PROBABILITY MAPS COMPARED TO FACT ALGORITHM IN HUMAN GLIOMAS

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Introduction

The FACT algorithm [1] has been shown to be reliable for glioma and cavernoma resection [2, 3]. Problems arise, when a strong deviation of the fibers is present or an oedema or infiltration by tumour tissue change the anisotropy of the tissue. Pobabilistic fiber tracking [4, 5] is less susceptible to these limitations, but not clinically proven so far. The aim of this work was to compare FACT algorithm with probability maps in human glial brain tumours (WHO grade II and III) and to relate the depicted fibers to the grade of motor deficit and to the localisation, mass effect and WHO grading of the tumour.

Patients and Methods

Ten patients (8 males, 2 females, mean age: 36.2 years) with 6 WHO grade III and 4 WHO grade II tumours received fiber tracking and motor fMRI within the framework of a long-tern plasticity study. Motor fMRI consisted of single shot EPI sequences (3^3 mm^3) during passive and active hand movements in block design at a 3T scanner. Passive movement was performed by a pressure-driven arm splint, active movement was self-paced and visually controlled and counted. DTI was performed by a diffusion-sensitive Spin-Echo EPI sequence with 61 diffusion encoding gradient directions. Voxel size was 2^3 mm^3. A high resolution T1w data set with a voxel size of 1^3 mm^3 was acquired, and taken for normalisation and co-registration. The calculation of the diffusion tensor, and the evaluation by the FACT algorithm and probability maps were performed by in-house software [5 - 6].
Seed points were taken from fMRI by spm8. Only for anterior and posterior hemipons no fMRI data were available. There, seed points were created manually according to Kamali et al. 2009 [7]. Motor function was assessed by the Fugle Mayr test [8, 9], where finally the following score was used 0=no, 1=slight, 2=moderate, 3=marked, 4=severe motor impairment.

Results

Probability maps of motor fibers could be obtained in every case. FACT algorithm was not successful in two patients (cases 1 and 2, Figures 1 and 2, respectively) with a marked and in one patient with a moderate motor impairment (case 10, Figure 3), all three with tumours WHO grade III. The fiber tracking success for FACT was not dependent on the WHO grade, but was concordant with the motor score and the deviation of fibers. For particular results see Table 1.

Discussion

Probability maps are robust means for the detection of the motor fiber system in infiltrative brain tumours. The value of the FACT algorithm has been substantiated for surgical planning in a prospective study with 238 patients [10], but not for probability maps. The missing of the motor fibers by FACT was related to a marked motor impairment being reflected by a stronger deviation of the fibers on the probability maps. Only in case # 10, a moderate motor impairment and a moderate fiber deviation in the probability maps were attended by a missing of the fibers by FACT. The cause for this finding remains unclear; especially as in both methods a lower FA limit of 0.1 was taken. The question is, whether probability maps lead to false positive fiber detection, where already true fiber damage has occurred. In these cases (#1 and 2), a transcranial magnet stimulation would have been helpful, but could not be applied to the patients because of an epilepsy. On the other hand, the course of the fibers on probability maps seemed anatomically plausible.

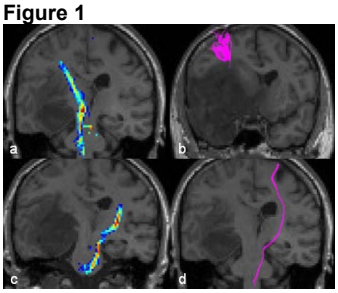
Table 1: Descriptives of the Tumours

Patient number	WHO class. °II - °III	Tumour localisation	Fugl Mayr Test Score 0 - 4	FACT	Probability maps	Deviation of fibers
7	°II	L frontal	0	yes	yes	no
9	°II	R frontal	0	yes	yes	no
3	°III	L frontal	0	yes	yes	no
6	°II	L frontal	1	yes	yes	slight
8	°II	L temporal	1	yes	yes	slight
5	°III	R frontal	2	yes	yes	moderate
10	°III	L fronto-temporal	**2**	**no**	yes	moderate
4	°III	L frontal	3	yes	yes	moderate
2	°III	L frontal	**3**	**no**	yes	marked & oedema
1	°III	R fronto-temporal	**3**	**no**	yes	marked

Patient numbers are assorted according to the motor score (Fugl-Mayr Test). R=right, L=left.

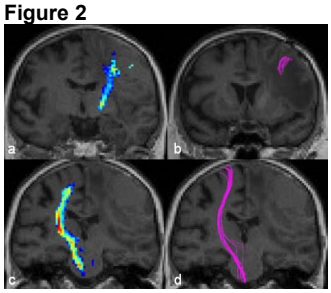
References
1. Mori, S., et al., Ann Neurol 1999. **45**: p. 265-269.
2. Nimsky, C., et al., Neurol Res, 2006. **28**(5): p. 482-487
3. Nimsky, C., et al. Neurosurgery, 2006. **58**(4 Suppl 2)
4. Parker, G.J., et al., J Magn Reson Imaging, 2003. **18**(2): p. 242-254.
5. Kreher, B.W., et al., Neuroimage, 2008. **43**(1): p. 81-89.
6. Kreher, B.W., et al., Magn Reson Med, 2005. **54**(5): p. 1216-1225.
7. Kamali, A., et al., Eur Radiol, 2009. **19**(6): p. 1480-1488.
8. Fugl-Meyer, A.R., et al., Scand J Rehabil Med, 1975. **7**(1): p. 13-31.
9. Fugl-Meyer, A.R., Scand J Rehabil Med Suppl, 1980. **7**: p. 85-93.
10. Wu, J.S. et al., Neurosurgery, 2007. **61**:935-949.

Figure 1



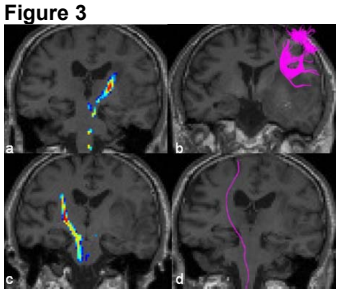
Case #1
a, c: Probability maps, given as section;
b, d: FACT, given as projection.
The midline and the motor fibers are shifted to the left on probability maps. FACT was not successful (b).

Figure 2



Case #2
a, c: Probability maps, given as section;
b, d: FACT, given as projection.
The motor fibers are shifted to the midline and in frontal direction (not shown). FACT stops within oedema.

Figure 3



Case #10
a, c: Probability maps, given as section;
b, d: FACT, given as projection.
The whole extent of the fibers in probability maps is not shown (sections). The projection image of the FACT algorithm leads to an overlay on skull structures, but the fibers are within the brain in more posterior slices.