

# Headache due to spinothalamic tract injury in patients with mild traumatic brain injury

## Two case reports

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### Abstract

**Rationale:** Headache is the most common physical complaint reported by the following traumatic brain injury (TBI). Several studies using diffusion tensor tractography (DTT) have demonstrated that injury of the spinothalamic tract (STT) is a pathogenetic mechanism of central pain following TBI. However, no study of headache due to injury of the STT has been reported.

**Patient concerns:** Patient 1 was a 52-year-old female who suffered head trauma resulting from an in-car traffic crash. While sitting in a passenger seat in a moving vehicle, another vehicle suddenly hit the car from the right side. Her head hit the door and she suffered a flexion-hyperextension-rotation injury. She began to feel headaches in both fronto-parieto-occipital areas approximately 2 weeks after the crash. The characteristics and severity of pain were as follows: constant tingling and intermittent stabbing pain without allodynia or hyperalgesia (visual analogue scale score: 7). Patient 2 was a 50-year-old male who suffered head trauma from a flexion-hyperextension injury that occurred after being hit from behind by a vehicle while driving his car. He began to feel headache in both fronto-parieto-occipital areas the day after the crash: constant tingling pain without allodynia or hyperalgesia (visual analogue scale score: 6).

**Diagnoses:** The patient 1 was diagnosed as mild TBI due to head flexion-hyperextension-rotation injury. The patient 2 was diagnosed as mild TBI due to head flexion-hyperextension injury.

**Interventions:** Clinical assessment and DTT were performed at 5 months (patient 1) and 10 months (patient 2) after the initial injury.

**Outcomes:** On DTTs of patient 1 and 2, the STTs showed narrowing in both hemispheres. In addition, discontinuations at the subcortical white matter were observed in both hemispheres in patient 2.

**Lessons:** Headache due to injury of the STT was diagnosed in patients with mild TBI. Precise diagnosis of central pain from other types of pain is clinically important because the management of central pain is quite different from those for other types of pain. Our results suggest that headache might be ascribed to the injury of the STT in patients with mild TBI. Therefore, we recommend evaluation of the STT using DTT in patients with mild TBI who complain of headache having the characteristics of neuropathic pain.

**Abbreviations:** AF = arcuate fasciculus, DTI = diffusion tensor imaging, DTT = diffusion tensor tractography, fMRI = functional magnetic resonance imaging of the brain, GCS = Glasgow Coma Scale, GRE = gradient recall echo, LOC = loss of consciousness, PTA = post-traumatic amnesia, ROI = regions of interest, STT = spinothalamic tract, TBI = traumatic brain injury.

**Keywords:** central pain, diffusion tensor imaging, mild traumatic brain injury, spinothalamic tract

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## 1. Introduction

Headache is the most common physical complaint reported by the following traumatic brain injury (TBI): prevalence of post-traumatic headache ranges from 30% to 90%.<sup>[1–3]</sup> International Headache Society classifies the primary headaches as migraine, tension type, cluster, and other primary types.<sup>[1,4,5]</sup> However, little is known about headache with central pain caused by injury of the brain.

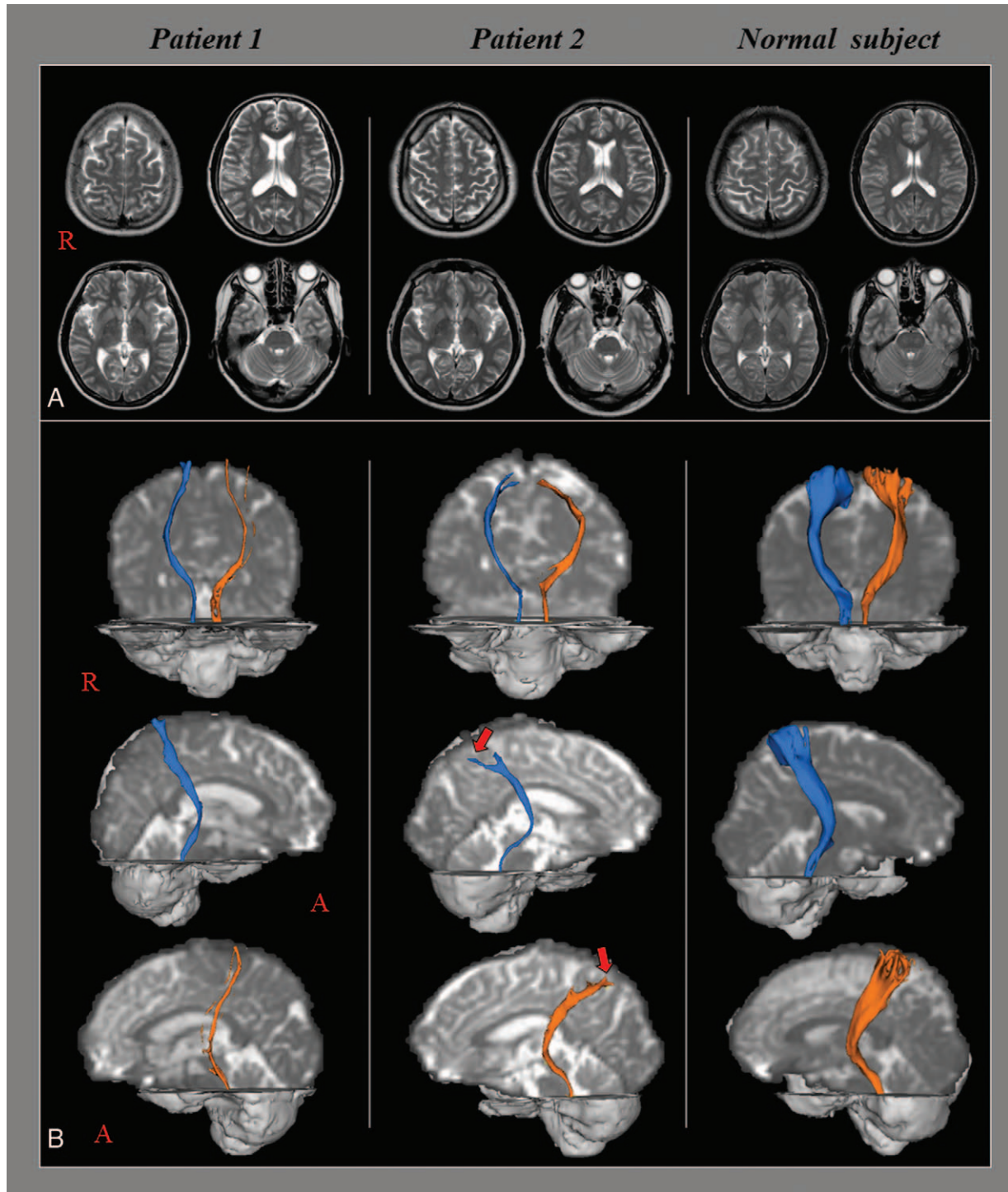
Diffusion tensor tractography (DTT), derived from diffusion tensor imaging (DTI), enables three-dimensional reconstruction, and evaluation of the spinothalamic tract (STT).<sup>[6]</sup> Several studies using DTT have demonstrated that injury of the STT is a pathogenetic mechanism of central pain following TBI.<sup>[7–10]</sup> However, no study of headache due to injury of the STT has been reported.

In the present study, we report two patients who developed headache following injury of the STT due to mild TBI.

## 2. Case report

Two patients were selected by the following inclusion criteria:

- (1) loss of consciousness (LOC) for 30 min or less, post-traumatic amnesia (PTA) for less than 24 h, and Glasgow Coma Scale (GCS) score of 13 to 15 recorded 30 min post-injury or later upon presentation for health care,<sup>[11]</sup>
  - (2) no visible lesion on T1-weighted, T2-weighted, Fluid attenuated inversion recovery (FLAIR), and T2-weighted gradient recall echo (GRE) brain images,
  - (3) development of headache after mild TBI,
  - (4) other types of headache (migraine, tension type headache, cervicogenic headache, myofascial pain syndrome, and neuritis) were ruled out by physical examination,
  - (5) no history of previous head trauma, psychiatric, or neurological diseases.
- Both patients provided signed, informed consent, and our Institutional Review Board approved the study protocol.



**Figure 1.** (A) T2-weighted brain MR images show no abnormal lesion. (B) Results of diffusion tensor tractography (DTT) for the spinothalamic tract (STT). The STTs show narrowing in both hemispheres compared with those of a normal subject (85-year old female). In addition, discontinuities (red arrows) at the subcortical white matter are observed in both hemispheres in patient 2.

## 2.1. Case 1

Patient 1 was a 52-year-old female who suffered from head trauma from an in-car traffic crash. While sitting in a passenger seat in a moving vehicle, another vehicle suddenly hit her vehicle from the right side. At the time of head trauma, her head hit the door and she suffered a flexion-hyperextension-rotation injury. The patient experienced LOC and PTA for approximately 30 min at the time of head trauma, and her GCS was 15 when she arrived at the hospital. She began to feel headache in both fronto-parieto-occipital area approximately 2 weeks after the crash. The characteristics and severity of pain were as follows: constant tingling and intermittent stabbing pain without allodynia or hyperalgesia (visual analogue scale score: 7).<sup>[12]</sup> She was prescribed gabapentin (600mg/day) and her headache was well-controlled to a tolerable level.

## 2.2. Case 2

Patient 2 was a 50-year-old male who suffered from head trauma resulting from flexion-hyperextension injury after being hit from behind by another vehicle while driving. He did not lose consciousness and experienced PTA for approximately 30 s from the time of the accident. His Glasgow Coma Scale score was 15. He began to feel headache in both fronto-parieto-occipital area the day after the crash: constant tingling pain without allodynia or hyperalgesia (visual analogue scale score: 6).<sup>[12]</sup> His headache was well-controlled to a tolerable level with the prescription of gabapentin (900 mg/day).

## 3. Diffusion tensor imaging

DTI data were acquired at 5 months (patient 1) and 10 months (patient 2) after the initial injuries using a 6-channel head coil on a 1.5 T Philips Gyroscan Intera (Philips, Best, Netherlands) with single-shot echo-planar imaging. For each of the 32 noncollinear diffusion sensitizing gradients, 67 contiguous slices were acquired parallel to the anterior commissure-posterior commissure line. Imaging parameters were as follows: acquisition matrix =  $96 \times 96$ , reconstructed to matrix =  $192 \times 192$ , field of view =  $240 \times 240 \text{ mm}^2$ , TR = 10,398 ms, TE = 72 ms, parallel imaging reduction factor (SENSE factor) = 2, echo-planar imaging factor = 59,  $b = 1000 \text{ s/mm}^2$ , NEX = 1, and a slice thickness of 2.5 mm.

## 4. Fiber tracking

The Oxford Centre for Functional Magnetic Resonance Imaging of the Brain (FMRIB) Software Library was used for analysis of DTI data. Eddy current correction was applied to correct the head motion effect and image distortion. FMRIB Diffusion Software with routines option (0.5 mm step lengths, 5000 streamline samples, and curvature thresholds = 0.2) was used for fiber tracking.<sup>[13]</sup> For reconstruction of the STT, the seed region of interest was placed in accordance with known anatomy (posterolateral to the inferior olivary nucleus and anterior to the inferior cerebellar peduncle in the medulla).<sup>[14]</sup> Two target regions of interest were placed on the portion of the ventro-postero-lateral nucleus of the thalamus and primary somatosensory cortex.<sup>[14]</sup> The threshold of two streamlines was applied for the results of fibre tracking.

On DTTs of patient 1 and 2, the STTs showed narrowing in both hemispheres. In addition, discontinuations at the subcortical white matter were observed in both hemispheres in patient 2 (Fig. 1B).

## 5. Discussion

On DTT of the two patients in this study, the narrowing or discontinuation of both the STTs appeared to indicate the partial injury. We believe that the headaches were attributable to injury of the STT based on the following facts:

- (1) typical pain characteristics of neuropathic pain: tingling or stabbing pain,
- (2) other types of headache were ruled out by physical examination, and
- (3) good response to gabapentin, a drug specific for neuropathic pain.

Thus the injury of the STT in the brain appeared to be the cause of headache in these patients, and traumatic axonal injury was the most likely pathogenetic mechanism for the STT injuries because no abnormality was detected on the conventional brain MRI.<sup>[15,16]</sup> Considering that the patients felt headache later after head trauma (approximately 2 weeks (patient 1) and 1 day (patient 2)), their headaches likely resulted from the secondary injury of the STT.<sup>[16,17]</sup>

Since the introduction of DTI, several studies have reported central pain due to injury of the STT in patients with mild TBI.<sup>[7–10]</sup> However, these studies focused on the central pain that developed in the extremities and trunk. To the best of our knowledge, this is the first study to demonstrate the headache that developed from injury of the STT in patients with mild TBI. However, the limitations of DTT should be considered: because regions of fiber complexity and crossing can prevent full reflection of the underlying fiber architecture by DTT, it may underestimate the fibers of the neural tracts.<sup>[18]</sup>

In conclusion, headache due to injury of the STT was diagnosed in patients with mild TBI. Precise diagnosis of central pain from other types of pain is clinically important because the management of central pain is quite different from those for other types of pain. Our results suggest that headache might be ascribed to the injury of the STT in patients with mild TBI. Therefore, we recommend evaluation of the STT using DTT in patients with mild TBI who complain of headache having the characteristics of neuropathic pain. However, this study is limited because it was based on two cases; thus, conduct of further complementary studies including larger number of patients is warranted.

## Author contributions

Conceptualization: SungHo Jang.

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