GRADIENT INDUCED SIDEBAND ARTIFACTS IN NON WATER-SUPPRESSED PROTON CSI OF THE HUMAN BRAIN AT 9.4 T

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Introduction: It has been shown that chemical shift imaging without water suppression offers several advantages, like the possibility to use the water signal for spectral corrections and for absolute quantification [1]. However, the unsuppressed spectra are hampered by gradient induced sidebands, which have to be removed before the quantification [2]. Despite known difficulties (shorter T_2 and longer T_1 relaxation times, larger B_0 and B_1 inhomogeneities), previous studies demonstrated that proton spectroscopy at ultra-high magnetic field is possible [3, 4]. The aim of this study was to verify the feasibility of short echo time proton CSI on the human brain without water suppression at the field strength of 9.4 T and to examine the influence of gradient induced sidebands on the measured spectra.

Materials and Methods: CSI spectra were acquired at 3 and 9.4 T whole body scanners (Siemens, Erlangen, Germany) from the superior part of the brain of a healthy volunteer. The 3 T system was equipped with a 32 channel receive-only head coil and a whole body gradient system, whereas the 9.4 T was equipped with a home-built 8 channel transmit, 24 channel receive head coil and a head-only gradient insert. For the assessment of the sidebands, at both field strengths a standard water phantom provided by the scanner manufacturer was used. In-vivo and phantom spectra were acquired at 3 T with a point resolved spectroscopy sequence (PRESS; TE: 30 ms, TR: 1500 ms, spectral bandwidth 1000 Hz, voxel size 10 mm^3 isotropic). Measurements at 9.4 T were performed with a stimulated echo acquisition mode sequence (STEAM; TE: 20 ms, TM: 11 ms, TR: 2000 ms, spectral bandwidth: 4000 Hz, voxel size: 10 mm^3 isotropic). Standard h-sinc 90° RF pulses had to be replaced with hermite RF pulses to keep the reference voltage below hardware limitations. To minimize the influence of chemical shift displacement, the duration of RF pulses used in the STEAM sequence was decreased from 2600 to 1400 µs, which resulted in an increase of the RF bandwidth from 1650 to 3100 Hz.

Results: In Fig. 1 unsuppressed spectra and sidebands measured at field strengths of 3 T and 9.4 T are compared. It can be seen that the influence of gradient induced sidebands on unsuppressed spectra measured at 3 T (Fig. 1a) is much larger than for spectra measured at 9.4 T (Fig. 1b). A direct comparison of sidebands measured at both field strengths reveals that their magnitude is comparable (Fig. 1c), however the amplitude of the water signal in spectrum measured at 9.4 T was greater compared to that in 3 T spectrum (4×10^7 and 3×10^6 respectively). Fig. 2 shows a comparison of spectra measured at 9.4 T acquired with (black) and without (red) water suppression. Here both data sets (acquired with and without water suppression) are similar. The slight differences are only observable for the metabolites located between 3.5 and 4.2 ppm (inositol, glutamine, glutamate and creatine-CH2) and between 3.2 and 3.5 ppm (creatine, phosphocreatine). This suggests that those regions are mainly influenced by the sidebands.

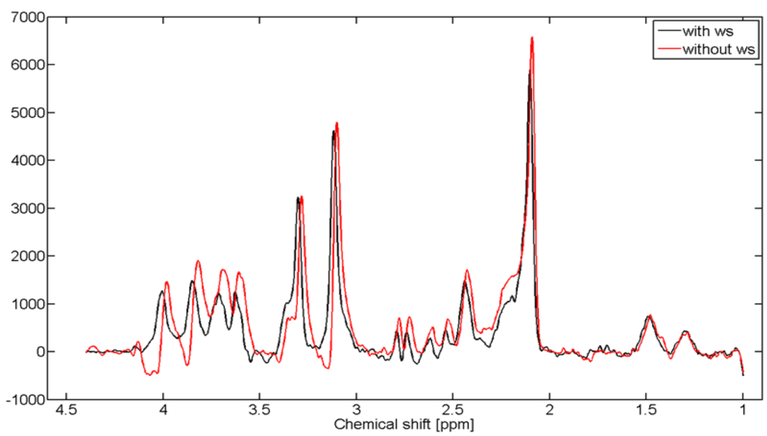

Fig. 2: An example of CSI spectra acquired at 9.4 T with (black) and without (red) water suppression

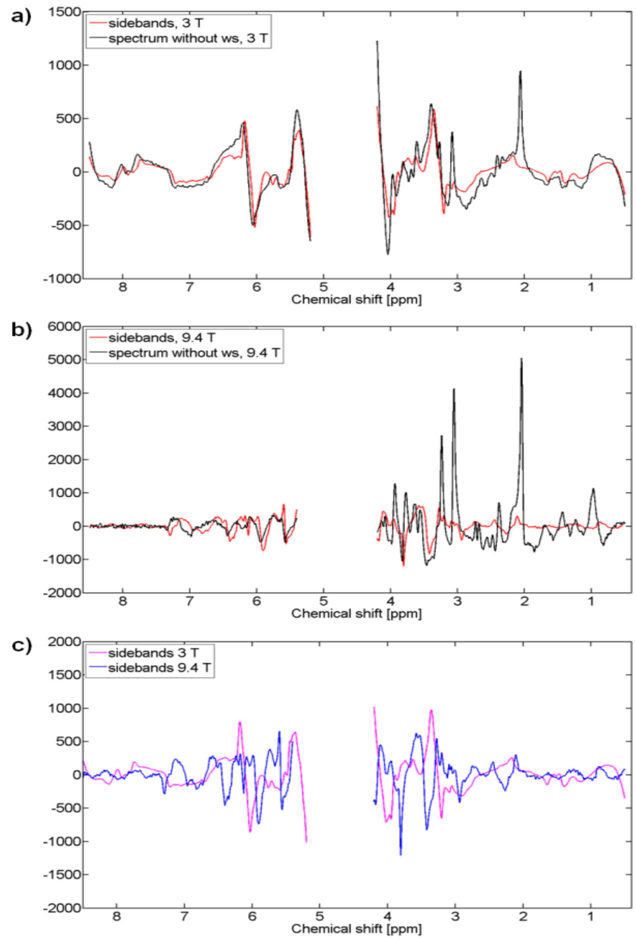

Fig. 1: Comparison of spectra and sidebands acquired at different field strengths: unsuppressed spectrum (black) and sidebands (red) acquired at 3 T (a) and at 9.4 T (b), sidebands acquired at 3 T (magenta) and at 9.4 T (c).

Discussion/Conclusion: We have shown that CSI without water suppression at a field strength of 9.4 T is feasible. Moreover, the influence of the sidebands on unsuppressed spectra acquired at 9.4 T is significantly smaller than at 3 T. The intensity of the water signal at 9.4 T is approximately one order in magnitude higher compared to 3 T while the amplitude of the NAA signal is roughly 5 times greater (Fig. 1a, 1b). This could suggest that the influence of the sidebands at 9.4 T should be even stronger. However, this is not the case, since the sidebands at both field strengths are comparable (Fig. 1c). The possible explanation for this observation could be differences in parameters and construction details of the gradient systems installed in both MR scanners. In conclusion, we have demonstrated that CSI without water suppression can benefit from the increased signal-to-noise ratio offered by ultra-high magnetic field.

References: [1] Dong Z, et al. Magn Reson Med 51:602-606 (2004); [2] Clayton DB, et al. J Magn Reson Imaging 153:203-209 (2001) [3] Avdievich NI, et al. Magn Reson Med 62:17-25 (2009); [4] Deelchand DK, et al. J Magn Reson 206:74-80 (2010).