Whole-Cerebrum guanidino and amide CEST mapping at 3T by a 3D stack-of-spirals gradient echo acquisition

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INTRODUCTION:

Recently, Guanidino (Guan) CEST has been successfully extracted from the human brain at 3T using the polynomial Lorentzian line-shape fitting (PLOF) method[1]. However, current methods only achieve partial brain coverage in 7 min, necessitating a faster and more robust imaging technique for clinical application. To address this challenge, we have developed a whole-cerebrum, high-sensitivity CEST mapping technique based on the 3D stack-of-spirals (3DSOS) gradient echo readout[2]. We compared it with other acquisition to evaluate its efficacy in concurrently mapping Guan and amide CEST in the human brain at 3T.

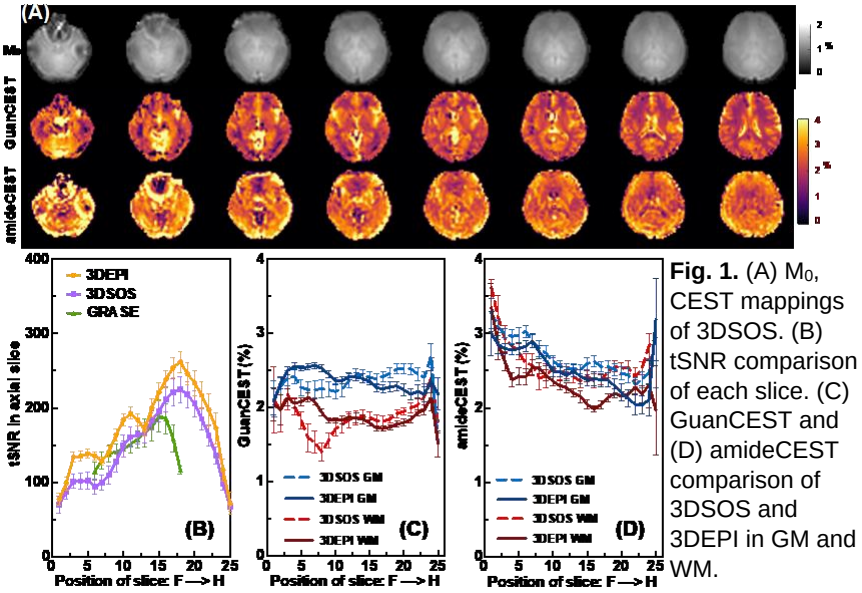

Fig. 1. (A) M_0, CEST mappings of 3DSOS. (B) tSNR comparison of each slice. (C) GuanCEST and (D) amideCEST comparison of 3DSOS and 3DEPI in GM and WM.

METHODS: 22 healthy volunteers and a low-grade glioma patient (28 years, male) underwent scans at 3T (Philips). We first optimized the T_{sat} (1/2/3/4 s) and T_{rec} (1.4/3 s) for the most time-efficient acquisition (defined by $\eta = CEST/\sqrt{t_{offset}}$). Then we evaluated the 3DSOS against 3D echo-planar imaging (3DEPI), and other spin echo techniques (GRASE and TSE), comparing temporal SNR (tSNR) (defined by the ratio of mean value of 20 repeated measurements at 2 ppm with B_1 turned off and their standard deviation), signal intensity in gray matter (GM) and white matter (WM), test-retest reliability, and motion robustness. CEST contrasts were extracted by PLOF method. Then the optimized protocol was applied to the patient.

RESULTS: The optimal T_{rec}/T_{sat} were determined as 1.4/2 s considering both the signal intensity and time-efficiency. Only 3DSOS and 3DEPI achieved whole-cerebrum CEST imaging within a clinically acceptable timeframe (around 4 min). Both methods provided similar GuanCEST contrast (3DSOS: (2.14-2.59)% vs 3DEPI: (2.15-2.61)% in GM; 3DSOS: (1.49-2.11)% vs 3DEPI: (1.64-2.09)% in WM), enhanced by more than 30% than previous studies (see in Fig. 1), while 3DSOS outperformed with significantly higher test-retest reliability (correlation coefficient: 3DSOS: 0.58-0.96 vs 3DEPI: -0.02-0.75), and motion robustness. For the glioma (see in Fig. 2), GuanCEST from 3DSOS showed markedly enhanced contrast compared to 3DEPI, while M_0 and amideCEST images exhibited no significant differences in both techniques.

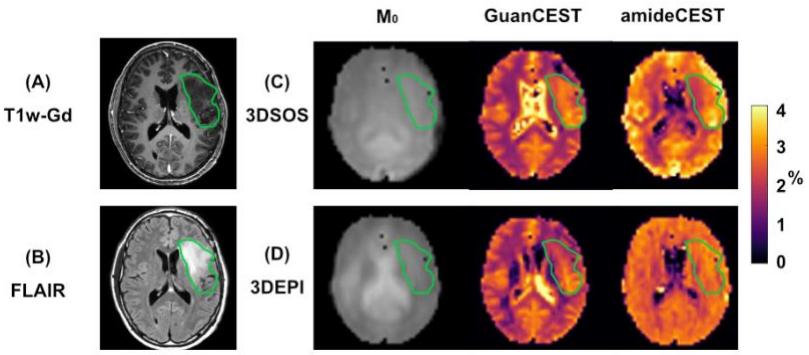

Fig. 2. Demo of a glioma patient. Tumor circled in green defined by (A) T1-weighted image after the injection of gadolinium and (B) FLAIR. M_0 image, GuanCEST, and amideCEST mappings by (C) 3DSOS and (D) 3DEPI.

DISCUSSION: We have demonstrated that both 3DEPI and 3DSOS provide similar tSNR and CEST contrasts compared to the TSE and GRASE. Additionally, 3DEPI and 3DSOS offer much higher brain coverage than TSE and GRASE within shorter scan time. Due to their significantly lower SAR, a much longer saturation time (4 s) can be implemented with 3DEPI and 3DSOS. 3DSOS is more robust to motion as expected due to its higher acquisition rate in the center of k-space. The elevated GuanCEST in tumors may be attributed to a higher Cr concentration, necessitating further large-scale studies for confirmation. GuanCEST is promising to reflect the treatment effect and differentiate progressive tumors.

CONCLUSION: Whole-cerebrum GuanCEST mappings have been achieved by 3DSOS with consistent contrast and robustness to motion in around 4 min at 3T. It provides a promising mapping tool for creatine metabolism in the brain and studying tumor metabolism.

REFERENCES: 1. Wang K, *et al*. Magn Reson Med 2023;89(1):177-191.
2. Zhu D, *et al.* Magn Reson Med 2023;90(3):939-949.