Mapping the language network in grade II gliomas: a longitudinal study with fMRI, MR Tractography and Neuropsychology

A. Bizzi[1], F. Ferrè[2], G. Castelli[1], M. Mandelli[1], S. Piacentini[2], F. Ciaraffa[1], D. Aquino[1], C. Marras[3], F. Di Meco[3], G. Broggi[3], and C. L. Solero[3]
[1]Neuroradiology, Fondazione Istituto Neurologico Besta, Milan, Milan, Italy, [2]Neurology, Fondazione Istituto Neurologico Besta, Milan, Milan, Italy, [3]Neurosurgery, Fondazione Istituto Neurologico Besta, Milan, Milan, Italy

Background

MR Tractography and functional MR imaging (fMRI) have the potential to map nodes and connections of a functional network. Modern imaging methods may determine hemispheric dominance, establish the relationship of a lesion to functional gray and white matter structures, and in the future they might predict postoperative outcome. Recently, it has been suggested that eloquent cortical areas of the language network are connected through a dorsal (arcuate fasciculus-AF) and a ventral (uncinate-UF and inferior frontal-occipital fasciculus-IFOF) pathway. Low grade gliomas may infiltrate language eloquent structures, however, it is unclear whether a relationship between lesion anatomic location and language deficits exists (1).

Aims

To identify the relationship of the tumor with functional elements (nodes and connections) of the language network.
To determine a clinical-anatomical relationship between specific language deficits and location of the tumor.
To determine longitudinal imaging changes occurring after surgery and rehabilitation.

Patients, Materials & Methods

Thirty right-handed patients with glioma in the left perisylvian areas were evaluated longitudinally with fMRI and MR Tractography of the language network and the Aachener Aphasie Test (AAT) before surgery, at 3 and 12 months follow-up. Three fMRI language tasks were performed: phonological fluency, verb generation and sentence comprehension. Hemispheric dominance was measured in Broca's area with the lateralization index. Diffusion Tensor Imaging (DTI) datasets with 96 averages (12 gradient directions), spatial resolution of 2x2x2 mm were acquired and realigned. Streamlines of the AF, UF and IFOF were reconstructed on both hemispheres with deterministic MR Tractography (2), using the software Trackvis v 0.4.4 (interpolated streamline algorithm with threshold FA>0.15 and angle>35°). Language proficiency and deficits were evaluated with AAT by a neuropsychologist. Tumor volume was measured on 3D-FLAIR. Patients had surgery with awake asleep anesthesia and intraoperative monitoring of verbal language.

Results

Histopathological diagnosis of grade II and high grade glioma were made in 14 and 16 patients, respectively. Only patients with grade II were the object of this study. Grade II gliomas were distributed in 3 locations: a) insula, temporal pole, temporal stem and orbitofrontal cortex in 9 patients; b) inferior frontal gyrus (Broca) in 3 patients; c) middle frontal gyrus in 2 patients.
At baseline fMRI showed left hemisphere dominance for language in 12, bilateral dominance in 2 patients. MR Tractography showed streamline interruption of the IFOF and UF in 9/9 patients with infiltration of the temporal stem. The AF was intact but slightly deviated in all patients. The AAT showed important presurgical fluency deficits (phonemic and semantic) in 8/9 patients with tumor located in the left insula and temporal pole. Fluency deficits were mild in the other 6 patients. Mild language deficits were measured in the other linguistic processes tested. In all 14 patients a partial resection was made.
Immediately after surgery 3 patients experienced severe dysarthria that recovered within the first week.
At 3 months verbal fluency was worse than preoperatively in 8/14 patients. fMRI showed that left hemispheric dominance was unchanged in 9, became bilateral in 4 and contralateral only in 1 patient.
At 12 months fluency was improved in 6, unchanged in 6 and slightly worsen in 2 patients in comparison with preoperative status.

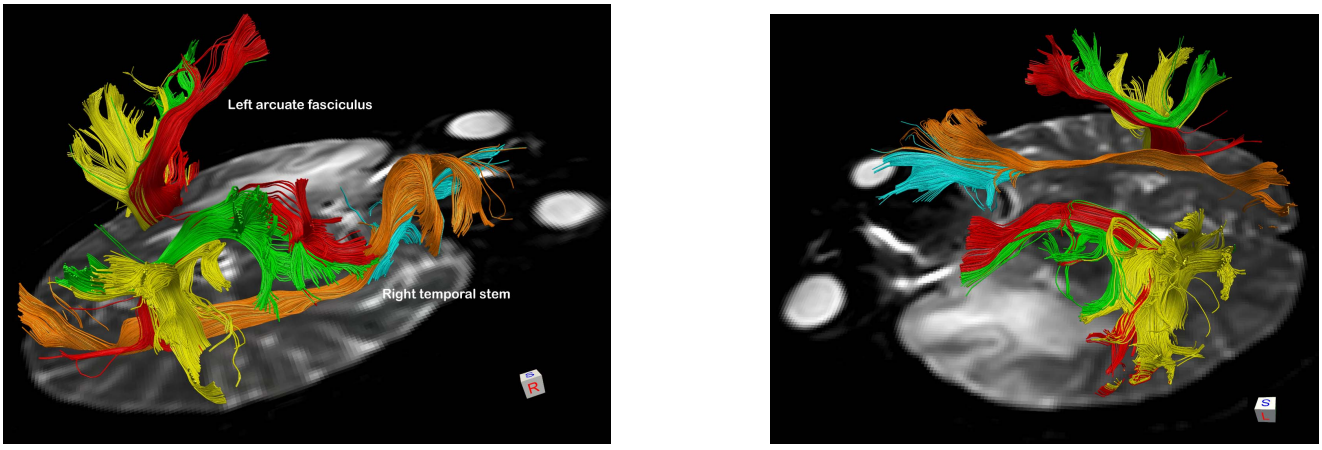

Fig. 1 DTI-based MR Tractography shows streamlines of the three segments (direct (red), anterior (green), posterior (yellow)) of the AF on both sides, streamlines of the UF (cyan) and IFOF (orange) only on the right side. It was not possible to visualize streamilines of the left UF and IFOF in this oligoastrocytoma infiltrating the left insula, temporal stem and pole. The left AF is intact but displaced dorsally and posteriorly.

Discussion

Deficits in phonemic and semantic fluency were prevalent in patients with glioma infiltrating the insula, temporal pole and stem. These deficits were associated with interruption of the ventral pathway. Deficits in other language processes were mild or absent in all patients.
Despite a transient deterioration of verbal fluency in half of the patients, left hemispheric dominance was preserved in the majority of patients. These imaging data suggest that ipsilateral rather than contralateral mechanisms of functional reorganization of the language network are more common in grade II gliomas.

References:

1. Duffau H, Moritz-Gasser S, Gatignol P. Functional outcome after language mapping for insular World Health Organization Grade II gliomas in the dominant hemisphere: experience with 24 patients. Neurosurg Focus. 2009; 27(2):2-10.
2. Catani M, Jones DK, ffytche DH. Perisylvian language networks of the human brain. Ann Neurol. 2005;57(1):8-16.