FREE-BREATHING 2D MYOCARDIAL T_1 MAPPING

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TARGET AUDIENCE: Scientists and clinicians interested in myocardial tissue characterization.

INTRODUCTION: Myocardial T_1 mapping allows non-invasive assessment of diffuse fibrosis[1]. T_1 mapping is commonly performed during a single breath-hold. However, despite breath-holding, in over 50% of patients, there are respiratory motion artifacts in the form of a respiratory drift[3]. Furthermore, a breath-hold scan limits the number of sampling points along the longitudinal recovery curve, which adversely impacts the precision of the T_1 mapping sequence. T_1 mapping and extracellular volume (ECV) measurement of the LV currently require 20-24 additional breath-hold scans, which is not convenient for the patient. In this study, we sought to develop an efficient free-breathing navigator-gated 2D T_1 mapping sequence based on the SAPPHIRE T_1 mapping sequence[2] (i.e. a hybrid of saturation and inversion pulse for magnetization preparation).

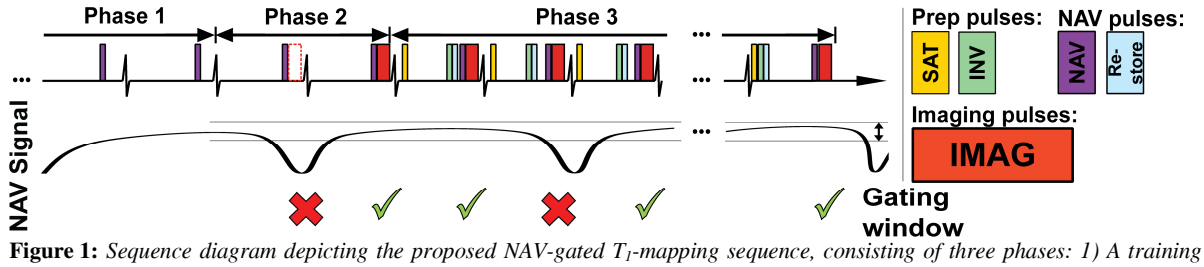

Figure 1: *Sequence diagram depicting the proposed NAV-gated T_1-mapping sequence, consisting of three phases: 1) A training phase of multiple NAV acquisitions. 2) The sampling of the full magnetization recovery. 3) Multiple SAPPHIRE prepared images, with varying inversion time.*

	Vial #1	Vial #2	Vial #3	Vial #4
Spin Echo	431 ± 2	610 ± 3	1180 ± 7	1537 ± 11
Breath-hold	420 ± 27	583 ± 28	1196 ± 52	1553 ± 51
NAV gated 20 s	424 ± 27	595 ± 24	1168 ± 52	1544 ± 51
NAV gated 30 s	437 ± 26	604 ± 16	1189 ± 40	1548 ± 36

Table 1: *T_1 measurements in a phantom using the proposed NAV gated T_1 mapping technique with a duration of 20 and 30 seconds, compared to conventional breath-hold SAPPHIRE T_1 mapping and a spin-echo reference.*

METHODS: Figure 1 shows the schematic of the proposed sequence. Multiple 2D single-shot images are acquired with varying T_1 weighting in three phases for training, acquisition of the "infinity" point on the longitudinal recovery curve (i.e. baseline magnetization without any preparation pulse) and other points along the recovery curve. For navigator training, we propose to acquire data over 10 heart cycles with the acquisition of a right hemi-diaphragm NAV only. For the infinity point an image without magnetization preparation and an associated preceding NAV-signal is acquired. In case the NAV-signal is outside the pre-defined gating window, no imaging pulses are played and the acquisition is repeated in the next heart-beat. For the remaining images a saturation pulse is played right after the detection of each R-wave and followed by an inversion pulse after a variable delay. The inversion pulses are followed by a NAV-restore pulse (diameter: NAV/NAV-restore: 20mm/60mm) preceding each image acquisition. In case an image is acquired with an associated NAV-signal outside the gating-window, the acquisition is repeated with the same inversion time. All NAV signals were used for prospective slice-tracking.

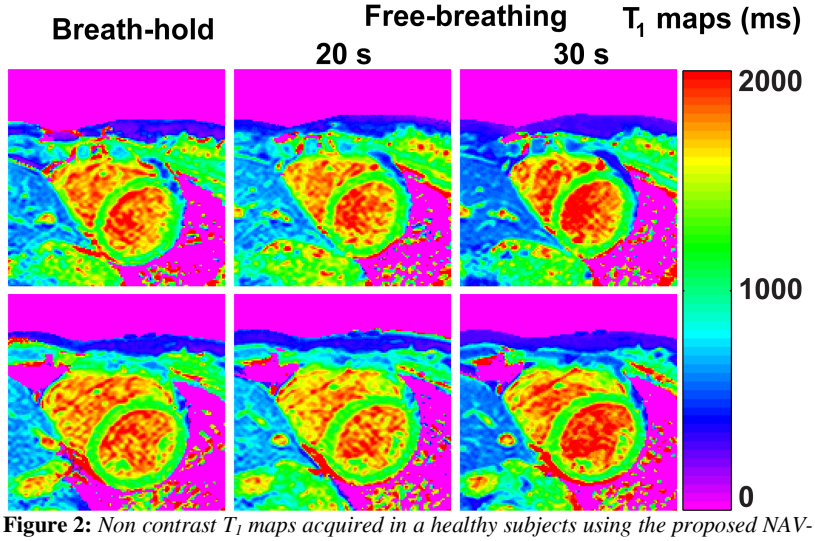

Figure 2: *Non contrast T_1 maps acquired in a healthy subjects using the proposed NAV-gated T_1 mapping technique with 20 and 30 seconds acquisition compared to conventional breath-hold SAPPHIRE T_1 mapping.*

Imaging: All imaging was performed on a 1.5T Philips Achieva system. Phantom measurements were performed to compare the T_1 values obtained with the proposed free-breathing sequence to conventional breath-hold SAPPHIRE T_1 maps and a spin-echo reference. The proposed free-breathing sequence was performed in two versions: 1) 20 sec scan time with same sampling points as in the breath-hold sequence. 2) 30 sec scan time with increased number of sampling points on the longitudinal recovery curve. Furthermore, 5 healthy subjects (3 male, 33±13 years), were scanned for non-contrast T_1 mapping with the proposed free-breathing sequence in the short and long version as well as conventional breath-hold SAPPHIRE. The obtained T_1 values in the myocardium were compared using a paired student's t-test.

RESULTS: Table 1 shows the T_1 times measured in the phantom experiments. Breath-hold and free-breathing scans yield very similar T_1 measurements. The standard deviation within each phantom component is comparable between the short free-breathing sequence and breath-hold SAPPHIRE and reduced with the prolonged version.

Figure 2 shows representative T_1-maps, acquired with breath-hold, short and long free-breathing SAPPHIRE. The quality of the breath-hold sequence and the short free-breathing sequence is comparable. No significant difference in the assessed T_1 times was found between the breath-hold sequence and either of the free-breathing sequences (breath-hold: 1198 ± 10 ms, free-breathing 20 s: 1200 ± 6 ms, free-breathing 30 s: 1205 ± 15 ms $p > 0.8$).

CONCLUSIONS: The proposed sequence enables two dimensional T_1-mapping during free-breathing, enabling long acquisition times per slice.

REFERENCES: 1. Messroghli, D. R. Radiology, 2006;2. Weingärtner, S. MRM, 2013; 3. Hue, X. MRM 2012;