**DTI/fMRI fusion at 1.5T confirms robust relationship between structural and functional connectivity in a glioma patient**

Maxime Descoteaux1,2, David Fortin2, Kevin Whittingstall2

1MOIVRE center, Computer Science department & 2Centre de Recherche Clinique Étienne Lebel, Université de Sherbrooke

**Introduction**

Diffusion tensor imaging (DTI) and Functional Magnetic Resonance Imaging (fMRI) are non-invasive tools which reveal anatomical (AC) and functional connectivity (FC), respectively, in the human brain. Several studies have investigated the relationship between AC and FC in healthy individuals [1, 2], though little is known whether this relationship holds in patients with primary brain tumours. Specifically, it is unclear how AC and FC are affected in tissue sites in or near glial tumors, which are known to aggressively infiltrate the white matter [3]. The goal of this work was to assess the dependence of FC on AC in a 28 year old man patient bearing a malignant glioma. Specifically, as the non-dominant (right) temporal area was infiltrated by the tumor, visual memory testing was assayed as an FC subtask.

**Methods**

The data were acquired on a Siemens 1.5T MRI system. For anatomical reference, a gadolinium-enhanced high resolution (0.49x0.49x1.75mm3) T1-weighted image was acquired. For structural connectivity, a single-shot echo-planar (EPI) spin echo sequence (TR/TE = 12500/95 ms) was used, with b-value of 1000 s/mm², the default 12 directions for DTI and 3 averages (NEX). Before diffusion tensor estimation, susceptibility and motion artifacts were corrected [4, 5] and the raw diffusion-weighted images are de-noised with a non-local means Rician noise correction [6]. Tractography was performed from every voxel in the white matter whose fractional anisotropy (FA) exceeded a value of 0.15 using the tensor deflection streamline algorithm [7, 8]. fMRI was acquired using an EPI sequence (TR/TE = 2000/40 ms) while the patient silently performed Roland’s hometown walking task. Images were motion corrected, spatially smoothed (8mm Gaussian Kernel). Nuisance signals from the CSF and white matter were regressed prior to connectivity analysis. Whole brain FC was computed using a seed point from a voxel that was significantly modulated by the memory task. AC and FC maps were then registered to the T1-weighted scan using rigid registration based on mutual information. The FiberNavigator software [9, 10] was used to define regions of interests (ROIs) based on anatomical and/or FC sites of interest while isolating the fiber tracts passing through them.

**Results**

|  |  |  |  |
| --- | --- | --- | --- |
| a) fMRI activation map revealed two significant (p<0.01) activation clusters near the glioma. The first (yellow arrow) was near the parahippocampal gyrus (MNI coordinates: -42,-44,-6) and the second (red arrow) was in middle temporal gyrus (-58, -24, -6). | ::::::Data:CRC:1.5T:Gosselin:Kevin:Images:ROI1_am.png  b) Fiber tracts based on fMRI activation cluster (red arrow in a)) within the glioma. This is the most lateral activated area of the glioma. All fiber tracts remain local inside the glioma and no fiber tracts cross to the other hemisphere. | ::::::Data:CRC:1.5T:Gosselin:Kevin:Images:ROI_zone_activation_zone_functionnelle.png  c) FC based on posterior fMRI activation site (yellow arrow in a)) near glioma periphery. Blue areas indicate significant FC (p<0.01). A selection box was put on each of these 3 FC ROIs to see the connections between all 3 functionally connected regions. | x ::::::Data:CRC:1.5T:Gosselin:Kevin:Images:ROI_func_connectivity_left.png  d) Same Figure as in c) but from a sagittal view to appreciate the connections between all 3 functionally connected regions. The FC ROIs are connected by fibers passing through the corpus callosum and in the fronto-occipital tract. |

**Discussion & Conclusions**

Figure b) shows that the activated region within the glioma presents only a local network of structural connections. Hence, we feel that this might be an indication supporting the safety of resection. In fact, most of the glioma was removed without triggering any neuro-cognitive decline after surgery. The insula was however left intact. Fibers can be appreciated in this area of the tumor. In this study, figures c) and d) show that FC and AC closely agreed. A pre-op detailed neuro-cognitive assessment did not show any deficits in this patient. To complement this data, FC was performed using a visual memory orientation subtask. Interestingly, the 3 most activated regions were also highly connected structurally. As one of these activated areas borders the posterior aspect of the infiltrated tumor, this suggests that a resection of this area could have translated into a significant deficit for this patient. We feel that this interesting case illustrates the plasticity of the CNS and the active remodeling in function and connectivity triggered by a glial tumor. This work also emphasize the fact that each and every patient bearing a glioma should be considered unique in that the relocalization of function produced by a tumor probably has parallel reconnection patterns that can hardly be predicted other than by detailed DTI/fMRI analyses. Consequently, we propose that AC/FC study as a complement to standard anatomical MRI will allow to maximize surgical resection while minimizing deficits, thus improving the safety of surgery and ultimately, improving the quality of life of these patients.

**References**

[1] Koch et al., MRM 2002. [2] Honey et al., PNAS 2009. [3] Nimsky et al., Neurosurgery 2007. [4] Behrens, Johansen-berg 2009. [5] FSL : http://www.fmrib.ox.ac.uk/fsl/fdt/index.html. [6] Descoteaux et al MICCAI 2008. [7] Lazar et al., HBM 2003. [8] MedINRIA : http://www-sop.inria.fr/asclepios/software/MedINRIA/ [9] FiberNavigator: <http://code.google.com/p/fibernavigator/> [10] Vaillancourt et al., IEEE Visualization 2010.