Application of B_1^+ shimming for relaxation-compensated 7T CEST-MRI

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INTRODUCTION:

Ultra high-field MRI provides significant advantages for CEST imaging – higher SNR and spectral resolution. However, abdominal CEST-MRI at ultra high-fields is challenged by strong B_1 inhomogeneity and B_1^+ dropouts. In this study we investigate CEST at 7T in the liver by addressing these challenges with static parallel transmission (B_1^+ shimming).

METHODS:

A dataset was obtained in a healthy volunteer (female, 25 y.o.) on a Magnetom 7T (Siemens Healthineers, Germany) using a local 8-channel Tx/Rx body coil [1]. B_1^+ shimming was applied for two ROIs in different liver regions to locally maximize the B_1^+ efficiency [2], i.e. B_1^+ magnitude per input power. The B_1^+ field was mapped for two different B_1^+ shim settings using an absolute, MRF-based B_1^+ mapping technique [3]. Relative B_1^+ values (rB_1) were calculated as the ratio of the obtained actual FA to nominal FA (= 40°). CEST sequence (res:1.5×1.5×6 mm3; 130 Gaussian-shaped, 15ms-long saturation RF pulses, duty cycle = 80%; recovery time = 3s, total acquisition time = 8min, 73 offsets) was acquired twice with mean nominal saturation amplitudes B_1 = 0.6 and 0.9μT. The acquisition of each single offset time (5.5s) was synchronized with the respiratory cycle. Postprocessing of the data, as well as amide, rNOE MTR_{Rex} values quantification and reconstruction to B_1=0.8μT was performed as in [4].

RESULTS:

Figure 1 (C, D) shows rB_1 maps for two shims in different ROIs. Representative Z-spectra demostrated for two regions of shim 2 (Fig1. D): shimmed region with high rB_1 =1.02 (Fig.1 A) and B_1^+ dropout region with low rB_1 = 0.2 (Fig.1 B). Amide and rNOE MTR_{Rex} maps for two shims are demonstrated on Fig.2 (A-D). Quantitative data in ROI for shim 1: rB_1 = 1.09±0.09 (Fig.1 C), amide MTR_{Rex} = 0.12±0.03 (Fig.2 A), rNOE MTR_{Rex} = 0.16±0.05 (Fig.2 C); for shim 2: rB_1 = 1.19±0.07 (Fig.1 D), amide MTR_{Rex} = 0.12±0.04 (Fig.2 B), rNOE MTR_{Rex} = 0.15±0.06 (Fig.3 D).

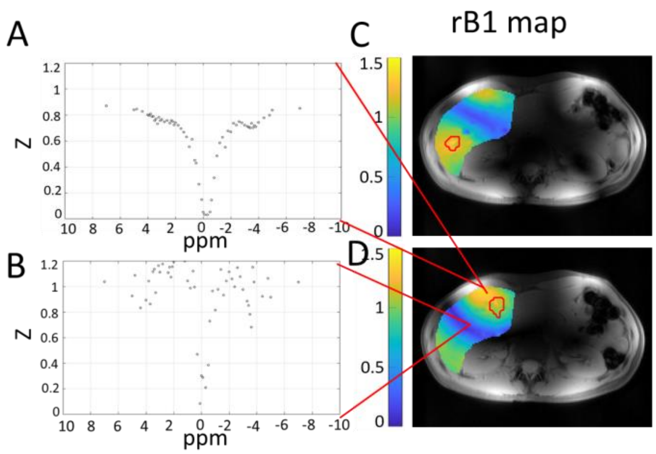

Figure 1. rB_1 maps for two shims in different ROIs (C, D) (shimming ROIs are indicated by red line) and Z-spectra from two regions: shimmed region with high rB_1 *=1.02(A)* and B_1^+ dropout region with low rB_1 *= 0.2 (B).*

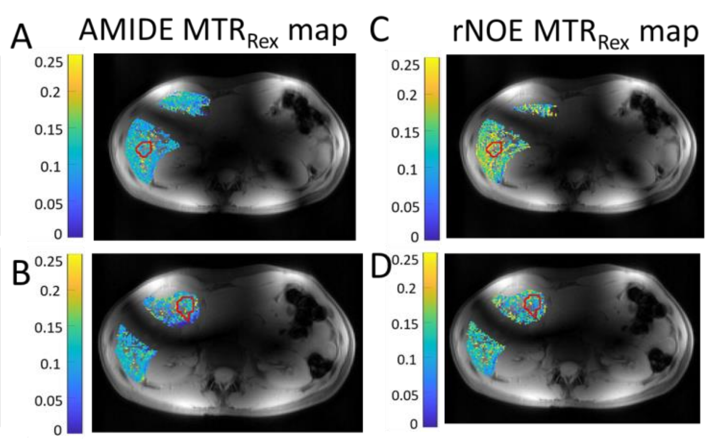

Figure 2. Amide (A, B) and rNOE (C, D) MTR_{Rex} maps collected with two B_1^+ shims (A-C and B-D) in different ROIs. MTR_{Rex} data from voxels with B_1^+ dropouts were masked out. The shimming ROIs are indicated by the red line.

DISCUSSION:

The necessity of employing B_1^+ shimming techniques for ensuring robust data acquisition from the target region is demonstrated – spectra from regions with low rB_1 are unsuitable for processing (Fig1. B) and the spectra from shimming area (Fig.1 B) have appropriate quality for accurate quantification. There are no significant differences in MTR_{Rex} values in two shimming regions, which underscore the method reliability and independence from the target region. MTR_{Rex} values for CEST effects are comparable to the corresponding values in gray brain matter (amide: ≈0.12, rNOE: ≈0.3) [4].

CONCLUSION:

To the best of our knowledge, we present the first robust acquisition of liver amide and rNOE CEST MTR_{Rex} contrasts. Relaxation-compensated CEST-MRI is very promising technique for liver biochemistry and tumor investigation with vast number of possible clinical applications.

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