CEST-DREAM imaging provides intrinsic dynamic B0 and B1 correction

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INTRODUCTION The "dual refocusing echo acquisition mode" (DREAM) sequence is an ultrafast method for B0 and B1 field mapping in 2D [1], and 3D [4]. In this work, a CEST-prepared DREAM sequence is proposed tested for APTw CEST [2]. This combination yields the advantages of CEST-preparation, as well as the B1 and B0 maps from the DREAM sequence for each and every single CEST offset. This allows dynamic field correction with no additional time.

METHODS The CEST-DREAM sequence was created with Pulseq, by combining the APTw_001 CEST preparation block [5] with two-dimensional, centric reordered STE-first [1] DREAM readouts (FoV: 220x220x8mm³; matrix: 64x64; FA_{STE1}=FA_{STE2}=55°; FA=15°; TE_{FID}=3.6ms; TE_{STE}=2.6ms; TR=5.6ms; TA_{DREAM}=387ms; CEST offsets: 34 (-1560.0, -4:0.25:4 ppm); TA_{total}≈3.5min). As a reference for the acquired B1 and B0 maps, a WASABI [3] sequence was applied before the DREAM CEST (t_p=5ms; nominal B1=3.7μT; $T_{rec,M0}$=12s; T_{rec}=3s; WASABI offsets: 32 (-300, -2:0.13:2 ppm); TA≈2min). Two healthy subjects were scanned after written informed consent and under approval of the local ethics committee, at a MAGNETOM Prisma 3T scanner (Siemens Healthcare GmbH, Erlangen, Germany).

DREAM provides for every offset a B0 and a B1 map by [1]:

$$\phi_{B0} = \arg(FID \cdot STE^*) \quad (1)$$

$$\mathrm{rB1} = \arctan\left(\sqrt{\left(\frac{2STE}{FID}\right)}\right)/\mathrm{FA}_{\mathrm{STE1}} \quad (2)$$

$$\mathrm{S}\,(\Delta\omega) = \frac{1}{2}\left(\frac{|FID(\Delta\omega)|}{|FID(-300ppm)|} + \frac{|STE(\Delta\omega)|}{|STE(-300ppm)|}\right) \quad (3)$$

RESULTS DREAM B1 and B0 maps (Fig. 1) show low deviations from the WASABI reference as long as CEST saturation is more than ±1 ppm off-resonant from water. Figure 2 shows that the DREAM magnitude images provide magnetization-prepared CEST spectra for both the STE and the FID image, which can be averaged to have a high SNR CEST-spectrum (Eq. (3), Fig. 2C). During data acquisition, a dielectric pad was removed leading to a dynamic B0 shift (Fig. 2D) and B0 artifact (E). The dynamic DREAM correction approach corrects this (F).

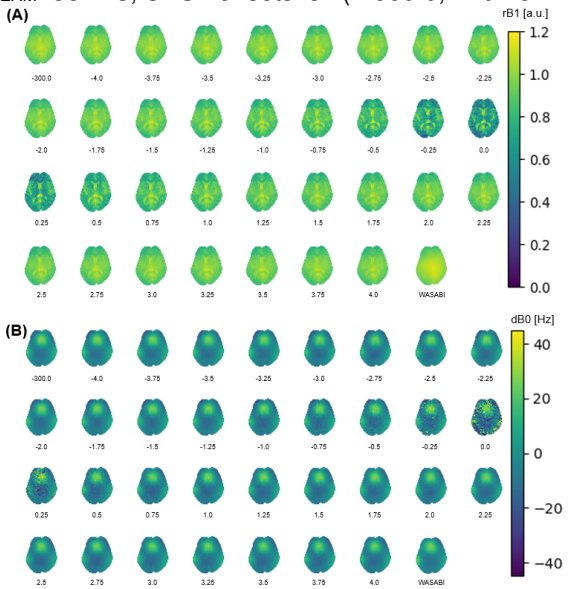

Fig. 1: For every CEST-prepared scan between -4 and 4 ppm, B0 (A) and B1 maps (B) are available. Both correlate well with the WASABI for |Δω| > 1ppm.

DISCUSSION The presented CEST-DREAM sequence allows the simultaneous mapping of B0 and B1 values during a CEST measurement and thus dynamic field correction of CEST MRI. Residual tissue contrasts observed in these maps can be further removed by suitable post-processing for which we have first evidence (not shown). This study also shows for the first time that the known DREAM sequence can be used in a magnetization-prepared fashion. The separated DREAM readouts require a twice as long ADC time prolonging TR with regard to a GRE, yet this does not double the TR.

CONCLUSION

CEST-DREAM allows for dynamically B0 and B1 field corrected CEST MRI with almost no additional scan time.

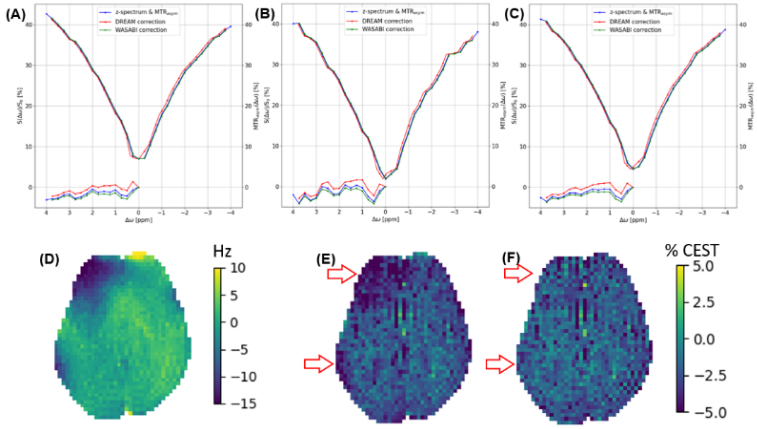

Fig. 2: CEST-prepared DREAM signals. (A) FID, (B) STE, (C) combined. The induced dynamic B0 change by removing a di-electric pad during the CEST scan (D) leads to artifacts in APTw-CEST contrast with only static B0 correction (E), which is corrected by the dynamic correction approach using the dynamic field information provided by the DREAM readout (F).

REFERENCES

[1] Nehrke and Börnert (2012), MRM 68: 1517-1526.
[2] Sedykh et al. snapshot CEST++ : NBM 2023;e4955.
[3] Schuenke et al. (2017), MRM, 77: 571-580. [4] Ehses et al. (2019), MRM 82: 924– 934.
[5] https://github.com/kherz/pulseq-cest-library/tree/master/seq-library/APTw_3T_001_2uT_36SincGauss_DC90_2s_braintumor