Validation of external B0 shimming tools for 7T CEST

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INTRODUCTION: Chemical Exchange Saturation Transfer (CEST) profit from higher field strength such a 7T due to higher signal, prolonged longitudinal relaxation times and increased spectral resolution. However, the correction of field inhomogeneities such as B_0 becomes even more challenging with increasing field strength, especially in vivo due to air-tissue boundaries. As a result, B_0 shimming is essential to ensure high quality images. In this study, we compare on a 7T Terra.X scanner the vendor-provided mapping and shimming algorithms with an external shim software based on a B_0 loop encoded read out (Bolero)[1,2] with the NeuroShim Pro2 software (https://www.rricorp.com/products/human-application/software-neuroshim-pro-2/).

METHODS: For assessing the quality in CEST data after performing B_0 shimming, we scanned one healthy subject on the 7T Terra.X scanner (Siemens, Healthineers). In order to compare the different shim modes, we tested the three on the scanner implemented shims: (i) standard shim, (ii) standard brain shim, (iii) advanced shim towards (iv) the improved auto-shim software Bolero, which acquires a 3-TE field map and optimizes the B_0 homogeneity. After each shim, a WASABI sequence determined the B0 map used for correction of CEST data. As example CEST contrast we used the MTR_{asym}-based amine- and glutamate-sensitive CEST imaging at a mean B_1 of 2 µT according to the literature[3,4]. Only few offsets are acquired at $\Delta\omega$= -3.7, -3, -2.25, -1.5, +1.5, +2.25, +3, +3.7 ppm. Multiple interleaved mode saturation (MIMOSA) acquisition at two B_1 levels was used to achieve homogeneous reconstructed CEST images across all measurements[5].

RESULTS: Figure 1 presents the different B_0 maps after shimming. The maps reveal that the vendor-provided standard shim and brain shim are not ideal. The advanced shimming option of the vendor yields improved results that are outperformed by Bolero in the central part of the brain. In the frontal regions the advanced vendor shim actually shows best results. The calculated B_0-corrected MTR_{asym} maps within these slices (Fig. 2) show similar image contrasts.

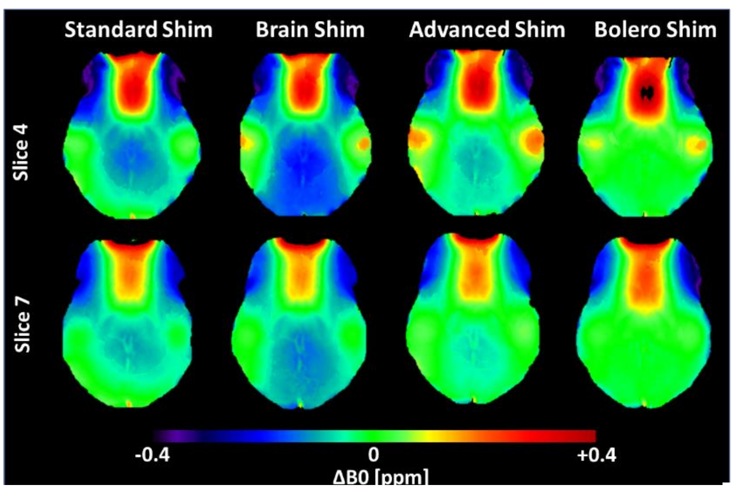

Fig.1: Comparison of the B_0 maps created with Wasabi after performing different shimming modes resulted in the most homogeneous B_0 map after Bolero shimming

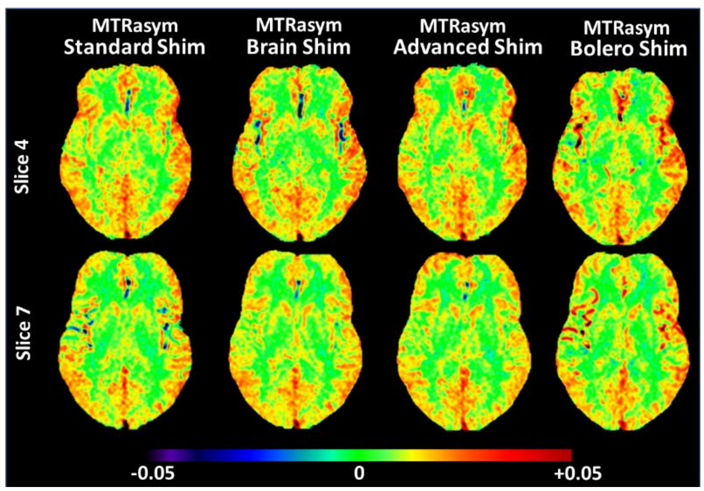

Fig.2: Associated MTR_{asym} maps display a similar image contrast. The data shimmed with Bolero tended to have a more homogeneous contrast within the white matter

DISCUSSION: In this work, we compared an external shimming tool compared to vendor-provided shimming tools. In this first study, it shows that external tools provide similar results to advanced vendor tools. Importantly, the external tool allows much more flexibility and fine-tuning, which were not yet utilized during submission of this study. E.g. specific slices or regions of interest can be chosen to further improve the shim in the frontal brain, and the starting values of the shim tool can be manipulated. Currently we did not see major differences in MTR_{asym} maps, due to the conservative offset list. With an improved shim one could remove additional frequency offsets e.g +-1.5 ppm to accelerate this sequence by 25%.

CONCLUSION: External shimming tools can be used as drop-in replacement for vendor-provided tools allowing more flexible fine-tuning of tailored shimming at 7T.

REFERENCES: 1. Hetherington et al. MRM 2006; 56(1): 26-33; **2.** Pan et al. MRM 2012; 68(4): 1007-1017; **3.** O'Grady et al. Front. Neurol. (2022) Volume 13; **4.** Fabian et al. NMR in Biomedicine (2024), Volume 37, Issue 5 ; **5**. Liebert et al, MRM (2019); 82(2): 693-705