The somatotopic organization of thalamocortical projection fibers through the centrum semiovale

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Background and Purpose –. The somatotopic representations of the body parts (homunculus) of the primary motor cortex have been well documented in textbooks and the literature (1-3). The corresponding sensory homunculus lies posterior to the motor homunculus at the level of the sensory cortex of the parietal lobe, where the projection fibers from the ipsilateral thalamus terminate. Unlike the corticospinal trajectory through the centrum semiovale, the thalamocortical projection has not been fully documented in the past, neither in animal experiments nor in clinical reports (4-7). We sought to resolve this matter by using diffusion-tensor imaging (DTI) based tractography (8-9).

Materials and Methods –. Seven normal volunteers were recruited from the academic community (age; 20-55 years). All images were obtained using a 1.5 Tesla whole body scanner (Gyroscan *Intera*, Philips Medical Systems, Best, Netherlands). DTI was performed with an acquisition time of approximately 30 minutes. A single-shot EPI technique was used for DTI (TR/TE = 6000/88 ms) with a MPG in 15 orientations, a *b*-value of 1000 sec/mm^2, and image averaging of 9 times. Parallel imaging technique was used to record the data with a 128 x 128 resolution for a 256 mm x 256 mm field of view. A total of 41 slices were obtained with a thickness of 2 mm without interslice gaps. Thus the pixel size was isotropic (2 x 2 x 2 mm). The anisotropy at each pixel was calculated, and color maps were created with the use of a previously described method (10-12). When tracking the pyramidal and sensory tracts, we placed the ROI to cover the unilateral ventral/dorsal pons and part of the motor/sensory cortices (Figure 1). The ROI of the cortex were divided into three regions to characterize the rotation of the homunculus.

Results –. A total of seven pairs of pyramidal and sensory tracts were successfully depicted. All the pyramidal tracts had an anterior rotation, which corresponds well with the known trajectory of the pyramidal tract (2-3). Sensory tracts were also successfully depicted in a symmetric fashion in all subjects. A representative sensory tract from volunteer #3 was plotted onto a template of the brain (Figure 2). The sensory homunculus started at the level of the thalamus, where it was oriented in a horizontal fashion with the head part medial and the leg part lateral. The sensory homunculus made a posterior rotation as the tract traveled through the centrum semiovale, and was in a "headstand" position when it reached the level of the lateral ventricle. Slice by slice measurements of the rotational angles for both the sensory and pyramidal tracts were done, and the results plotted (Figure 3).

Conclusion –. Sensory and motor fibers of the lower extremity form an axis of rotation, around which the pyramidal tract takes an anterior turn to reach the internal capsule, and around which the sensory fibers take a posterior turn from the thalamus towards the sensory cortex of the parietal lobe. This organization of the sensorimotor tracts through the centrum semiovale has not been previously described and could have clinical implications in neurosurgery and neurology.

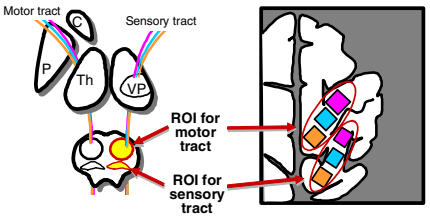

Figure 1

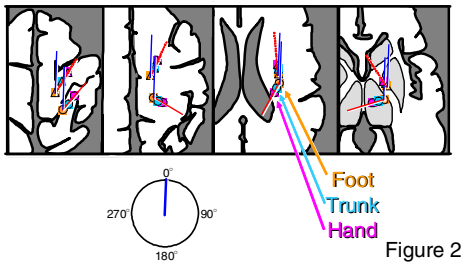

Figure 2

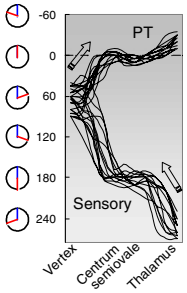

Figure 3

REFERENCES
1. Schott GD 1993. ***J Neurol Neurosurg Psychiatry*** 56, 329-333
2. Patten J. 1996. In Patten J, (ed). ***Neurological differential diagnosis*** 133-148
3. Morecraft RJ et al. 2002. ***Brain*** 125, 176-198
4. Groothuis DR et al. 1977. ***Ann Neurol*** 2, 328-331.
5. Isono O et al. 1993. ***Neurology*** 43, 51-55.
6. Bassetti C et al.. In: Bogousslavsky J et al. (eds). ***Stroke syndromes*** 15-29
7. Qi HX et al. 2002. ***J Comp Neurol*** 443, 168-182
8. Mori S et al. 1999. ***Ann Neurol*** 45, 265-269
9. Parker GJ et al. 2002. ***Neuroimage*** 15, 797-809
10. Basser PJ et al. 1994. ***J Magn Reson B*** 103, 247–254.
11. Pierpaoli C et al. 1996. ***Magn Reson Med*** 36, 893–906.
12. Makris N et al. 1997. ***Ann Neurol*** 42, 951–962.