

## Dynamic Slice-Optimized Shimming in Continuous Moving bed MRI

Saikat Sengupta<sup>1,2</sup>, David Smith<sup>1,2</sup>, and E. Brian Welch<sup>1,2</sup>

<sup>1</sup>Radiology and Radiological Sciences, Vanderbilt University, Nashville, TN, United States, <sup>2</sup>Vanderbilt University Institute of Imaging Science, Vanderbilt University, Nashville, TN, United States

### INTRODUCTION

Continuous moving bed MRI (COMBI) is a high throughput imaging technique that has been employed in rapid whole fat-water quantification<sup>1</sup>, MR angiography<sup>2</sup> and diffusion weighted imaging<sup>3</sup> among other applications. Existing COMBI implementations include both cartesian and radial methods [4,5]. One primary limitation of all current COMBI techniques is that the center frequency and  $B_0$  shim optimization is typically performed in the midsection of the body. Image quality and parameter quantification in COMBI suffers significantly from  $B_0$  field variations along the extent of the human body. The goal of this work is to mitigate the effects of these inhomogeneities and improve image quality in COMBI by developing slice-specific dynamic shimming of 0<sup>th</sup> and 1<sup>st</sup> order  $B_0$  field inhomogeneities at 3 Tesla.

### METHODS

COMBI was implemented on a Philips Achieva 3T scanner (Philips Healthcare, Best, The Netherlands). Scan control changes allowed table motion during a scan. COMBI was performed as a continuous radial scan with golden angle (GA, 111.25° step) sampling with  $N$  total profiles.

$$N = \text{Full } z\text{FOV} / (\text{Table Speed} * \text{Repetition Time})$$

GA radial  $B_0$  fieldmapping was performed on a phantom setup with all shims set to 0 (zFOV = 1500 mm, table speed = 20 mm/s, in-plane FOV = 400 x 400 mm<sup>2</sup>, resolution = 5 x 5 x 20 mm<sup>3</sup>, TR/TE = 5/1.2 ms,  $\Delta TE = 0.5$  ms). Slices with thickness of 5 mm (25 radial profiles) spaced at 5 mm intervals were reconstructed offline using projection reconstruction in MATLAB (Mathworks Inc, MA USA). Slice-wise field was estimated as  $\Delta B_0 = \Delta \phi / (2 \Delta TE \pi)$ . A total of 300 (1500/5) slice specific 1<sup>st</sup> order shims and 0<sup>th</sup> order frequency offsets were calculated for the full 1500 mm phantom setup from the fieldmaps, along with the number of profiles per shim value based on the target scan. Pulse program modifications enabled application of shims in real time via gradient (for 1<sup>st</sup> order X, Y, Z shims) and center frequency ( $f_0$ ) shifts. The scan was repeated twice with a resolution of 2 x 2 x 8 mm<sup>3</sup>, TR/TE = 4/1.2 ms, with a static, 0 Hz/cm<sup>n</sup> shim (representing a whole body average value) and with dynamically changing shims (31 profiles/shim). Both volumes were reconstructed with 8 mm slice thickness and 5 mm slice gaps for evaluation.

### RESULTS AND DISCUSSION

Figure 1a shows a coronal reformatted fieldmap without slice-specific shims for the phantom setup. The  $B_0$  field is observed to be extremely inhomogeneous in every slice as well as through the full extent of the setup. The setup included a mineral oil bottle with a chemical shift of ~500 Hz. Figure 1b shows the corresponding fieldmap in the dynamically shimmed scan, with the shim values shown in Figure 1c. Figures 1d and 1e show the 1<sup>st</sup> echo images for the same slices with slice-specific field offsets and 1<sup>st</sup> order variations corrected. Future work will focus on correcting shim estimates in object transition locations, robust phase unwrapping for accurate fieldmapping and application to whole-body fat-water quantification.

### REFERENCES

1. Kullberg, J et al. *JMRI* 30. 185 (2009).
2. Kruger, DG et al. *MRM* 47. 224 (2002).
3. Han, Y et al. *MRM* 65.1557 (2011).
4. Börner et al. *JMRI* 28. 1(2008)
5. Shankaranarayanan, A et al. *MRM* 50.1053 (2003).
6. Winkelmann S et al. *IEEE TMI* 26.68 (2007).

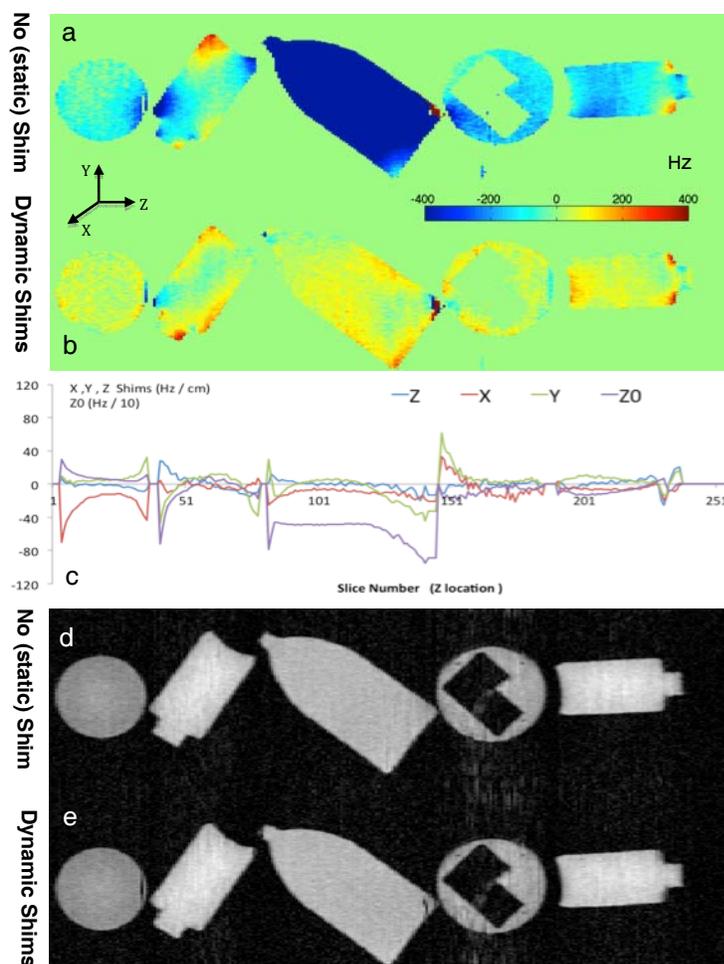


Figure 1 (a & b) Coronal fieldmaps without & with dynamic shims (c) slice-wise shims (d & e) Images without & with dynamic shims.