Chemical shift change shows spatial orientation of lipids in human brain

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Introduction

Lipids in the body are either stored in adipocytes in subcutaneous or adipose tissue (e.g. extra-myocellular lipid (EMCL) in muscle) or as liquid droplets in the cytoplasm of other cells (e.g. intra-myocellular lipid (IMCL)). Proton signals of EMCL show a chemical shift which is dependent on the orientation of muscle fibers with respect to the main field. This is explained by anisotropic magnetic susceptibility caused by the presence of lipids on the surface of tube-like structures [1]. Intracranial lipid signals are not common. They are associated with tissue degeneration and the formation of necrosis and therefore usually with high malignancy. However, lipid signals from intracranial lipomas are not associated with malignancy. Intracranial lipomas are rare benign congenital malformations, which account for less than 0.5 % of all intracranial tumors and are found mostly incidentally [2]. Here we report for the lipid signal of an intracranial lipoma a similar angle dependence as that of EMCL, in contrast to metabolite and lipid signals from a tumor in the same patient.

Methods

In a 65-year-old male with a right parietal anaplastic ependymoma, confirmed by histopathology, the MRI and MRS showed accidentally an intracranial lipoma. The MRI scan (TIM-TRIO, 3.0 T, Siemens, Erlangen, pre- and post gadolinium T1-weighted imaging) showed a space occupying lesion right parietal, with enhancement after gadolinium and a hyperintense lesion without gadolinium in the left quadrigeminal cistern orientated along the straight sinus [figure 1A]. The MRS examination (3D multivoxel semi-LASER, TE 30 ms, TR 1500 ms) [3]) showed a shifted lipid signal resonance frequency in several voxels. After radiation therapy for the anaplastic ependymoma and approval of the patient the MRS was performed three times in one session with the head positioned in three different sagittal orientations with respect to the main magnetic field [figure 1B]. The data was analyzed with jMRUI.

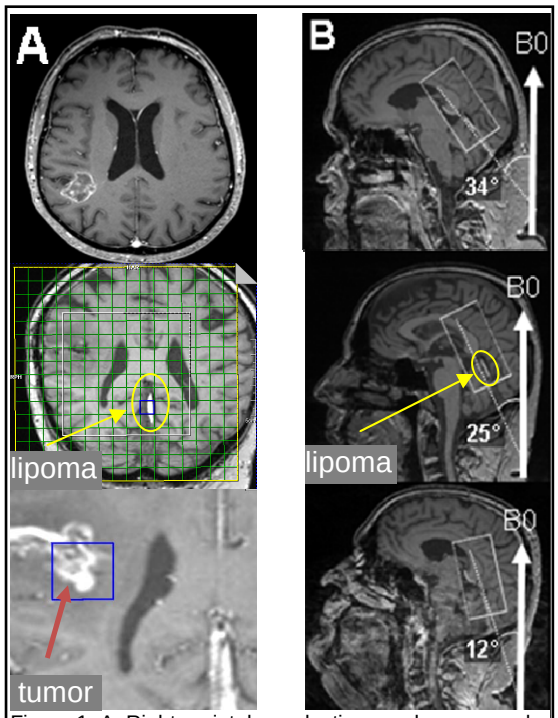

Figure 1. A. Right parietal anaplastic ependymome and intracranial lipoma in left quadrigeminal cistern. B. Three different orientations of the head and lipoma with respect to the external magnetic fiel B0.

Results

The lipid signal in the intracranial lipoma from the methylene group shifts from 1.37 ppm to 1.43 ppm to 1.49 ppm with increasing angle between the intracranial lipoma and external magnetic field from12^0 to 25^0 and 34^0 respectively. Similarly a shift is also seen for the methyl groups; from 0.97 to 1.03 to 1.09 ppm, for the –HC=CH– group; from 5.41 to 5.47 to 5.5 ppm (data not shown) and for the C=C groups from 2.1 to 2.4. The methyl signals of the N-acetyl-aspartate (NAA) peak at 2.0 ppm, and from creatine at 3.02 ppm and from choline at 3.2 ppm do not shift due to the change in orientation of the head [figure 2A]. Also in the tumor spectra there is no shift of the methylene and methyl signals of lipids from necrosis [figure 2C]. The observed shift dependency of the angle between the lipids in the lipoma and the external magnetic field (θ) corresponds to the model for angle dependency described with the formula $\cos 2\theta / r^2$ as proposed for EMCL [1], in which r is the radius of the model tube .

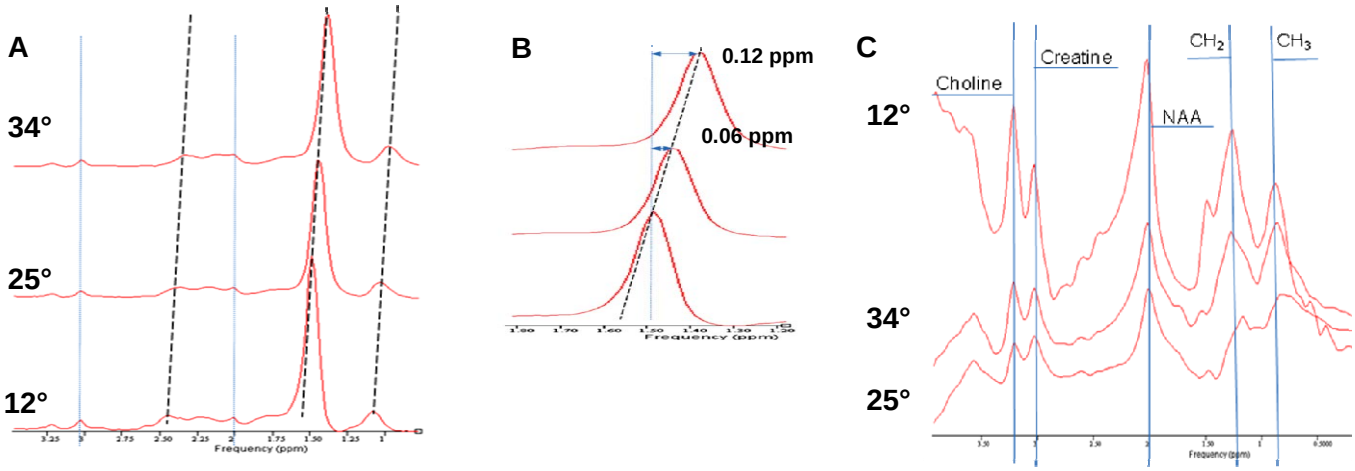

Figure 2A. Spectra from the intracranial lipoma (voxel fig. 1A) in 3 different orientations, indicated with the angle to the external magnetic field. B. Detail of the methylene signal shift. C Spectra of the tumor (voxel fig. 1A)in 3 different directions with no shift for methyl or methylene signals.

Discussion and Conclusion

In this patient, it was shown for the first time that lipid signals in the human brain from an intracranial lipoma show a chemical shift change and broadening due to changes in the orientation of the head to the magnetic field. This is not the case for the lipid signals in the primary brain tumor, nor for signals of metabolites like NAA, Creatine and Choline. This strongly suggests that the lipids in this lipoma are present on the surface of a tube-like structure similar to that of EMCL. An explanation for this orientation of lipids in this lipoma could be the organized structure of lipoma cells along the blood vessels compared to the diffuse structure of lipids in necrosis. A second explanation is the structure of this particular lipoma, which can be seen as a long cylinder oriented along the straight sinus in the quadrigeminal cistern.

References

[1] Boesch C et al. MRM, 1997, 37: 484-493. [2] Truwit CL. AJNR, 1990; 11: 665-674.[3] Scheenen TW et al. MRM, 2008; 59: 1-6.