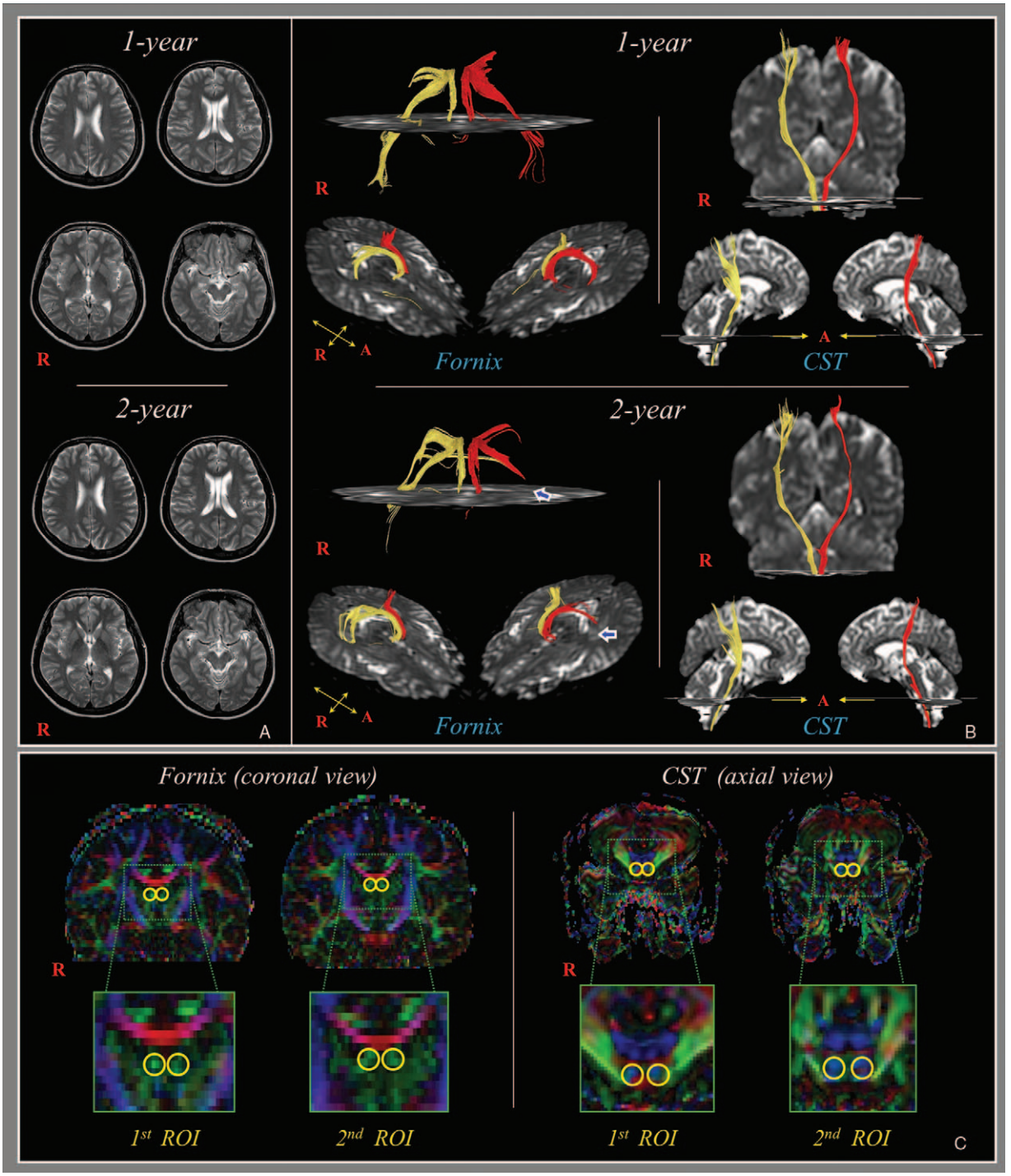

Figure 1. (A) T2-weighted magnetic resonance images taken at 1-year and 2-year after onset showed no specific lesions. (B) Diffusion tensor tractography (DTT) of the fornix. The integrity of the fornix is well preserved between the fornical column and fornical crus on 1-year DTT. By contrast on 2-year DTT, a discontinuation (arrows) is observed in the left fornical crus. DTT = diffusion tensor tractography.

visited our hospital, she was diagnosed as a concussion and did not undergo detailed brain evaluations except brain CT (Fig. 1A). The patient did not complain of memory impairment after head trauma and showed normal memory function at 1 year after onset: the Memory Assessment Scale (global memory: 124 (95 percentile (%ile)), short term memory: 107 (68%ile), verbal memory: 111 (77%ile), and visual memory: 132 (98%ile) (A percentile is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall).[10] However, the patient began to experience decline of memory function such as forgetfulness at approximately 1.5 years after onset, although she did not suffer another head trauma or any disease and her memory function showed gradual aggravation with passage of time. Therefore, she complained of having some difficulties in activities of daily living and had to use frequently memory aids such as writing

down on cell phone memo application. On the 2-year evaluation, she showed decrement of memory function, particularly verbal memory, as follows: the Memory Assessment Scale (global memory: 108 (70%ile), short term memory: 95 (37%ile), verbal memory: 86 (18%ile), and visual memory: 129 (97%ile).[10] The patient understood the purpose of the study and provided written, informed consent prior to participation. The study protocol was approved by the local Institutional Research Board of a university hospital (YUMC 2015-07-065-010).

2.1. Diffusion tensor imaging

DTI was performed 2 times (1 and 2 years after onset) using a 6-channel head coil on a 1.5T Philips Gyroscan Intera (Philips, Ltd, Best, The Netherlands) with single-shot echo-planar imaging. For each of the 32 noncollinear, diffusion-sensitizing gradients, 65 contiguous slices were acquired 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 = $240 \times 240\,mm^2$, TR = 10,726 ms, TE = 76 ms, parallel imaging reduction factor (SENSE factor) = 2, EPI factor = 49, $b = 1000\,s/mm^2$, NEX = 1, and slice thickness 2.5 mm (acquired isotropic voxel size $2.5 \times 2.5 \times 2.5\,mm^3$). 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.).[11,12] For reconstruction of the fornix, the first regions of interest (ROIs) were placed on the middle of the body and the second ROI on the junction between the body and crus on the coronal slice of the color map (green color).[8] For reconstruction of the corticospinal tract (CST), the seed region of interest (ROI) was placed on the upper pons (portion of anterior blue color) on the color map with an axial image (Fig. 1C). Fiber tracking was performed using a fractional anisotropy (FA) threshold of >0.2 and direction threshold < 60°. The FA value and fiber number of the fornix were measured in both hemispheres.

On 1-year DTT, the integrity of the fornix was well preserved between the fornical column and fornical crus. However, on 2-year DTT, a discontinuation was observed in the left fornical crus. The integrity of the CST was preserved between the cerebral cortex and medulla in both hemispheres on 1-year and 2-year DTTs (Fig. 1B). The FA value and fiber number of left fornix on 2-year DTT were decreased compared with those of left fornix on 1-yaer DTT (Table 1).

2.2. Neuropsychological tests

The Memory Assessment Scale (MAS) was used for estimation of memory function. The MAS is a comprehensive standardized memory assessment battery, consisting of 4 memory subsets, including short-term memory, verbal memory, visual memory and total memory derived from verbal and visual memory.[10] The reliability and validity of MAS is well established.[10]

3. Discussion

In the current study, our patient began to experience gradual impairment of verbal memory at approximately 1.5 years after the onset of head trauma without another head trauma or other disease and showed memory impairment (particularly verbal memory) on 2-year evaluation although she showed normal memory function on 1-year evaluation. We found the discontinuation of the left fornical crus on 2-year DTT, which was not observed on 1-year DTT. Our results appeared to coincide with those of previous studies showing that the right medial temporal lobe is specialized for visual memory and the left medial temporal lobe for verbal memory.[13–16] Considering that the memory impairment started approximately 1.5 years after head trauma in this patient, we think that the injury of the left fornical crus was ascribed not to the secondary injury of the traumatic axonal injury but the delayed neuronal degeneration.[9,17–20] Early onset degeneration is defined neuronal degeneration within 1 month after acute neurological injury, in contrast, other delayed onset degeneration after acute neurological injury is defined delayed neuronal degeneration.[20] Therefore, the degeneration of the fornix in our patient appeared to belongs to a delayed neuronal degeneneration. After introduction of DTI and DTT, several studies have reported on neuronal degeneration following TBI.[8,9,21,22] These studies focused on the degeneration from early stage to chronic stage.[8,9,21,22] In 2008, Sidaros et al[21] demonstrated injury of the white matter regions (posterior aspect of corpus callosum, posterior limb of internal capsule, centrum semiovale, cerebral peduncle) within eight weeks after head trauma in 30 patients with severe TBI using DTI. Subsequently, Kumar et al[22] reported injury of the rostrum and genu of the corpus callosum at six months after head trauma compared with those at 5~14 days in 23 patients with mild TBI using DTI. In 2010, using DTT, Hong and Jang[8] demonstrated neuronal degeneration of fornix between 3 and 19 months after head trauma in a patient with diffuse axonal injury. Recently, Adnan et al[9] demonstrated loss of structural integrity in the fornix between 5 and 30 months after moderate and severe TBI in 29 patients using DTI. As a result, to the best of our knowledge, this is the first study to demonstrate delayed neuronal degeneration of the fornix in a patient with mild TBI. However, some limitations should be considered.[23] First, DTT is a powerful anatomic imaging tool which can demonstrate gross fiber architecture, however it may underestimate or overestimate

Table 1

Comparisons of memory function and diffusion tensor imaging parameters for the fornix and corticospinal tract between 1-year DTT and 2-year DTT.

	1-year	2-years
GCS	15	15
MAS		
Global memory	124 (95%ile)	108 (95%ile)
Short term memory	107 (95%ile)	95 (95%ile)
Verbal memory	111 (95%ile)	86 (95%ile)
Visual memory	132 (95%ile)	129 (95%ile)
MMSE	30	30
DTT parameters		
Fornix		
FA value		
Right	0.374	0.375
Left	0.356	0.324
Fiber number		
Right	1156	1169
Left	958	557
Corticospinal tract		
FA value		
Right	0.505	0.504
Left	0.520	0.529
Fiber number		
Right	825	813
Left	551	554

DTT = diffusion tensor tractography, FA = fractional anisotropy, GCS = Glasgow Coma Scale, MAS = Memory Assessment Scale, MMSE = Mini-mental State Examination.

the neural tracts due to regions of fiber complexity and crossing.[23] Second, we did not perform brain positron emission tomography scan and detailed neuropsychological evaluation. In addition, this study is limited to a case report. Conduct of further complementary studies involving larger case numbers is warranted.

In conclusion, delayed degeneration of the left fornical crus was demonstrated in a patient who showed delayed onset of verbal memory impairment following mild TBI. We believe that the evaluation using follow up DTT would be useful for patients with delayed onset of neurological symptoms following TBI.

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