

DTI based assessment of which brain tumour patients are in need of presurgical language fMRI

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Introduction: Clinical fMRI in patients with brain tumours is increasingly used to provide neurosurgeons with information regarding lateralisation of language and the tumour relationship to eloquent cortex. This is facilitating the decision-making on operability, surgical approach and extent of the resection. It is currently not possible to make a medical indication in a strict sense for the need of presurgical language fMRI.

The functional language area consists of both grey matter (Broca's and Wernicke's area) which can be visualised by fMRI and white matter (the arcuate fasciculus (AF)) which can be visualised by Diffusion Tensor Imaging (DTI). Damage to any of these areas will result in language deficits. The study was approved by the National Danish Board of Health and the Danish Data Protection Agency.

Purpose: To perform virtual dissection of the AF in brain tumour patients, in order to study if the relationship between the tumour and the AF would alter the decision regarding which patients are in need of presurgical language fMRI.

Materials and methods: *Patients:* Retrospective study of 20 patients (11 men and 9 women, average age 39 years (range 18-62)) with low grade brain tumours, who all had undergone presurgical fMRI and DTI in order to facilitate the decision-making on operability. The DTI were not used for planning. The need of presurgical language fMRI was determined according to the algorithm proposed by Stippich C et al. [1] based on morphological T1 and T2 MRI sequences. This divided the patients in two groups: Group A - Patients who had had no presurgical language fMRI (table 1). Group B - Patients who had presurgical language fMRI, with measurements of the shortest distance from tumour to eloquent language cortex by the method described by Laustsen SR et al. [2] (table 1). *MRI protocol:* MRI was performed on a 3T system (Signa HDx, R14M5, GE Healthcare). Axial 2D DTI SE-EPI: 32 directions, b-value 1300, isotropic voxel size of 2.4x2.4x2.4mm³ 40 slices, TR/TE = 9000/105, FOV 30.7cm, recon. matrix 128x128, scan time 5:42min. MRI included a morphological axial T1-weighted 3D BRAVO sequence and one or more axial 2D fMRI SS-GRE-EPI sequences. *Post Processing:* The DTI data were analysed using nordicICE (NordicImagingLab ver. 2.3.11) (Figur 1). The following threshold parameters were used: track turning angle $\leq 60^\circ$ and FA ≥ 0.2 . Volumes of interest (VOI's) were placed according to the method described by Catani M et al. [3]. *Analysis:* Data was analysed by t-test. Estimates are given with 95% confidence intervals.

Results and discussion: The DTI-analysis was performed successfully in all 20 patients. In group A the mean distance from tumour to the AF (Dist(AF)) was 7(2;11)mm. In group B the mean Dist(AF) was 8(1;15)mm. No difference in Dist(AF) was seen between the two groups (mean diff 1(-7;9)mm $p=0.76$). The left hemisphere is known to be the dominant language hemisphere in approximately 90% of all individuals. 4 patients (id 7-10) in group A had tumours in the left hemisphere. In 3 of the cases (id 8-10) the distance from tumour to the AF was less than 5mm. This is in the range of what could be expected from brain shift after the craniotomy. Based on this one could argue that these 3 patients also were in need of presurgical language fMRI. The last 6 patients (id 1-6) in group A all had the tumour in the right hemisphere. The algorithm used suggests that only patients with the tumour in the right hemisphere who are left-handed, multilingual or have tumour associated language deficits are in need of presurgical language fMRI. Only 1 patient experienced language deficits prior to surgery (group B, id 15, DistAF=0mm). It seems like a short distance from the tumour to the AF not necessarily corresponds to preoperatively language deficits. This talks in favour of using DTI in patients with right sided tumours in order to decide which patients are in need of presurgical language fMRI.

In group B, 8 patients (id 13-20) had language lateralisation in the hemisphere containing the tumour. The distance between the tumour and the AF showed a tendency to be lower than the distance from eloquent cortex to the tumour (mean diff 9(-4;21)mm $p=0.15$). This again indicates the importance of presurgical DTI as a tool for preoperational planning.

Conclusion: Based on this study we propose that the DTI-analysis could alter the decision regarding which patients are in need of presurgical language fMRI. However it depends on where one would place the limit of distance between tumour and the AF. To our knowledge no DTI study so far exists describing the relationship between distance from the AF to the tumour and the risk of postoperative language deficits.

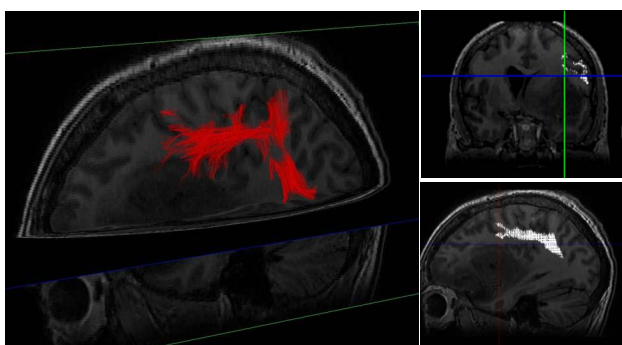


Figure 1. DTI analysis.

A: 3D display of the right arcuate fasciculus (patient 19)

B: Coronal display of the burnt in pixelmap used for measuring Dist(AF)

C: Sagittal display of the burnt in pixelmap used for measuring Dist(AF)

Table 1. Group A			Table 2. Group B				
Patient id	Tumour location	Dist(AF) [mm]	Patient id	Tumour location	Language Lateralisation	Dist(AF) [mm]	Dist(ELC) [mm]
1	R parietal	10	11	R temporal	L	0	-
2	R frontal	4	12	R frontal	L	20	-
3	R temporal	3	13	L frontal	L	3	12
4	R frontal	11	14	L frontal	L	8	0
5	R frontal	5	15*	L temporal	L	0	12
6	R frontoparietal	8	16	L frontal	L	2	31
7	L frontal	22	17	L temporal	L	31	22
8	L frontal	4	18	L frontal	L	4	34
9	L frontotemporal	0	19	L frontal	L	6	10
10	L frontoparietal	0	20	L temporal	L	5	6

Table 1. Patient characteristics of Group A & B

R, right; L, left

Dist(AF), distance from tumour to the arcuate fasciculus.

Dist(ELC), shortest distance from tumour to eloquent language cortex.

(-) Tumour and language lateralisation on opposite sides.

(*) Patient with preoperative language deficits (Broca's aphasia).

References:

- [1] Stippich C et al. Selection of Candidates for Presurgical Language fMRI. In: Clinical Functional MRI - Presurgical Functional Neuroimaging. Springer; 2007. p. 120.
- [2] Laustsen SR et al. [Preoperative functional magnetic resonance imaging in patients with brain tumors]. Ugeskr Laeger 2010 Aug 30;172(35):2370-6.
- [3] Catani M et al. A diffusion tensor imaging tractography atlas for virtual in vivo dissections. Cortex 2008 Sep;44(8):1105-32.