Comparing MRSI, PWI and DWI of meningiomas and glioblastoma multiforme at 3T to find a marker for diffuse infiltrative brain tumor tissue.

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Introduction:
Gliomas are very heterogeneous infiltrative brain tumors. Conventional imaging techniques have difficulties in distinguishing between the infiltrative part of the tumor, edema and healthy brain tissue. A non-invasive way to detect this is important for the patient's treatment and therapy planning. Especially those regions surrounding the contrast enhancing part of the tumor, which are abnormal on conventional T1 and T2 weighted images are of interest. It is often unknown whether these regions contain tumor cells, or deviate from normal appearing brain tissue because of (e.g. pressure-induced) edema. In this work we try to find a non-invasive marker for infiltrative tumor tissue by evaluating parameters extracted from MRSI, PWI and DWI. MRSI provides metabolic information, whereas PWI and DWI are used to get information about (neo)vascularization and changes in morphology of the tumor and surrounding tissue. As the spatial resolution of MRSI is low compared to the other imaging modalities, these other modalities could ideally be used to better resolve the tumor extent. Since we do not have histo-pathological information of the non-enhancing part of the tumors we compared regions located in the non-enhancing part, but abnormal on T1 and T2 weighted imaging, of glioblastoma multiforme (GBM) with those of meningiomas. As meningiomas generally do not show diffuse infiltrative growth, regions just outside the contrast enhancing part of the tumor will not contain tumor cells, in contrast to regions just outside the contrast enhancing part of GBMs, which are likely to contain invading tumor cells. Preliminary results of this comparison are presented.

Method:
Patients with newly diagnosed glioblastoma multiforme (GBM; n=6) and patients with newly diagnosed meningioma (n=5) were examined on a 3T whole body scanner (Magnetom TRIO, Siemens, Erlangen), the body coil was used for excitation and a 12-channel receive only head coil was used for reception of the MR signal. The MRI protocol includes T2-weighted axial images (0.6x0.6mm, slice thickness 5mm, TR/TE 4040/102ms), Diffusion weighted MRI (spin-echo EPI, 1.8x1.8x5 mm, TR/TE 7800/91ms, b=0 and b=1000 s/mm^2, 12 diffusion directions), dynamic perfusion weighted MRI (single shot spin-echo EPI 1.8x1.8X5 mm, TR/TE 1670/45ms) T1 weighted 3D images (1x1x1mm, TR/TE 2300/4.71ms) after contrast administration (15ml 0.5mM Dotarem (Guerbet,France)), and 2D MRSI using a semi LASER sequence (1) (TR/TE 2000/30ms, nominal resolution 8x8x10mm, water suppression). Also as a reference to normal tissue, 2 healthy volunteers were examined with DWI and MRSI. We used Siemens Syngo software to quantify perfusion weighted images to calculate relative cerebral blood volume (rCBV) and relative cerebral blood flow (rCBF) maps, diffusion weighted images to calculate apparent diffusion coefficient (ADC) and fractional anisotropy (FA) maps. We analyzed MRSI data with LCModel (2) to obtain Cho/NAA ratios. Regions of interest (ROI) are manually drawn in the non-enhancing part of the tumor (NCEL), but clearly appearing abnormal on T1 and T2 weighted MRI, in the axial plane, which corresponds to the MRSI plane. The values of the parameters for the different modalities are normalized with those in ROIs selected in contra lateral (if possible) normal appearing white matter (NAWM).

Results and discussion:
From the examinations by the 3 different MR modalities, maps were reconstructed as shown in figure 1 for one patient; in this figure also the regions of interest are indicated. For both tumors the ADC in NCEL is higher than in NAWM, however the relative values are comparable for both (Fig 2). Higher ADC values have been previously reported for gliomas in NCEL, e.g. (3). The Cho/NAA ratio in NCEL is higher than in NAWM for all glioblastomas, whereas in NCEL of meningiomas the ratio Cho/NAA is comparable to that of NAWM. Increased Cho/NAA is a general finding in glial and other brain tumors e.g. (4-6); thus an increase in Cho/NAA outside the contrast-enhancing lesion is a strong indicator for the presence of infiltrating tumor tissue (7). The standard deviation of the Cho/NAA ratio of NCEL of meningiomas is smaller than in NCEL of GBMs likely reflecting the heterogenous nature of tumor infiltration. NCEL regions generally have lower FA than NAWM, which is earlier reported (3). However, no difference in FA between NCEL of GBMs and meningiomas was observed (Fig 3). FA values show larger standard deviations than ADC values, this is also true for ROIs of healthy volunteers. The rCBV in NCEL was slightly lower than that of NAWM, as has been reported earlier for GBMs (8), but it is not different between meningiomas and GBMs. Also for the rCBF we could not observe a difference between the NCEL of meningiomas and GBMs

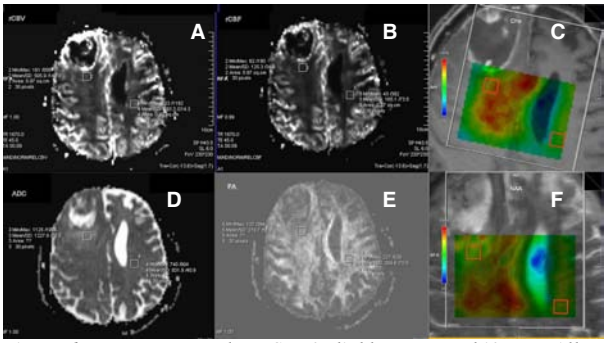
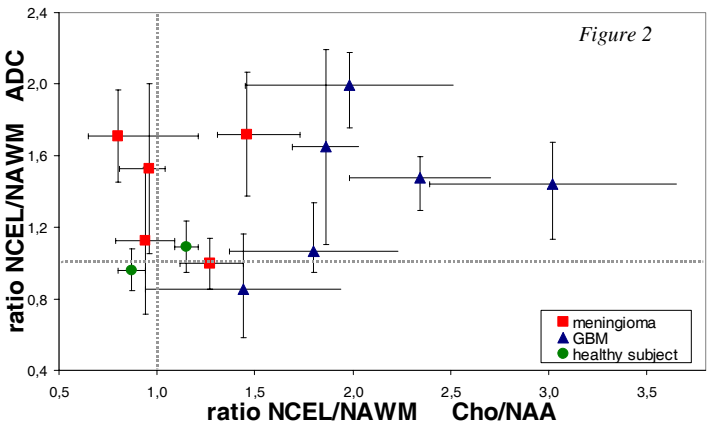
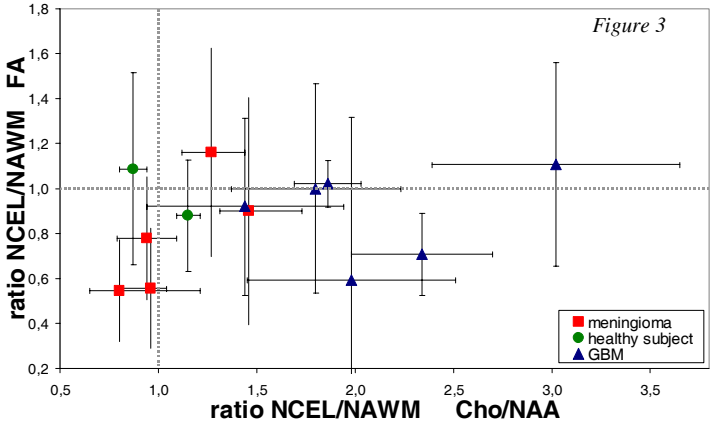


*Figure 1: PWI, DWI and MRSI of glioblastoma multiforme. All images show equal transverse planes and 2 regions of interest; one just below the enhancing part of the lesion, possibly containing diffuse infiltrative tumor tissue, and one in NAWM. **A**: relative CBV map. **B**: relative CBF map. **C**: choline map overlaid on an axial T1-weighted (contrast enhanced) image. **D**: ADC map. **E**: FA map. **F**: NAA map overlaid on an axial T2-weighted image.*

Conclusion:
The preliminary results of this study demonstrate that among the PWI, DWI and MRSI parameters evaluated for the non-enhancing lesion of meningiomas and GBMs only the Cho/NAA ratio showed a significant difference. This indicates that this parameter is useful to identify infiltrating tumor outside the Gd enhancing lesion. However, because of the better spatial resolution of the other MR modalities a combination of MRSI with these approaches might be more effective.





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