DETERMINATION OF HAND MOTOR CORTICOSPINAL TRACT IN CORONA RADIATA BY FUNCTIONAL MRI AND DIFFUSION TENSOR IMAGING

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Introduction

The corticospinal tract (CST) is the major pathway of the motor fibers in human body. Since the CST originates from the pyramidal cells in cerebral cortex which has somatotopic organization, it also has somatotopic organization. Although many studies for the somatotopic organization of CST related to hand and foot motor function have thus far been performed [1-4], the accurate somatotopic location of the CST is still controversial because of the individual variation of the CST pathway [2-4]. In this work, we obtained the probability map of hand motor CST and measured the relative mediolateral distance and anteroposterior distance of the center of the hand motor CST at the level of corona radiata in the normal human brain by using the similar method proposed by Kim et al. and combining Diffusion Tensor Tractography (DTT) and functional magnetic resonance imaging (fMRI) results.

Methods

Twenty healthy subjects (11 men, 9 women, mean age: 42 years) participated in this study. All subjects provided signed, informed consent prior to the commencement of the study, and our institutional review board approved the study protocol. Using a block paradigm (15 s control, 15 s stimulation: 3 cycles), hand grasp-release movements (1 Hz) were performed for stimulation. fMRI data were obtained at 1.5-T Philips Gyroscan Intera system using a standard head coil. Thirteen axial EPI-BOLD images were acquired (TR/TE = 2000/60 ms, FOV = 210 mm, matrix = 64 × 64, thickness = 5 mm). The obtained fMRI data was analyzed using SPM2 (Wellcome Department of Cognitive Neurology, London, UK). Statistical parametric maps were obtained using the criterion $p < 0.001$, uncorrected, minimum cluster size = 5. The Diffusion Tensor data were acquired at the same scanner with single-shot spin echo EPI with a navigator echo. Sixty contiguous slices (matrix = 128 × 128, FOV = 221 mm, TR/TE = 0726/76 ms, b = 600 $mm^2\ s^{-1}$, slice thickness = 2.3 mm) were acquired for each of the 32 noncollinear diffusion-sensitizing gradients. The effects of eddy currents and head motion were corrected by registering all DW images to b0 image using affine registration. DTI data were analyzed using the DtiStudio 2.40(Department of Radiology, Johns Hopkins University, Baltimore, Maryland, USA) with the termination criteria for fiber tracking : (FA < 0.15, angle change > 70°). Three regions of interest (ROI) were drawn in the posterior limb of internal capsule, superior part of cerebral peduncle, superior and middle portion of pons and one ROI was drawn in the area including the activated area in hand motor cortex which was identified by coregistering the fMRI activation map to b0 image. The fiber tract passing through all the above 4 ROIs were selected as the CST connected to hand motor cortex. As shown in figure 1, we defined the line (AC) passing the most medial point of the lateral ventricle as the medial boundary, the line (BD) passing the most lateral point of the lateral ventricle as the lateral boundary, the line (AB) passing the most anterior point of the lateral ventricle as the anterior boundary, and the line (CD) passing the most posterior point of the lateral ventricle as the posterior boundary. The O was defined as the location of the center of the hand motor CST. The Lx and Ly were defined as the distances from line (AC) to O and from line (CD) to O, respectively. We measured the relative mediolateral distance (Lx/AB×100 %) and anteroposterior distance(Ly/AC×100 %) of the location of the CST at the level of the upper CR and lower CR. To make the probability map, the abscissa and the ordinate of each pixel in lower and upper CR were rescaled by the length of AB and AC, respectively. For each individual data, 1 was assigned to pixel value for pixels included in hand motor CST otherwise 0. The twenty individual data were summed pixel by pixel and the probability of each pixel was defined by the percentage ratio of the pixel value to number of subjects, 20.

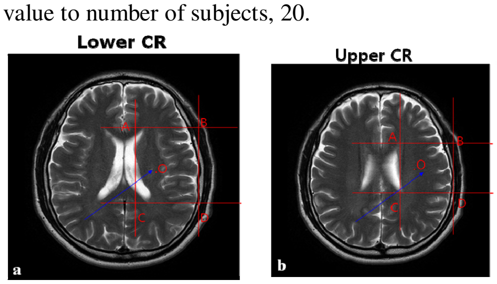

Figure 1. Demonstration of the mediolateral and anteroposterior distances. O represents the center of CST location

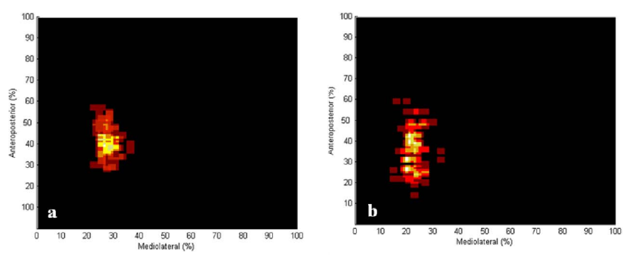

Figure 2. Relative probability maps in lower CR (a) and in upper CR

Results

The Lx/AB ratios were 26.3 ± 3.0 % in the upper CR and 21.9 ± 3.3% in the lower CR and Ly/AC ratios were 42.9 ± 7.0% in the upper CR and 36.2 ± 9.8% in the lower CR. The figure 2 shows the probability maps of the hand motor CST in lower CR (a) and upper CR (b).

Discussion

In this study we successfully obtained the relative probability map and measured the relative mediolateral distance and anteroposterior distance. The anteroposterior distance (Ly/AC) in the lower CR shows good agreement with previous work (35.8 ± 8.3%)[1]. Although our method has some limitations, our results may be useful for diagnosis of the patients with hand motor impairment.

Reference

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