Method to Quantify Improvement in Brain White Matter Integrity in Response to Motor Learning in a Stroke Patient, by Integrating Functional Magnetic Resonance Imaging and Diffusion Tensor Imaging.

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Background: Motor recovery after stroke is associated with changes in brain structure, i.e. brain plasticity. Plasticity of the adult brain was demonstrated in histological animal studies, but brain plasticity in humans can be measured only with non-invasive methods and therefore presents a challenge for measuring treatment response. It is difficult to accurately specify the location and structural integrity of white matter tracts using any one given imagining method. Therefore, purpose of this study was to investigate the feasibility of specifying white matter tracts and their integrity by integrating Functional Magnetic Resonance (fMRI) and Diffusion Tensor Imaging (DTI).

Methods: A patient with upper extremity weakness and dyscoordination after stroke (_6 mos) was treated with an intensive 12-week (5 hr/day, 5 d/week) motor learning program. Fractional anisotropy (FA; scale, 0 –1) was used to measure corticospinal tract (CST) integrity. fMRI and DTI data were obtained on 1.5T MRI machine before and after the treatment. The DTI was obtained with a single-shot, diffusion weighted spin-echo EPI sequence (TR / TE_6.0 sec/103 ms, two b values_0 and 1000 mm2/s; 12 diffusion gradient directions). The fMRI for wrist/forearm movement task was acquired using an interleaved multislice gradient echo EPI sequence (TR / TE_2.5 sec/30 ms). The fMRI and DTI data were co-registered and analyzed with SPM5 and MedInria software. CST of the affected hemisphere were reconstructed using two seeds: the fMRI activation area within the precentral gyrus and the crus cerebri of the ipsilateral midbrain. A healthy control subject was evaluated with the same imaging protocol. Motor function was assessed with Fugl-Meyer Coordination test (FM) and Arm Motor Ability test (AMAT).

Results: It was feasible to objectively specify the CST based on fMRI activations and measure CST integrity using integrated fMRI and DTI. Co-registration of fMRI and DTI data was possible for both control and stroke. For FA (mean FA across voxels within each tract_standard deviation) of the CST pre-/post-treatment values were 0.30_0.19 and 0.348_0.21, respectively. FA of the healthy control subject's CST was 0.449_0.25. There was a pre-/post-treatment improvement in motor coordination (FM; 8 points) and function (AMAT; 18 secs).

Conclusion: The FA measure of white matter integrity was feasible and practical to use in quantifying CST integrity, and may prove valuable in quantifying changes in response to rehabilitation. A positive change after treatment occurred in this subject for both white matter tract structure and motor function.