

● IMAGING IN NEURAL REGENERATION

Gait deterioration due to neural degeneration of the corticoreticular pathway: a case report

The corticoreticular pathway (CRP) mainly mediates proximal and axial muscles and therefore it is an important neural tract for walking (Miyai et al., 2002; Matsuyama et al., 2004; Mendoza and Foundas, 2007). Diffusion tensor tractography (DTT), derived from diffusion tensor imaging (DTI), enables reconstruction of the CRP three-dimensionally and several studies have reported on the association between the CRP and gait recovery (Yeo et al., 2012a, 2013; Jang et al., 2013, 2015; Jang and Seo, 2014; Kwon and Jang, 2014). However, to the best of our knowledge, there has been no report on degeneration of the CRP. In the current study, we reported on a patient with intracerebral hemorrhages (ICHs) in both hemispheres, presenting with gait deterioration due to neural degeneration of the CRP as shown on DTT images.

A 64-year-old male presented with gait deterioration which started 2 months ago. He had a history of spontaneous ICHs in both putamens (the right ICH: 19 years ago, and the left ICH: 11 years ago). The patient's motor weakness was measured using Medical Research Council (MRC) scale (Council, 1976). His walking ability was assessed using Functional Ambulatory Category (FAC) (Cunha et al., 2002).

Before the onset of gait deterioration, his motor function had recovered to a subnormal state in the right extremities and a nearly normal state in the left extremities; therefore, he was able to walk independently, even on stairs (FAC: 4). Since about 2 months ago, his gait function had begun to deteriorate and aggravated progressively with time. Two months after the onset of gait disturbance, he could not walk independently, even on floors (FAC: 1.5). He presented with weakness of proximal joints along with more severe weakness in the right extremities compared with the left side (MRC scale, shoulder abductor: 4⁻/4, elbow flexor: 4/4⁺, finger extensor: 4/4⁺, hip flexor: 4⁻/4, knee extensor: 4/4⁺, ankle dorsiflexor: 4/4⁺) (Council, 1976). Brain MR images taken at 2 months after onset of gait deterioration showed leukomalactic lesions in both subcortical white matter and basal ganglia (Figure 1B).

DTI data were obtained twice (first DTI: 6 years ago and second DTI: 2 months after onset of gait deterioration). Sixty contiguous slices (field of view = 240 × 240 mm²; repetition time = 10,726 ms; echo time = 76 ms; *b* = 1,000 s/mm²; number of excitations = 1; and thickness = 2.5 mm) were acquired. FACT algorithm was used for fiber tracking. The CRP was reconstructed using fibers passing through two regions of interest (ROIs) on the color map. The first ROI was given at the medullary reticular formation and the second ROI at the midbrain tegmentum. Termination criteria used for fiber tracking were fractional anisotropy (FA) of less than 0.2 and angle of less than 60°.

On the first DTT scan performed 6 years ago, the integrities of the CRPs in both hemispheres were preserved from the cerebral cortex to the medulla. By contrast, on the second DTT taken at 2 months after onset of gait deterioration, both CRPs

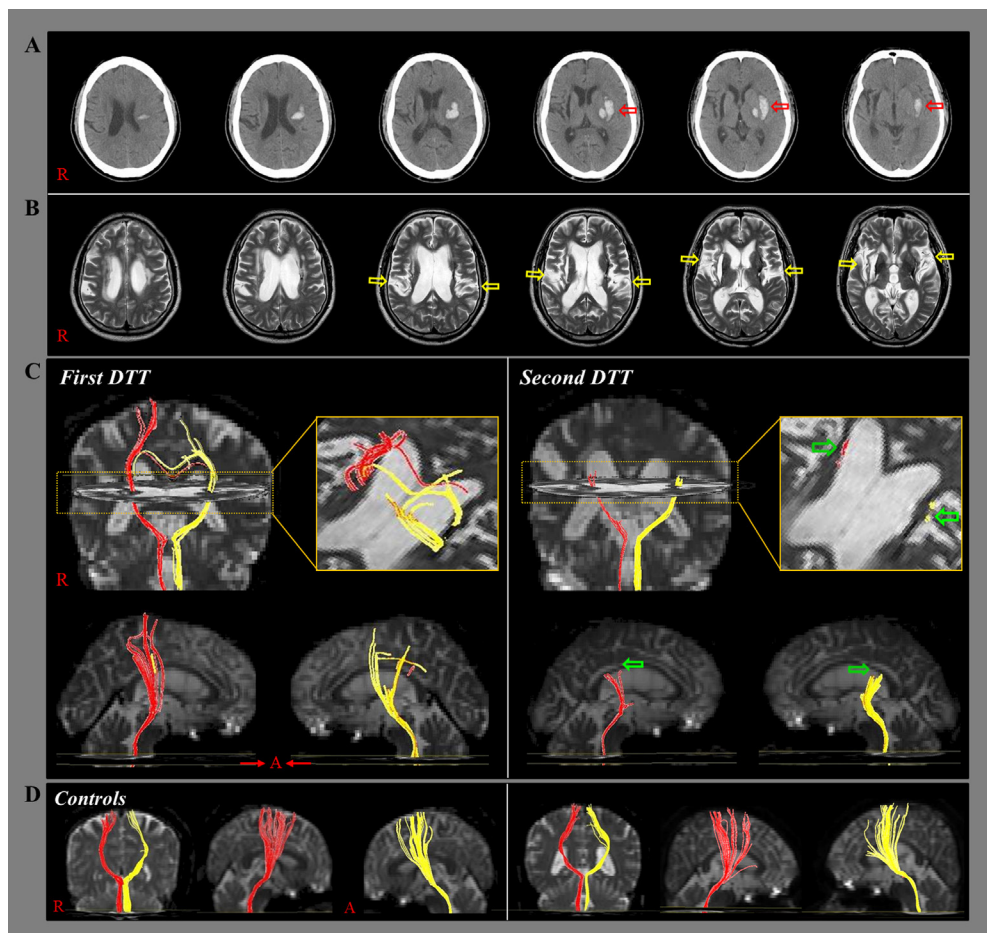


Figure 1 Brain CT and MR images and results of diffusion tensor tractography (DTT) in a 64-year-old male patient with gait deterioration.

(A) Brain CT images at 11 years before onset of gait deterioration show a spontaneous intracerebral hemorrhage in the left putamen (red arrows). (B) Brain MR images taken at 2 months after onset of gait deterioration showed leukomalactic lesions in both subcortical white matter and basal ganglia (yellow arrows). (C) Results of DTT. On the first DTT images (6 years before onset of gait deterioration), the integrities of the corticoreticular pathways (CRPs) in both hemispheres were preserved from the cerebral cortex to the medulla. By contrast, on the second DTT images (2 months after onset of gait deterioration), both CRPs showed discontinuities (green arrows) at the corona radiata level compared with the first DTT images. (D) DTTs of the CRP of two age- and sex-matched normal control subjects (62- and 66-year-old males). The red (C) and yellow (D) mean the right and left corticoreticular pathway, respectively.



showed discontinuation at the corona radiata level compared with the first DTT (**Figure 1C**).

In this study, the gait deterioration in this patient was ascribed to delayed neural degeneration of both CRPs.

The patient began to show gait deterioration 2 months ago, before undergoing the second DTT. The second DTT for the CRP, taken at 2 months after onset of gait deterioration, showed discontinuations at the corona radiata compared with the first DTT (6 years ago), which showed that integrities of both CRPs were intact. This finding was consistent with the characteristics of motor weakness of the patient (more severe weakness of proximal muscles) (Matsuyama et al., 2004; Mendoza and Foundas, 2007; Yeo et al., 2013). Regarding the pathophysiological mechanism of delayed neural degeneration of the CRP in the corona radiata, injury of peri-lesional white matter might occur through a chemical mechanism: a blood clot might release potentially toxic substances which can induce injury to neural tissue, such as free iron, which might release free radicals or inflammatory cytokines (Chua et al., 2009; Yeo et al., 2012b). However, other factors that can deteriorate the gait function such as normal aging or physical deconditioning should be also considered.

Accompanying neural degeneration is often observed after stroke (Yu et al., 2009; Puig et al., 2010). Many studies have reported on Wallerian degeneration that started immediately after neuronal injury in the acute stage of stroke (Yu et al., 2009; Puig et al., 2010). Wallerian degeneration is a process characterized by degeneration of axons and their distal part myelin sheath in the central and peripheral nervous system. However, little is known about delayed neural degeneration in stroke patients. To the best of our knowledge, this is the first study to report on neural degeneration of the CRP although a few previous studies have reported on neural degeneration of the CST in stroke patients (Radlinska et al., 2009; Jang and Seo, 2016). However, DTI might underestimate the neural fibers due to the fiber-crossing effect (Yamada et al., 2009), which should be considered.

In conclusion, we report on a patient who showed delayed gait deterioration due to neural degeneration of the CRP. We believe that DTT evaluation of the CRP would be helpful to elucidate the mechanism behind delayed gait deterioration in stroke patients.

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