Validation of diffusion tensor imaging tractography of language tracts with intraoperative subcortical stimulations.

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Synopsis. In this study, we used intraoperative subcortical electrical stimulations was to validate diffusion tensor imaging (DTI) tractography of language fiber tracts. Positive stimulation mapping was concordant with DTI fiber bundles in 81% of the stimulations. Stimulations of the different fasciculi induced variable language disorders that were specific of each fiber tract.

Introduction. DTI tractography is increasingly used to map fiber tracts in patients with surgical brain lesions to reduce the risk of postoperative functional deficit. There are few validation studies of DTI tractography in these patients (1). The aim of this study was to validate diffusion tensor imaging (DTI) tractography of language fiber tracts by using intraoperative subcortical electrical stimulations.

Material and methods. Ten patients were referred for surgery of low-grade gliomas located in language areas. Patients were examined using a 1.5T MRI scanner one to five months prior to surgery. The MRI examination included three dimensional T_1-weighted images for anatomical coregistration, FLAIR and DTI images. Diffusion parameters were: TR/TE, 10000/88 ms; flip angle 90°, voxel size 3x3x3 mm^3, no gap, 4 averages, 6 directions, *b*-value of 900 s/mm^2. DTI images were corrected for geometric distortions. Diffusion tensors and fiber tracts were calculated using a in-house software. The fiber tracking algorithm employed is based on a continuous diffusion tensor approximation combined with the Euler method as described in (2).
Four tracts were reconstructed in each patient including the arcuate fasciculus, the inferior occipito-frontal fasciculus and motor fasciculi: the subcallosal medialis fiber tract, connecting the supplementary motor area (SMA) and the caudate nucleus, and cortical fibers originating from the SMA and motor and ventral premotor cortex in the face area. Fiber tracts were reconstructed using a two regions of interest approach. Fiber tracts were compared with intraoperative subcortical language mapping as described in (3). Language tasks were given by a speech therapist. Language tasks included counting and naming tasks. Positive stimulation sites were associated with various language disturbances such as speech arrest, paraphasia, dysarthria, anomia. Positive stimulation sites and fiber tracts (after coregistration) were mapped onto postoperative T_1-weighted images obtained 3 to 6 months after surgery.

Results

A total of 21 positive stimulations were obtained in the ten patients (figure 1). 17 positive stimulations sites were located within less than 6 mm of a fiber tract. Four positive stimulations were not located in the vicinity of a DTI fiber tract. Therefore, positive stimulation mapping was concordant with DTI fiber bundles in 17/21 (81%) of the stimulations.
Stimulations of the arcuate fasciculus mostly induced arthric/phonemic paraphasias and less often semantic paraphasias. Stimulations of the inferior occipito-frontal fasciculus induced semantic paraphasias. Stimulations of the motor fasciculi induced arthric disorders.

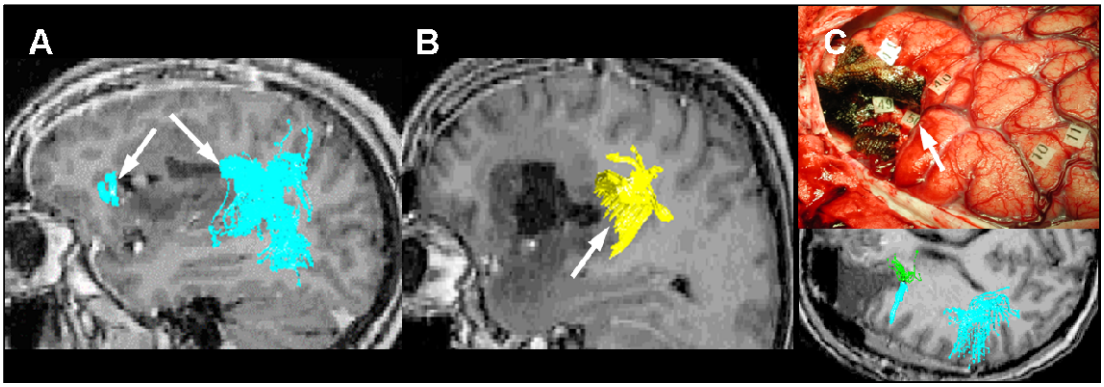

Figure 1. Three dimensional reconstructions of language white matter bundles in three different patients (A to C) superimposed to post-operative three-dimensional T_1-weighted images. Positive stimulations sites are indicated with the arrows. C) Correspondence between the operative view and the fiber tracts.

Conclusion

There was a good correspondence between positive stimulation sites and fiber tracts suggesting that DTI fiber tracking is a reliable technique to map language tracts in patients with brain lesions. In one patient, the arcuate fasciculus could not be reconstructured although stimulations were positive suggesting that negative tractography does not rule out the persistence of a fiber tract.

References

(1) Berman et al. J Neurosurg 2007; 107:488, (2) Lehericy et al. Ann Neurol 2004;55:522, (3) Duffau et al. Brain 2002;125:199.