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Original Article

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Injury of Corticostriatal Tract between the Striatum and the Premotor Area in a Patient with Traumatic Brain Injury

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Objectives: We investigated injury of corticostriatal (CStr) tract in patient with mild traumatic brain injury (mTBI), which was demonstrated by DTT.
Method: A 44-year-old female with no previous history of neurological, physical, or psychiatric illness had suffered from head trauma resulting from a pedestrian car accident. She complained that could not quickly move the left hand with her intension. After three month's administration, her slowness movement of left hand recovered rapidly to the point that she was able to extend all fingers quickly.
Results: On DTT configuration, the integrity of the left CStr tract was well-preserved, however the right CStr tract showed narrowing and partial tearing in the subcortical white matter on a DTT at 25 months after onset.
Conclusion: Injury of the right CStr tract was demonstrated in a patient who developed mild motor control problems following mild TBI. We believe that the evaluation of the CStr tract from the secondary motor area for patients who showed unexplained motor control problem is necessary.

Keywords: Traumatic brain injury, Corticostriatal tract, Motor control, Diffusion tensor tractography.

INTRODUCTION

The input nucleus of the basal ganglia is the striatum, which coming from motor cortical regions which include the primary sensory-motor cortex, the secondary motor area.[1,2] The corticostriatal (CStr) tract, which connecting between cerebral cortex and the striatum of the basal ganglia, is concerned with important roles in cognitive and motor functions, including action selection, motor control, sequence learning, and habit formation.[3] In addition, connectivity between the striatum and the premotor cortex (PMC) is concerned with the skilled movements and movement sequences including behavioral sequences of hand movements.[4-6] Although the CStr tract is a large neural tract in the human brain, injuries of the CStr tract have not been elucidated in detail following mild traumatic brain injury (mTBI). The introduction of diffusion tensor tractography (DTT), which is derived from diffusion tensor imaging (DTI), has enabled three-dimensional visualization and estimation of the neural tract.[7-9] However, no study has reported on the injury of the CStr tract. In this study, we report on a patient with mTBI who showed the injured CStr tract, which was demonstrated by DTT.

METHODS

1. Case report

A 44-year-old female with no previous history of neurological, physical, or psychiatric illness had suffered from head trauma resulting from a pedestrian car accident. During walk at a crosswalk, she was struck in the left leg by a sedan and fall down to the ground, and directly hit her head after hitting the car. The patient underwent the lost consciousness and post-traumatic amnesia for approximately ten minutes. She complained that could not quickly move the left hand with her intension. When she came the rehabilitation department of a university hospital two years after the stuck, although she showed mild weakness of the left upper extremity in the manual muscle test (manual muscle test: 4/5), we observed the slow, clumsy, and mutilated movements of the left hand when executing grasp-re-

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lease movements. Particularly, she could extend her left fingers slowly only with the order from the little finger to the thumb (within ten seconds). No specific lesion was observed on brain MRI (T1-weighted, T2-weighted, and fluid attenuated inversion recovery [FLAIR] images). After three month's administration of dopaminergic drugs for improvement of apraxia, her slowness movement of left hand recovered rapidly to the point that she was able to extend all fingers quickly (within three seconds).[10-12] In addition, the clumsiness and mutilated movement was almost disappeared. The patient provided signed, informed consent and our institutional review board approved the study protocol.

2. Diffusion tensor tractography

A six-channel head coil on a 1.5 T Philips Gyroscan Intera (Philips, Ltd., Best, the Netherlands) with single-shot echo-planar imaging was used for acquisition of DTI data at 25 months after onset. 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 matrix; field of view = 240 × 240 mm; TR = 10,398 ms; TE = 72 ms; parallel imaging reduction factor (SENSE factor) = 2; EPI factor = 59; b = 1,000 seconds/mm^2; NEX = 1; and a slice thickness of 2.5 mm. Analysis of DTI data was performed using the Oxford Centre for Functional Magnetic Resonance Imaging of the Brain (FMRIB) Software Library (FSL; www.fmrib.ox.ac.uk/fsl). Eddy current correction was applied to correct the head motion effect and image distortion. Fiber tracking was performed using probabilistic tractography, and applied in the default tractography option in FMRIB Diffusion Software (5,000 streamline samples, 0.5 mm step lengths, curvature thresholds = 0.2).[13,14]

A probabilistic tractography method, based on a multifiber model, was used in performance of fiber tracking, which was applied in the present study utilizing tractography routines implemented in FMRIB diffusion (5,000 streamline samples, 0.5 mm step lengths, curvature thresholds = 0.2).[13] For reconstruction of the CStr tract from the PMC, the seed region of interest (ROI) was placed on the striatum that was isolated on the FA map at the levels of internal capsule. The target ROIs was placed on the PMC (anterior boundary-the line drawn through the anterior commissure perpendicular to the anterior commissure–posterior commissure line, posterior boundary-precentral sulcus, medial boundary-midline between the right and left hemispheres, lateral boundary-the line passing through the lateral margin of the precentral knob and horizontal to the midline).[15]

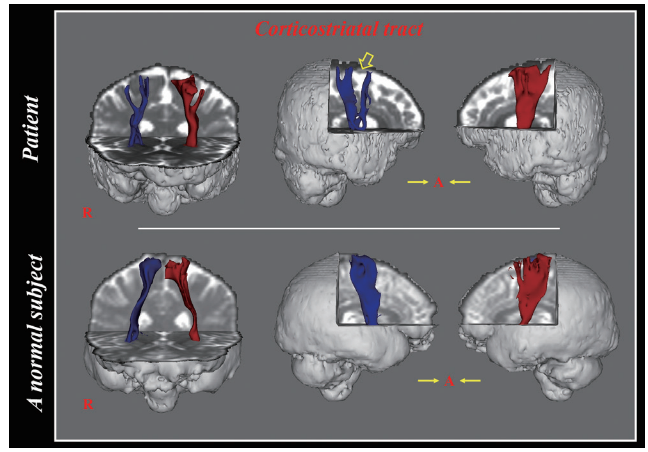

Figure 1. Results of diffusion tensor tractography (DTT) images of the Corticostriatal tract.

RESULTS

On DTT configuration, the integrity of the left CStr tract was well-preserved, however the right CStr tract showed narrowing and partial tearing in the subcortical whit matter on a DTT at 25 months after onset (Figure 1).

DISCUSSION

In this study, using DTT, injury of the right CStr tract was found in a patient who showed abnormal movement of the left hand following mild TBI. We think that the abnormal movement of the left hand in this patient was mainly ascribed to limb kinetic apraxia (LKA). Because we could found characteristics of left hand movements (slow, clumsy, and mutilated), that is compatible with those of LKA (awkward, clumsy, coarse, mutilated pattern of execution of simple movements, confined mainly to movements of the affected hand). In addition, we were able to rule out ideational and ideomotor apraxia because the patient showed normal cognition for motor performance and a normal result on the ideomotor apraxia test. On the other hands, dopaminergic drugs, which have been reported to be effective for treatment of apraxia, appeared to have been effective for improvement of LKA.[10,12,15,16] As a result, we thought that the motor problem of the left hand was attributable to the injury of the CStr tract.

In conclusion, injuries of the right CStr tract were investigated in a patient who developed mild motor control problems following mild TBI. Since the introduction of DTI, several neurochemical studies reported on the CStr pathway in the human brain.[5,6,17-21] To the best of our knowledge, this is the first DTT study on injury of the CStr tract in a patient with mTBI. Our results suggest the necessity of evaluation of the CStr tract

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from the secondary motor area for patients who showed unexplained motor control problem. However, the limitations of DTT should be considered that may produce both false positive and negative results throughout the white matter of the brain, due to crossing fiber or partial volume effect.[22]

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