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Case Report

Neural Tract Injuries by Penetration of Foreign Body: a Diffusion Tensor Tractography Study

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We presented with a patient who showed injury of the cingulum and fornix by penetration of a foreign body into the brain on diffusion tensor tractography (DTT). A 63-year-old man suffered a brain injury by a part of a power saw blade that was suddenly detached from a power saw during work. A part of the power saw blade penetrated his right frontal skull and advanced to the right posterior horn of the lateral ventricle. This penetration caused traumatic intracerebral hemorrhage in the right frontal lobe and intraventricular hemorrhage in the lateral ventricle. He underwent craniotomy and removal of intracranial foreign bodies (bony pieces and saw blade). The patient's Memory Assessment Scale scores were 74 (4%ile) for global memory, 78 (7%ile) for verbal memory, and 80 (9%ile) for visual memory. DTTs showed disruptions in the anterior portion of the fornical body, right fornical crus, the anterior portion of the right cingulum, and the middle portion of the left cingulum, compared to the control. It seems that the sustained memory impairment of this patient might be related to injury of the cingulum and fornix.

Keywords: Fornix, Cingulum, Diffusion tensor imaging, Memory, Brain injury, Head trauma.

Ⅰ. Introduction

The cingulum and fornix are important neural tracts of the Papez circuit and limbic system.[1-4] The cingulum is a passage of fibers that extend from the orbitofrontal cortex to the medial temporal lobe, whereas the fornix connects the hippocampus and mamillary body.[1-4] Therefore, these two structures have importance with regard to memory function. In the past, a number of difficulties have been associated with assessment of these structures due to their long and thin shape and their location deep within the brain.

Brain injury have remained the disability such as motor weakness, memory problem, poor cognition and so on.[5-8] Therefore, accurate elucidation of presence and severity of lesions in patients with brain injury is essential for guiding neurorehabilitation strategies and for providing information regarding final outcomes. Recent advancements in diffusion tensor tractography (DTT) have allowed three-dimensional visualization of the cingulum and fornix[9-11] and many DTT studies have reported on injury of the cingulum or fornix following head trauma.[12-19] However, little is known about focal injury of these neural tracts.[15,16,19]

In the current study, we report on a patient who showed injury of the cingulum and fornix by penetration of a foreign body into the brain on DTT.

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Ⅱ. Case Report

A 63-year-old man suffered a brain injury by a part of a power saw blade that was suddenly detached from a power saw during work. A part of the power saw blade penetrated his right frontal skull and advanced to the right posterior horn of the lateral ventricle. This penetration caused traumatic intracerebral hemorrhage in the right frontal lobe and intraventricular hemorrhage in the lateral ventricle. Brain CT images taken at onset showed scattered bony pieces in the right frontal area and a part of the saw blade in the right temporal horn of the lateral ventricle. He underwent craniotomy and removal of intracranial foreign bodies (bony pieces and saw blade) using navigation in the department of neurosurgery at a university hospital. Brain MRI, which was taken at 10 weeks after onset, showed leukomalactic lesions in both orbitofrontal areas, right cingulate gyrus, and white matter around the right temporal horn of the lateral ventricle. The patient signed an informed consent statement, and the study protocol was approved by our institutional review board.

1) Clinical evaluation: Cognitive function was evaluated using the Wechsler Intelligence Scale and Memory Assessment Scale at 10 weeks after onset.[20,21] IQs on the Wechsler adult intelligence scale were total (79), verbal (84), and performance (74), respectively. Memory Assessment Scale scores were 74 (4%ile) for global memory, 78 (7%ile) for verbal memory, and 80 (9%ile) for visual memory.

2) Diffusion tensor imaging: Diffusion tensor images (10 weeks after onset) were obtained by a multi-channel head coil on a 1.5-T Philips Gyroscan Intera (Philips, Ltd, Best, the Netherlands) with single-shot echo-planar imaging. Imaging was performed using a 6-channel head coil. For each of the 32 non-collinear diffusion-sensitizing gradients, we acquired 67 contiguous slices parallel to the anterior commissure-posterior commissure line. Imaging parameters used were as follows: acquisition matrix=96×96, reconstructed to= 128 × 128, field of view= 221×221mm^2, TR=10,726ms, TE=76ms, SENSE factor=2, EPI factor=49 andb=1000s/mm^2, NEX=1, and a slice thickness of 2.3mm. Eddy current-induced image distortions were removed using affine multi-scale two-dimensional registration at the Oxford Centre for Functional Magnetic Resonance Imaging of Brain (FMRIB) Software Library (FSL; www.fmrib.ox.ac.uk/fsl). DTI-Studio software (CMRM, Johns Hopkins Medical Institute, Baltimore, MD, USA) was used for evaluation of the cingulum and fornix.Fiber tracking was based on the fiber assignment continuous tracking (FACT) algorithm and a multiple regions of interest (ROIs) approach. Two regions of interest were placed on the isolated area (cingulum: middle and posterior portion of the cingulum, fornix: body and crus).[9,11] Fiber tracking was started at the center of a seed voxel with a fractional anisotropy 〉0.15 and ended at a voxel with a fractional anisotropy of 〈0.15 and a tract turning-angle of 〈60 degrees. As a control subject, we recruited a 61-year old right-handed man without neurological disease history.
DTTs showed disruptions in the anterior portion of the fornical body, right fornical crus, the anterior portion of the right cingulum, and the middle portion of the left cingulum, compared to the control.

III. Discussion

In the current study, we presented with a patient who showed injury of the cingulum and fornix by penetration of a foreign body on DTT. According to the insertion site and final location of the saw blade, the saw blade penetrated the right frontal bone, and passed through the right frontal area and right lateral ventricle, and then finally reached the posterior horn of the right lateral ventricle. Considering this pathway, we could assume that the right cingulum and fornix might be injured; however, on DTT, we found that both the left cingulum and fornix and the right cingulum and fornix were injured. On the other hand, considering the pathway and duration between injury and DTI scanning, some portions of the injured fornix and cingulum appeared to have been degenerated.

Two main systems are known to be involved in declarative memory: the basal forebrain system and the medial temporal system. The cingulum extends from the basal forebrain and septal region, which contains the four cholinergic neurons, to the medial temporal lobe.[1-4] In addition, the cingulum is the passage of the medial cholinergic pathway, which originates from the nucleus basalis of Meynert and provides cortical cholinergic innervation to the cerebral cortex.[2,3] Furthemore, cholinergicpathway is known to be influenced the motor learning and motor skills. By contrast, the fornix connects the hippocampus and mamillary body and carries information on episodic memory between the hippocampus and the medial diencephalon.[1,9,11,22] Therefore, these two structures are important with regard to memory function. Although many other areas of the brain contribute to memory, it seems that the severe memory impairment of this patient is related to injury of the cingulum and fornix.

In the current study, we presented with a patient who showed injury of the cingulum and fornix by penetration of a foreign body on DTT.Particularly, injury of the cingulum, which is important for the cholinergic pathway, leads to the problems with the memory as well as motor learning and motor skills. For successful rehabilitation of patients with brain injury, a thorough estimation of the extent of injury is essential for guiding the treatment strategy and making an accurate prognosis. Therefore, we recommend evaluation of neural tracts using DTT for patients with head trauma.

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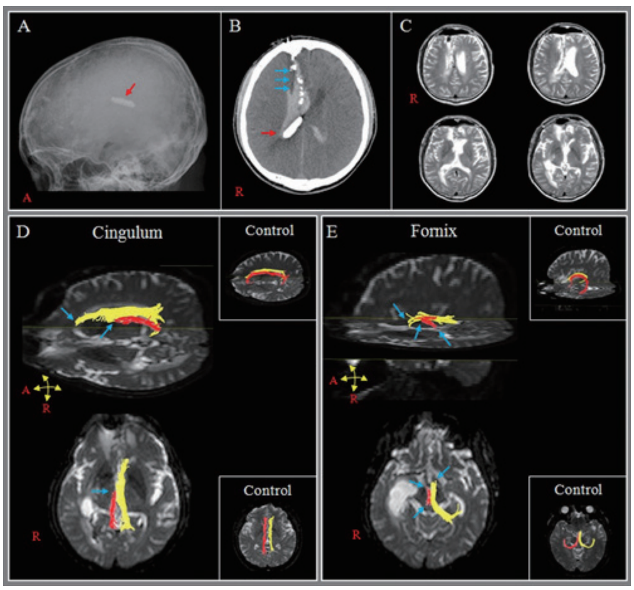

Figure 1. Brain CT, MRI, and results of diffusion tensor tractography.

A: Lateral skull image showing a part of the saw blade (red arrow).
B: Brain CT images taken at onset showed scattered bony pieces (blue arrows) in the right frontal area and a part of the saw blade (red arrow) in the right temporal horn of the lateral ventricle.
C: T2-weighted brain MRI taken at 10 weeks after onset showed leukomalactic lesions in both orbitofrontal areas, right cingulate gyrus, and white matter around the right temporal horn of the lateral ventricle.
D: Diffusion tensor tractography of the patient showed disruptions (blue arrows) in the anterior portion of the fornical body, right fornical crus, the anterior portion of the right cingulum, and the middle portion of the left cingulum, compared to the control.

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