Breathing life into renal CEST-imaging: A feasibility study on retrospective gating in renal CEST imaging

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INTRODUCTION:

Renal CEST imaging is challenging due to the respiratory motion that negatively affect the z-spectra. In our previous study, we performed in vivo renal CEST imaging in transplanted kidneys where the respiratory motion is minimal [1]. In this pilot study, we aim to investigate the CEST effects in native human kidneys. To reduce the respiratory motion artifacts, we apply a retrospective gating analysis method proposed by Jones et. al. [2].

METHODS:

The CEST measurements were performed in a healthy volunteer (male, 26 years) on a 3 Tesla MRI system (Siemens MAGNETOM Prisma), using body- and spine-coil in combination with a multi-echo gradient echo sequence consisting of a pulse train of 15 pulses, a pulse amplitude of 1.5 µT and a pulse and inter pulse duration of 100 ms, acquiring 80 frequency offsets in a range of ± 5 ppm. The CEST sequence was repeated three times to ensure sufficient sampling rate after the retrospective gating. A two point Dixon method (TE_1/TE_2 = (2.5/3.7) ms) was performed for fat suppression [1]. A respiratory cushion was used to assign each image a respiratory state. The water only images in the lower third of the breathing curve were retained for MTR_{asym} analysis. To obtain frequency shifts due to B_0-inhomogenities, a single Lorentzian line shape was fitted and the corresponding offset was used for frequency adjustment [2]. MTR_{asym} values were calculated pixel wise in the kidney and intervertebral discs (IVD) in the frequency ranges (1.2 ± 0.25) ppm for hydroxyl-, (2.0 ± 0.25) ppm for amine- and (3.5 ± 0.25) ppm for amide-proton groups. The IVD was used as a static reference to asses, whether the CEST effects get change due to data point rejection. Mann-Whitney U test was used to determine significant differences in the CEST effects.

RESULTS:

Determined renal CEST effects without retrospective gating are (0.80 ± 0.66) %, (0.36 ± 1.05) %, (-1.60 ± 1.76) % and (2.17 ± 1.96) %, (0.95 ± 1.28) %, (-1.20 ± 1.89) % with retrospective gating at 1.2, 2.0 and 3.5 ppm, respectively. The CEST effects in the IVD are correspondingly (0.56 ± 0.50) %, (0.73 ± 0.15) %, (-0.46 ± 0.58) % and (0.85 ± 0.66) %, (0.64 ± 0.24) %, (-0.24 ± 0.27) % at 1.2, 2.0 and 3.5 ppm, respectively. While the CEST effects measured in the kidney are significantly higher ($p < 0.01$), no significant changes were found in the IVD when the retrospective gating was used. Furthermore, MTR_{asym} maps obtained with retrospective gating showed visibility of the renal structures in the parenchyma.

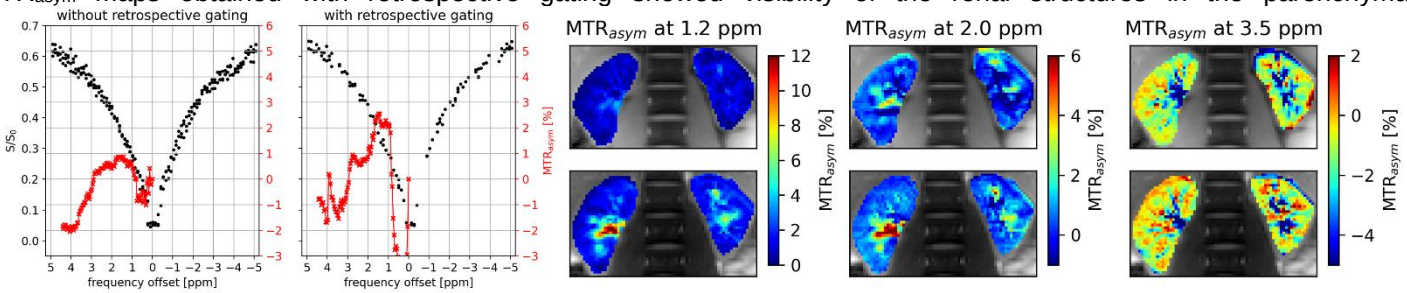

Figure 1. Exemplary z-spectra (black dots) and corresponding MTRasym (red crosses) from the medulla without (left) and with (right) retrospective gating. Upper MTRasym maps are calculated without and lower with retrospective gating.

DISCUSSION:

In our previous study [1] CEST effects of (2.3 ± 3.65) %, (1.4 ± 1.75) % and (0.3 ± 1.24) % were respectively measured for hydroxl-, amine- and amide-proton groups in the medulla of allograft patients. In the cortex, CEST effects of (3.3 ± 4.25) %, (1.3 ± 2.0) % and (-0.1 ± 1.49) % were obtained. The results obtained in this study are in good agreement with those findings. Slight differences were found in the CEST effect of the amide-group, which are likely due to differences in CEST protocols and high inter-subject variability.

CONCLUSION:

The method shows the feasibility of retrospective gating in renal CEST measurements. The reproducibility and possible applicability to pathologies will be investigated in further studies.

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