Comparison of semi-LASER localized Brain MRS at 3T and 7T using 32-channel head coils

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Target Audience

Researchers interested in assessing the benefit of measuring human brain metabolites at 7 Tesla (T) compared to 3T.

Purpose

Signal-to-noise ratio (SNR) is expected to increase approximately linearly with static magnetic field strength (B_0); a 2.3-fold increase in SNR is therefore predicted when moving from 3T to 7T. Increased precision in metabolite concentration measurement using MRS is also expected from the combination of increased SNR and chemical shift dispersion. The purpose of this study was to compare the SNR, spectral resolution and MRS measurement precision between 7T and 3T in the same subjects.

Methods

After obtaining written consent under local IRB approval, 4 healthy subjects (2M, age 35±7 years) were scanned at both 3T and 7T (Philips 'Achieva', Best, Netherlands) using 32-channel head coils. Spatial localization with the semi-LASER[1] sequence with 'Rosenfeld' refocusing pulses with linear frequency sweep of 3kHz, TE/TR = 32/3000 ms, 16-step phase cycle. 32 averages were collected from each of the anterior cingulate cortex (ACC) 3x3x3 cm^3, centrum semiovale (CSO) 4x2.5x2.5 cm^3 and dorsolateral prefrontal cortex (DLPFC) 3x3x3 cm^3 at both field strengths. The nominal maximum B_1 used were 13.5 and 15 μT at 3T and 7T respectively. VAPOR water suppression and 2nd order shimming was performed at both field strengths. The basis set used for LCModel[2] spectral analysis was generated in VESPA[3] by performing density matrix calculations that simulated both the experimental refocusing pulses and phase cycle used.

Results

Figure 1 shows representative spectra from the ACC acquired at 3 and 7T. Average SNR measured at 7T were 2.2, 1.6 and 1.9 times higher than at 3T for ACC, CSO and DLPFC respectively. Average linewidths were 0.46, 0.50, 0.50 ppm (3T) and 0.46, 0.46 and 0.46 ppm (7T) in the ACC, CSO and DLPFC respectively. The measurement precision of metabolite concentrations (as reflected by the Cramer-Rao Lower bounds (CRLB)) was better at 7T for Asp, Glu, Gln in all three regions, mI and GSH in ACC and DLPFC compared to 3T, as shown in Figure 2. NAAG was also measured with higher precision in the CSO and DLPFC at 7T than at 3T. CRLBs were comparable at both field strengths for the large signals of tNAA, tCr, tCho.

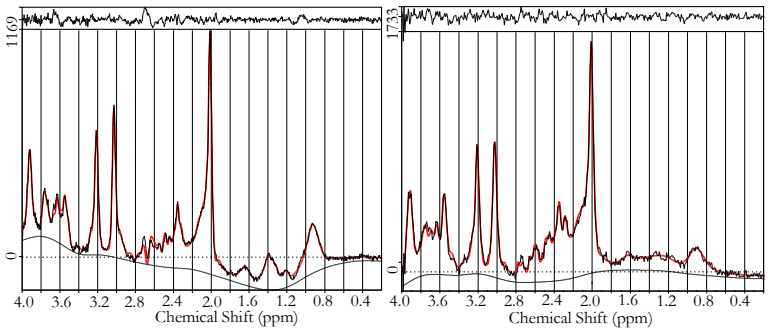

Figure 1. Representative ACC spectra acquired at 7T (left) and 3T (right)

Discussion and Conclusion

These results confirm the anticipated increase in SNR in brain MRS at 7T compared to lower field, as shown in previous studies using surface coil reception[4,5]. The current study confirms this improvement in multiple brain regions using a volume transmit coil paired with a SENSE-receive coil for whole brain coverage. The measurement precision of Glu and Gln in all three regions was better at 7T than 3T. Simultaneous detection of Glu and Gln, which is difficult without specialized pulse sequence at lower field strength, is achievable at 7T. 7T MRS with sLASER localization shows the ability to quantify more metabolites with higher precision than at 3T.

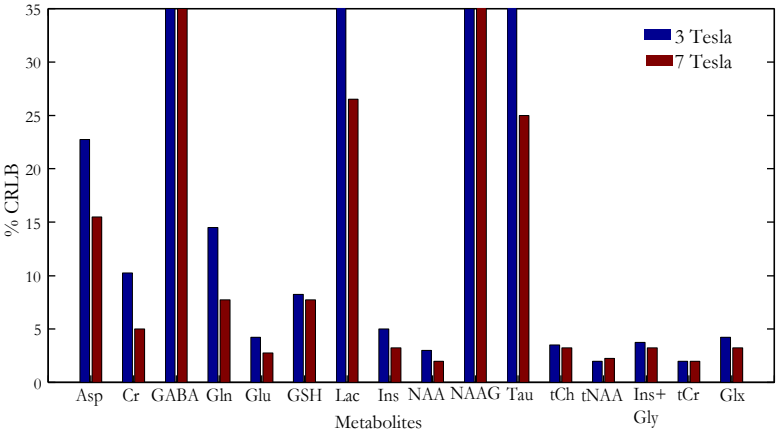

Figure 2. Average CRLB of metabolite concentrations measurements in the ACC (n=4) at 3T (blue) and 7T (red)

References

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