QUANTITATIVE DIFFUSION TENSOR IMAGING SHOWS REMODELLING OF THE INFARCT AREA AND FIBER TRATCS PLASTICITY IN PATIENTS RECOVERING FROM SMALL ISCHEMIC MCA STROKE.

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Background: Understanding brain plasticity after stroke is important in developing rehabilitation strategies but the anatomical changes underlying recovery remain obscure. Infarct shrinking (1) and increased functional activity of the periinfarct region have been shown to positively correlate with functional improvement after ischemic stroke. Wallerian degeneration, the anterograde degeneration of axons and their myelin sheaths after proximal axonal or cell body injury, have traditionally been described in large MCA strokes and reported to be predictive of poor outcome (2, 3). Contralateral changing of the electrical activity (4), cerebral blood flow (5) and/or metabolism (6) has also been correlated to functional recovery, suggesting possible structural remodelling of the non-lesioned hemisphere.

Objectives: We used new diffusion imaging tools to study ipsilateral and contralateral micro-structural and connectivity changes after stroke, which could be related to functional recovery.

Methods: Five patients with small ischemic MCA strokes were studied and followed-up longitudinally up to six months after stroke. MR DTI was performed within one week of symptoms onset and at 1 and 6 months after the acute event on 1.5-T scanner using an in-house 23 channel head coil. (EPI, TR 7500 ms, TE 99.3 ms, FOV 22x22 cm, b values=700 s/mm^{2}, 30 diffusion gradient directions plus 5 non-diffusion-weighted images, slice thickness 2.2 mm, no gap, total acquisition time 4:28 min:s). NIHSS scores were recorded at every time point. Trace and fractional anisotropy (FA) maps were computed for grey (GM) and white matter (WM) using constraints of FA<0.3/ADC<500 mm^{2} s^{-1} for GM and FA>0.4/ADC >1400 mm^{2} s^{-} for WM. Skull-stripped and CSF-masked brain volumes (FSL analysis system, BET; http://www.fmrib.ox.ac.uk/fsl/bet/) were used for registration across the multiple time points (FLIRT). The stroke volume (SV) was manually traced on low-b maps and secondary ROIs (SR) were selected along the functional tract involved in the main symptoms (corticospinal tract for 2 patients, arcuate fascicle for 2 patients and insulo-somatosensory area I connections for 1 patient). DTI tractography was performed using in-house tools (poistats, courtesy of Dr D. Tuch): a replica exchange Monte Carlo algorithm (n=100 replica) to calculated the optimal pathway between the regions of interest and the path was represented as a trilinear spline with n control points. The energy of the path was defined as the negative log product integral of the diffusion orientation distribution function along the path. Statistical analysis was performed with T tests and Spearmann correlation tests.

Results: All patients had complete functional recovery (final NIHSS=0). In the stroke area, GM FA and Trace respectively decreased and increased after stroke ($p<0.05$ and $p<0.001$) appearing to be positively and negatively correlated with NIHSS score ($p<0.05$ and $p<0.01$): increased diffusivity and loss of anisotropy could indicate atrophic involution and infarct shrinking which had previously been correlated with functional recovery (1).

Trace and FA, along the functional pathways sub-served by the injured area, differed significantly between the IL and CL hemisphere only during f.u. (1 and 6 months after stroke, $p<0.0001$). IL tract related-FA positively correlated with NIHSS score whereas IL tract-related-ADC showed a negative correlation ($p<0.05$), indicating probably wallerian degeneration. In this cohort of patients with small acute infarct sizes (1853 mm^{3} $\pm$ 2041), this phenomenon is therefore not predictive of poor outcome, as previously reported in case of large MCA strokes (2) . No significant tract-specific changes were observed in CL FA and trace.

Conclusion: This study demonstrates that ROI analysis and tractography DTI images should be combined to monitor remodelling after stroke. This approach opens new perspectives on possible mechanisms leading to functional recovery after ischemic brain injury.

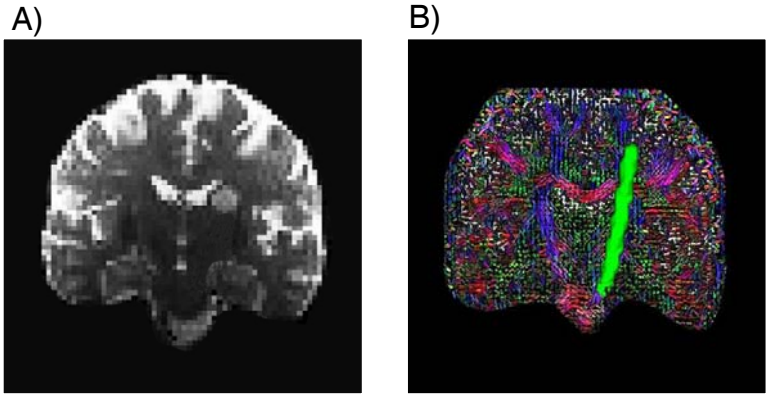

Figure 1: A) Coronal T2 image showing an acute stroke in left posterior internal capsule and corona radiate. B) Coronal poistats tractography of the cortico-spinal tract subserving the lesioned ischemic area

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References:

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