DSI TRACTOGRAPHY DEMONSTRATES CONNECTIVITY REMODELLING AFTER STROKE

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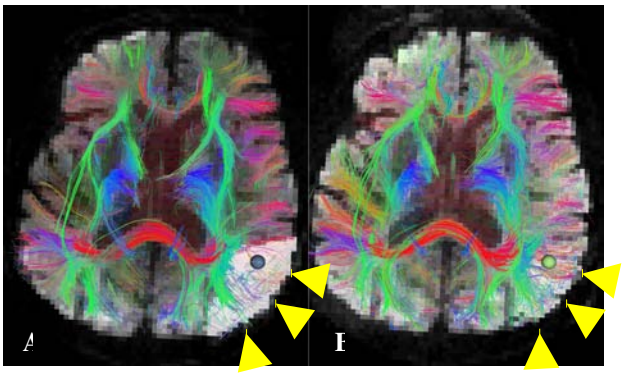
Background:
Wernicke's aphasia (fluent aphasia: impaired comprehension, naming and repetition) has been traditionally considered the result of a lesion in the posterior region of the left superior temporal gyrus, sometimes involving the inferior part of the parietal lobe (Penfield et al., 1959).
Recently, it has also been proposed that Wernicke-like syndromes could be originated by a selective lesion in the postero-lateral part of the arcuate fasciculum (Catani et al., 2005), which connects the postero-superior temporal area with the inferior parietal area. Recovery of speech function is related to the lesion size, the involvement of the parietal lobe (Kertesz et al., 1993) and to the remodeling of the connectivity underlying the lesioned cortical areas including potentially the arcuate fasciculum (Catani et al., 2005). We sought to use tractography to identify whether or not remodeling might be associated with recovery from Wernicke's aphasia.

Methods:
One right-handed subject with left middle cerebral artery ischemic stroke and aphasia was scanned in the acute phase (3 days after stroke) and at 1 month follow-up (f.u.) Clinical assessment was performed in the acute phase and at 1 month f.u. using an aphasia score for the four main language modalities based on the Boston Diagnostic Aphasia Examination (Croquelois et al. 2003).
DSI data were acquired as a set of diffusion-weighed images and specifically with 515 values in q-space comprising the points of a cubical lattice contained in the interior of a spherical volume. The maximum radius of this q-volume, q_{max}, corresponds to a diffusion sensitivity b_{max} equal to 8.5-10^3 $s\cdot cm^{-2}$ in vivo. Pulse sequence was multislice spin-echo EPI performed with 2.8 mm isotropic resolution [13]. Following reconstruction of the orientational dependence of the spin displacement density by integral transformation, data at each voxel were reduced to set of vectors V_1 that represent the orientations of maximum diffusion. Fiber tracts were reconstructed with a streamline algorithm: tracts were initiated at every voxel for every orientation vector of maximum diffusion V_1 and extended into a new voxel along the vector of maximum diffusion closest to its incoming orientation. Fibers terminated when no maximum vector exists within a fixed angular tolerance, typically set to 0.5 radian.

Results:
Applying Diffusion weighted imaging (DWI) and DSI stream line tractography at 2 different time points after stroke, we could demonstrate for the first time a remodelling of the infarct area (superior temporal, inferior parietal and posterior occipital region) and the underlying connectivity (green, blue and red fibers) paralleling a substantial clinical improvement in the aphasia scale (acute:10; 1 month f.u..: 5).
Moreover, a specific DSI analysis of the arcuate fasciculum, showed a different pattern of fiber trajectories in its postero-lateral part, thought to be involved in the processing of the functions affected in the Wernicke aphasia (comprehension, naming and repetition; figure 2 B).

Conclusion:
In this study, we could map the post-stroke remodelling of fibers located the stroke region and directly involved in the pathophysiology of the clinical picture (arcuate fasciculum).
This work demonstrates that DSI tractography could be used to study the connectivity involved in stroke recovery giving an anatomical insight into the complex mechanisms leading to functional improvement after an ischemic lesion.



Bibliography:

1) Penfield et al., Speech and Brain-Mechanisms. Princeton Univ. Press. Princeton, N.J. 1959.
2) Catani et al., Ann Neurol. 2005 Jan;57(1):8-1
3) Kertesz et al., Brain Lang. 1993 Feb;44(2):153-64
4) Croquelois et al., Ann Neurol. 2003 Sep;54(3):321-9

Figure 1:
DWI and DSI in the acute phase (A) and 1 month after stroke (B).
One month after stroke, the lesion evidenced with DWI was reduced in size and DSI could evidence a higher density of fiber trajectories (green, blue and red; see arrows) compared to the acute scan. The green bundle represents part of the arcuate fasciculum.

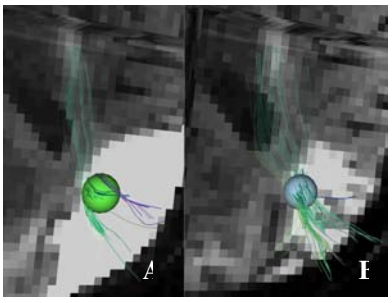


Figure 2 (left):
DSI tractography of the Arcuate Fasciculum in the acute phase (A) and 1 month after stroke (B). Its postero-lateral part appears to be denser in fiber trajectories at 1 month f.u than immediately after stroke. This aspect correlates with clinically relevant improving in the aphasia scale.

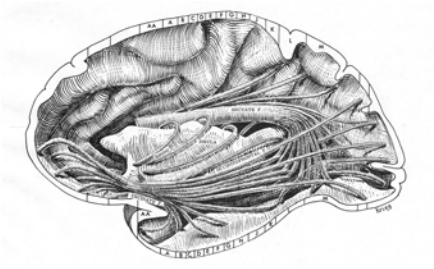


Figure 3 (right):
Schematic representation of the arcuate fasciculum.