Fiber Pathways Alteration Reveals Brain Tumor Typology

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Introduction

Several brain pathologies affect white matter (WM) fiber pathways[1]. Highly aggressive lesions significantly impair morphology and functionality of infiltrated WM, less aggressive tumors may simply displace the surrounding brain structures[2]. This different behavior influences the surgical strategy. Here we propose a novel tractography approach to assess brain-tumor induced alterations, without the need of *a priori* information about the anatomy of local fibers.

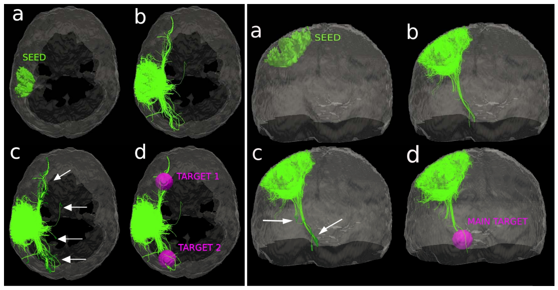

***Figure 1**: Definition of the target regions*

Methods

16 patients diagnosed with brain tumor were considered (5 Meningioma: M#1-5, 7 Low-Grade Glioma: LGG#1-7, 4 High-Grade Glioma: HGG#1-4), and for each of them Mib-1 proliferation index was also calculated. DWI data were obtained by a 3T scanner, 64 directions with a b-value of 1000 s*mm^{-2}. Eddy current-induced image distortions were first removed. In order to identify multiple fiber populations, PAS-MRI[3] was then performed. To speed up computation time, while maintaining good performance, a reduced encoding approach was adopted (16 directions)[4]. A tumoral region of interest (ROI) was manually drawn from the anatomical MR image, flipped around the sagittal plane to get the homologous region in the healthy hemisphere. This was used as "seed". A streamline deterministic tractography was performed (0.2 anisotropy and 60 degrees as stop criteria). Taking into account the last voxels of each estimated fiber tract, with a k-means clusterization algorithm, one or two centroid points, toward most of the tracked fibres from the seed projected to, were identified. Hence, drawing a 10mm diameter sphere on them, target regions were obtained. In cases where fibers projected from the seed to two diametrically opposed brain areas (see Figure 1, left panel) two target regions were detected and the fibre bundles connecting them were investigated. When fibres projected from the seed to nearby brain areas (see Figure 1, right panel), only the main target region, the one reached by most of the fibres was regarded. The homologous region mask was dilated by a factor equal to 1.20 and the fibres connecting the dilated mask and the target were tracked.

Subsequently, the two ROIs used for tracking in the healthy hemisphere were sagitally flipped to map the contralateral tracts connecting them in the pathological one (See figure 2).

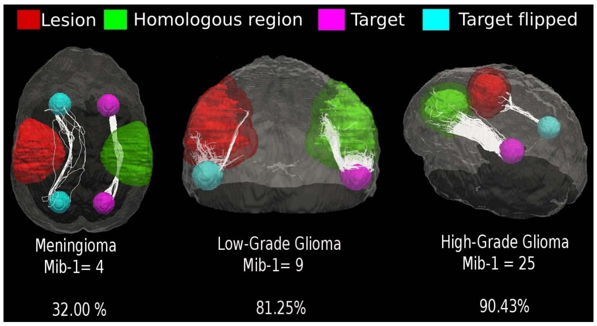

***Figure 2**: Comparative tractography study between the two hemispheres in 3 exemplificative cases. The estimated percentage of fibre tracts decrease is reported*

Results

The number of the estimated fiber tracts was calculated in each hemisphere and the percentage of tracts decrease, taking as reference the number of tracts found in the healthy hemisphere, was computed for each patient. The mean value and the standard error (SE) across the patients of the 3 types of lesion was evaluated (See the Table). The difference in the percentage of lesion-induced tracts decrease between the two main groups, meningiomas and gliomas, was statistically significant (p=0.0006).

	Meningiomas	**Low-Grade Gliomas**	**High-Grade Gliomas**
Average (± SE) percentage of tracts decrease	17.75 ± 4.1 %	61.9 ± 10.6 %	93.53 ± 1.39%

We ponderated the percentage of tracts decrease, dividing the computed value by each patient's estimated tumor size. Next, we studied the correlation between the resulting ponderated percentage of tracts decrease and the Mib1 indexes. The higher the Mib-1 label was, the more fibres were found destroyed, with a correlation coefficient equal to 0.8349 (See Figure 3).

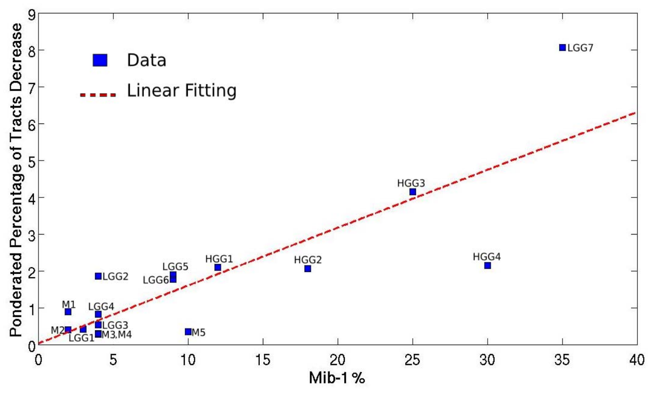

***Figure 3**: Linear regression between the ponderated tumor-induced tracts decrease and lesion specific histological features (Mib-1 index) across all the studied cases*

Conclusion

The results correlated with histopathological tumoral features. Our approach might be particularly helpful in those critical cases where the lesion does not involve major/known WM paths and a priori information about the local fibers' anatomy is lacking, suggesting its possible application as a very precise complementary diagnostic tool.

References

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