High field MR spectroscopy of the human brain at short TE and TR

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Introduction

At high field the use of traditional localisation methods for ^{1}H-MR spectroscopy is hampered by increased chemical-shift-displacement as well as limitations on the B1 field. Adiabatic alternatives (e.g. LASER) can partly overcome the chemical shift displacement artefact, but also lead to long echo times while T2 values tend to shorten with higher B_0 field. An alternative is a slice-selective pulse-acquire CSI sequence which is not sensitive to T2 relaxation. Since the SNR per unit voxel size and time is equal for CSI and single voxel scans, this promises to be an effective method for high-resolution brain spectroscopy at high field. However, when a complete slice is excited, poorly shimmed regions within the slice can cause artefacts in the region of interest through the pointspread-function. It has been shown that this pulse-acquire 2D-CSI sequence can be combined with SAR-demanding outer volume suppression (OVS) [1] to completely suppress these signals signal from badly shimmed regions, at the expense of increasing TR. However, when carefully orienting the slice such that the region of interest remains several voxels from poorly shimmed regions, OVS may not be necessary. Low-SAR water and lipid suppression may be sufficient, enabling a substantial reduction of the TR and thereby the SNR per unit of time.

In this study we propose a method for high spatial resolution ^{1}H-MR spectroscopy at short TE and TR combined with a low-SAR adiabatic water and lipid suppression technique and demonstrate the true gain between 3T and 7T.

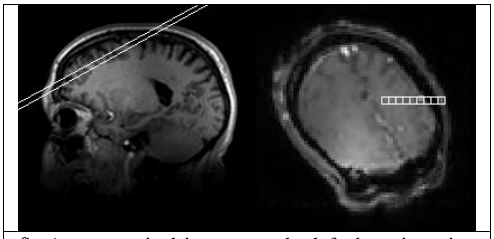

fig 1a. anatomical image, on the left the orientation of the slice in the frontal cortex is shown, on the right the overlaid raster indicates the voxels from fig 1b.

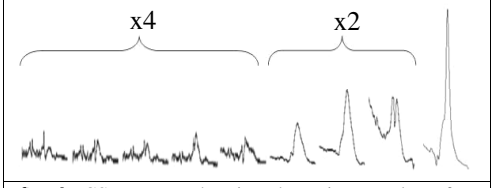

fig 1b. CSI spectra showing the pointspread-artefact from the lipid resonance at the edge of the brain. The artefact decreases rapidly, allowing the acquisition of high quality spectra several voxels away from the edge of the brain.

Methods

In-vivo spectra were acquired on a 3T and 7T whole body MR scanner. To demonstrate the versatility of the method a region of interest was chosen in the frontal lobe, close to the skull, however at a slice orientation perpendicular to the skull (Fig 1a). The voxelsize was set to 5x5x10mm^3, TR/TE = 1s/1.5ms with a matrix of 32x32 acquired in 12.5 minutes.

Water and fat suppression was performed with a modification of the SWAMP method [2]. Flanks of the adiabatic inversion pulses generate adiabatic transverse magnetization, and by tuning the bandwidth of the pulse it is possible to excite and spoil water and fat simultaneously. In all experiments two AFP pulses were used with a small frequency shift, therefore creating a broader suppression region (fig 2) and so enabling a broadband suppression over the whole slice. Pointspread-artifacts were confined to the edge of the brain, excluding the area of interest (fig 1b). Spatial Hamming filtering was performed in order to reduce pointspread-artifacts even further. Additionally a water file was acquired at the same spatial resolution in 1 minute (FA 2 degrees, TR = 70 ms), which served as a reference for eddy current correction and quantification of the spectra.

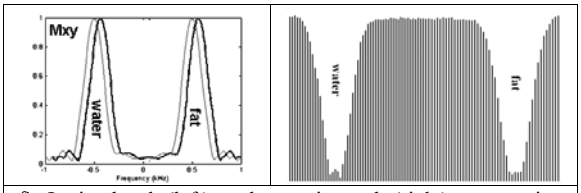

fig.2 simulated (left) and experimental (right) suppression bands of the double water and fat suppression pulses

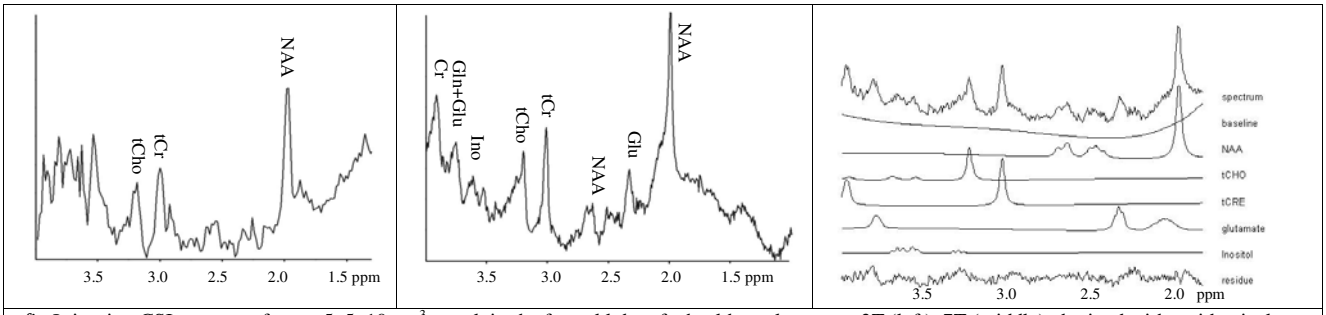

fig.3 in-vivo CSI spectrum from a 5x5x10mm^3 voxel in the frontal lobe of a healthy volunteer at 3T (left), 7T (middle) obtained with an identical sequence. (TE/TR = 1.5ms/1s, 32x32 matrix) The image on the right shows an LC model fit with a polynomial baseline of the in-vivo brain-spectrum.

Results&Discussion:

Fig 3 shows results obtained at 3T and 7T with the high resolution CSI protocol. The increase in chemical dispersion resolution and increase in SNR between 3T and 7T with the proposed method is evident. As the short TE enables the detection of macromolecules, quantification of these compounds may become more accurate. So far we have included only several metabolite compounds in the LCModel fit to demonstrate the ability to also fit resonances that have not been acquired on the echo-top, but with a delay of 1.5ms.

The proposed method shows the possibility to obtain high quality, high spatial resolution (5x5x10mm) spectra without volume selection at short echo times and short repetition times at 7T.

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References: ***(1)*** *A.Henning, proc. 16th ISMRM; 594 (2008)* ***(2)*** *R.A.de Graaf, MRM 40:5 p690-696 (2005)*