Initial results for gluCEST acquisition using low pulse energy PUSHUP saturation

Yannik Völzke[1,2] ,Daniel Löwen[2] Eberhard D Pracht[2] Rüdiger Stirmberg[2] Alexander Radbruch[1,2] Tony Stöcker[2,3]
[1] *Department of Neuroradiology, University Hospital Bonn, Bonn, Germany*, [2] *German Center for Neurodegenerative Diseases (DZNE), Bonn, Germany*, [3] *Department of Physics and Astronomy, University Bonn, Bonn, Germany*

INTRODUCTION:

Due to the fast exchange rates of glutamate protons, gluCEST saturation modules contain high amplitude saturation pulses. These pulses cause substantial SAR which limits the allowed amplitude. With high regularization PUSHUP[1,2], saturation allows to maximize the saturation intensity within allowed SAR deposition at the cost of limited saturation homogeneity.

METHODS:

The experiments were conducted on a 7T+ scanner (Siemens Healthineers) using a 32-channel receive, 8-channel transmit coil (Nova medical). For this coil, in 1st level mode the short time coil protection limit, restricts the electric power, measured at the coil plugs, to 70W averaged over 1 second.

PUSHUP saturation combines the PUSH[3] saturation approach with universal pulses (UP)[4]. It uses sub-pulses with multiple, optimized B1-shims, similar to MIMOSA[5], which was used as a starting point in the pulse optimization process. These B1 shims are calculated by minimizing the B1rms inhomogeneity within a database of B1 and B0 maps of 30 subjects. A regularization term allows to trade off SAR efficiency and saturation homogeneity. PUSHUP saturation, with a high regularization factor, was calculated with a target B1rms of 2.4μT. Using 2 alternating B1-shims, 10 cosine-filtered Gaussian sub-pulses with a duration of 80ms were applied in a whole-brain snapshot 3D-EPI sequence[6].

One young healthy volunteer was measured that was not part of the database. Using 54 off-center frequencies, whole-brain gluCEST images were acquired with 1.6mm isotropic resolution in under 5 minutes. Postprocessing included denoising, distortion correction and B0 correction. No B1 correction has been performed. The $CEST_{asym}$(3ppm) was calculated based on the B0 corrected Z-spectra[7].

RESULTS AND DISCUSSION:

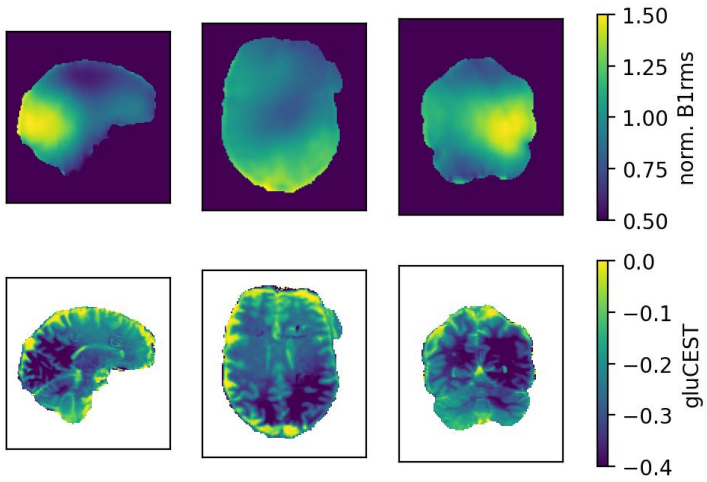

Figure 1: normalized B1rms of PUSHUP saturation (top) and CESTasym (bottom) in three orthogonal slices

During optimization, the NRMSE of the PUSHUP B1rms was 0.246, compared to the MIMOSA NRMSE of 0.162. Concurrently, the pulse power was reduced to 85% of MIMOSA saturation, allowing for an increase of B1 amplitude by a factor of 1.08.

The top row of Figure 1 shows the normalized B1rms amplitude of the saturation module. High values can be found in the posterior and right sites of the brain. These regions coincide with the high $CEST_{asym}$(3ppm) amplitudes.

Regions with high B1rms seem to have a much better contrast in $CEST_{asym}$(3ppm). This is especially obvious in the cerebellum, where the white matter to gray matter contrast is much more pronounced at the right site. Optimization of the saturation approach, such as sub-pulse number and duration might further increase the CEST sensitivity, especially in low B1rms regions.

CONCLUSION:

High-resultion, whole-brain gluCEST images could be measured using low pulse intensity PUSHUP saturation. Further optimization of the saturation module is needed to increase CEST sensitivity.

REFERENCES:

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