Preliminary Investigation of the use of Multi-transmit for Myocardial T2 and T2* Quantification in Normal Volunteers at 3T

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INTRODUCTION

With the increase in SNR and other technical improvements, 3T MRI scanners have become increasingly available for clinical investigations. Despite their advantages, increased B0 and B1 inhomogeneity effects, together with adverse physiological motion and flow artifacts present challenges for cardiac imaging and quantification [1]. Traditional myocardial T2 and T2* measurements employing free-breathing methods could no longer provide reproducible results to monitor iron overload in patients with thalassaemia major and other iron overload disorders. Earlier work has shown that the breath hold method [2] significantly reduced respiratory motion and blood flow artifacts and thus improved the measurement reproducibility [3,4] at 3T. The increased B1 non-uniformity may, however, deteriorate the accuracy and confound cardiac tissue quantification. Multi-transmit technology has the potential to alleviate this problem by compensating for flip angle inhomogeneity. The current study aims to investigate the cardiac quantification improvement using parallel RF transmission at 3T.

METHOD

Combining partial Fourier and SENSE acquisition, a hybrid TSE/MESE sequence [3] was implemented on a Philips Achieva 3T TX with multi-transmit. In brief, 2 k-space lines are acquired per TR (i.e., turbo factor = 2) so that the single-slice multi-echo T2 mapping can be obtained within a single breathhold (~15 cardiac cycles). The TE of the 1st echo was 5 ms. The effective echo spacing was 10 ms with FOV=370-400 mm, TR=1 cardiac cycle (800-1000ms), acquisition matrix=128x96, SENSE factor=2, partial Fourier factor=0.6, slice thickness = 10 mm for 90º excitation (and 30 mm thickness for 180º excitations to minimize stimulated echo effects), crushers along all 3 directions, and ECG trigger delay set to late diastole (~500ms). A double-inversion black blood technique was used for flow artifact reduction and better LV wall delineation [2,4]. The slice was positioned to cover the short-axis LV view at the mid-ventricular level. There were a total of 12 echo numbers (with 6 echo images accordingly). The single-breathhold acquisition was repeated twice during each scan for T2 averaging. A flex-L loop coil anteriorly and spine coil posteriorly were used for image acquisition (due to temporary unavailability of 32-channel torso/cardiac coil). To examine the effect of multi-transmit on myocardial T2 and T2* quantification at 3T, each subject was scanned with and without multi-transmit. Three healthy volunteers (23-26 yrs with mean age 23.3 ± 2.5 yrs) were recruited and provided informed written consent.

For Myocardial T2* measurement with a multi-echo gradient echo (MEGE) sequence, echo number was 25, turbo field echo factor was 4, and one breathhold with 9 cardiac cycles was used. The first TE and echo spacing were set to 3 ms and 2 ms, respectively. The reconstruction matrix was 256x256. All other parameters were the same as in the T2 measurement.

For data analysis, ROIs were drawn in the mid-ventricular septum. T2 and T2* values were calculated by fitting the ROI signals to a mono-exponential model. In each subject, the same ROI was used in analyzing all the acquisitions but with slight position adjustments to account for the shifts between the breathholds, and the mean value and standard deviation within the ROIs calculated.

RESULTS AND DISCUSSIONS

Fig. 1 shows the typical T2 maps without and with the multi-transmit in one subject. Note that the T2 map in the mid-ventricular septum (indicated by the arrow) with the RF parallel transmission (Fig. 1b) was more homogeneous than that without the multi-transmit (Fig. 1a). Fig 2 shows T2* maps without and with the multi-transmit in the same subject. Again the T2* map in the mid-ventricular septum (indicated by the arrow) with the RF parallel transmission (Fig. 2b) has uniform T2* values comparing with that without B1 shimming (Fig. 2a). The T2 map (Fig. 1) was more homogeneous than the corresponding T2* map (Fig. 2) [3] observed previously.

The average myocardial T2 was 38.8±8.7ms in Fig. 1a, whereas it was 34.5±4.6ms in Fig. 1b. The average myocardial T2* for the subject shown in Fig. 2a was 32.6±14.6ms, whereas it was 29.2±8.3ms in Fig. 2b. Note that ROIs were the same but for slight position adjustments to account for the shifts among the different breathholds.

In this study, we only used a two-channel flex-L loop coil and a 15-channel spine coil for the signal acquisition.
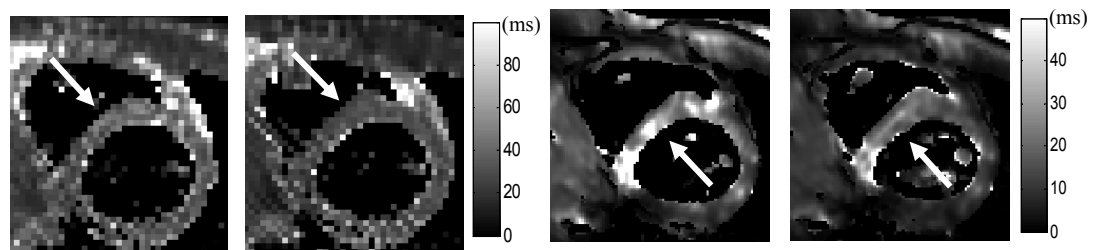

Fig. 1 Typical T2 maps from a single-breathhold TSE during one exam. (a) without multi-transmit; (b) with multi-transmit.

Fig. 2 Typical T2* maps from a single-breathhold MEGE during one exam. (a) without multi-transmit; (b) with multi-transmit.

Additionally, to realize single-breathhold imaging, we applied parallel imaging with acceleration factor of 2. The signal to noise ratio, therefore, was less optimal than that we acquired previously [3]. This could be the reason for the lack of conspicuity in the difference between the two measurements in Fig. 1 comparing with Fig. 2. For the current data, we did not observe obviously higher pericardium T2 than that in our previous studies using single RF transmission [3]. The issues are being quantitatively investigated. It is anticipated that further study using a 32-channel torso/cardiac coil, expected soon, should improve image quality and mapping quality accordingly. Also B1 field mapping is required to confirm the results in this preliminary study.

CONCLUSION

Preliminary results demonstrated the effectiveness of the multi-transmit technique for myocardial T2* and T2 quantification improvement at 3T. Further study will be needed to systematically evaluate the performance in patients with thalassaemia major.

References: [1] Singerman RW et al. JMR 1997;125:72. [2] He T et a. JMRI 2006;24:580. [3] Guo H et al. JMRI 2009;30:394. [3] Kim D et al. MRM 2009 62:300. [4] Greenman RL et al. JMRI 2003;17:648.