

POSTER PRESENTATION

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# Radial cardiac $T_2$ mapping with alternating $T_2$ preparation intrinsically introduces motion correction

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## Background

$T_2$  mapping through variation of the  $T_2$  preparation ( $T_2$ Prep) duration has been increasingly used to robustly detect and quantify cardiac edema (Giri et al., *JCardio-MagnReson*2009). However, if images with incremental  $T_2$ Prep duration are acquired in a sequential fashion, irregular breathing patterns and heart rates may adversely affect the quality of the  $T_2$  maps due to misalignment of the source images. A logical alternative is then to acquire all images in an alternating manner (Figure 1ab), where the  $T_2$ Prep duration changes cyclically from one heartbeat to the next. Combined with a radial signal readout, this may minimize the vulnerability to respiratory or RR variability. We therefore simulated, implemented and tested the utility of an alternating magnetization preparation approach to  $T_2$  mapping.

## Methods

A navigator-gated ECG-triggered radial gradient-recalled-echo pulse sequence (20 lines per heartbeat, trigger every 3 heartbeats) was implemented to obtain source images for the  $T_2$  maps (van Heeswijk et al., *JACCCardioImag*2012), with the possibility to apply the  $T_2$ Prep durations of 60/30/0 ms in both an alternating and sequential manner. Bloch equation simulations were performed in order to estimate the fitting residual due to  $T_1$  relaxation (van Heeswijk et al., *JACCCardioImag*2012) as well as the accuracy over a range of heart rates. The sequences were validated at 3T (12-channel

surface coil array, on a Magnetom Trio, Siemens, Erlangen, Germany) in agar-NiCl<sub>2</sub> phantoms by comparing the resulting  $T_2$  maps to gold-standard spin-echo (SE)  $T_2$  measurements. A mid-ventricular short-axis  $T_2$  map was then acquired with both pulse sequences in 7 healthy adult volunteers. The myocardial surface area was measured in the  $T_2$  maps, while a Student's t-test was applied to detect differences in  $T_2$  values and surface area.

## Results

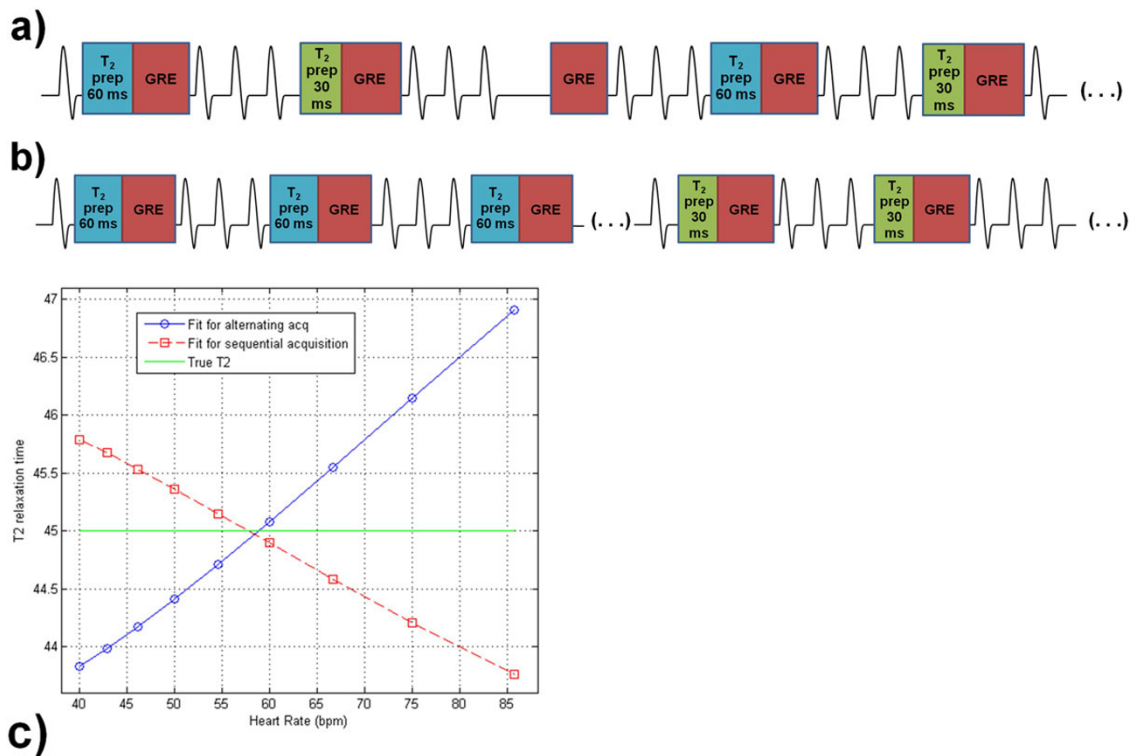
The alternating sequence was as robust to heart rate variation as its sequential counterpart (Figure 1c), while its accuracy was confirmed in the phantoms ( $T_2 = 45.4 \pm 0.7$  ms for the alternating method, vs  $45.3 \pm 0.7$  ms for the sequential method and  $45.1 \pm 0.7$  ms for the gold-standard). The myocardial surface area was increased in the alternated  $T_2$  maps of the volunteers ( $128 \pm 24$  cm<sup>2</sup> vs.  $111 \pm 20$  cm<sup>2</sup>,  $p = 0.04$ ) (Figure 2), while the average midventricular  $T_2$  value slightly differed between the alternated and sequential methods ( $T_2 = 37.6 \pm 6.6$  ms alternated vs.  $40.4 \pm 6.1$  ms sequential,  $p = 0.01$ ).

## Conclusions

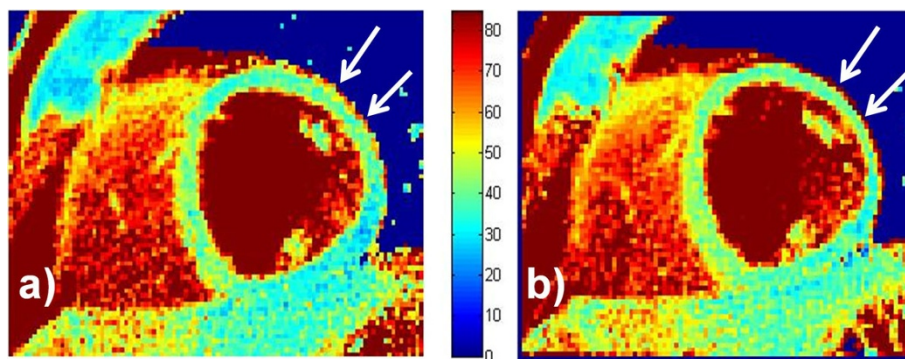
We successfully implemented and tested a  $T_2$  mapping methodology in which magnetization preparation is alternated. The *in vivo*  $T_2$  maps demonstrate that the alternated acquisition intrinsically aligns its sources images, resulting in a larger available myocardial surface, which in turn may allow for more accurate  $T_2$  value quantification.

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**Figure 1** a) Schematic of the alternating acquisition pattern. The T<sub>2</sub>Prep duration is alternated between 60, 30 and 0 (no T<sub>2</sub>Prep) ms from heartbeat to heartbeat. All images are acquired in an interleaved fashion and on average experience similar motion. b) Schematic of the conventional sequential acquisition pattern. The T<sub>2</sub>Prep duration is changed only after acquisition of an image. This approach may be more vulnerable to irregular heart rates or respiration patterns. c) Simulations of stability of fitted T<sub>2</sub> values for both methods against heart rate variation. For an input T<sub>2</sub> of 45 ms, both the alternating acquisition (solid line) and the sequential acquisition (dashed line) result in a T<sub>2</sub> variation of ~3 ms over the range of physiological heart rates.



**Figure 2** T<sub>2</sub> map of volunteer acquired with the alternating (a) and sequential (b) method. Note that consistent with the quantitative findings, the antero-lateral myocardium is thicker when acquired with the alternating method (arrows).

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