

Simultaneous Quantification of Myocardial Deformation and T1-Relaxation

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Introduction: Myocardial scar detection plays an important role in the clinical diagnosis of various heart diseases. Quantitative T₁-maps acquired late after contrast agent injection can be used to identify regions with myocardial scar [1]. Additionally, quantification of cardiac deformation using CSPAMM [2] or N-SPAMM [3] tagging can give valuable insight into the resulting functional changes of the heart. A new method is introduced that allows obtaining T₁-maps of the myocardium as well as deformation parameters in a single scan. The approach exploits the inherent properties of the tagging preparation sequence which partly inverts / saturates the magnetization prior to the acquisition.

Methods: The signal intensity I_{Tk} for the k^{th} ($k=1\dots n$) heart-phase image of a CSPAMM or N-SPAMM acquisition can be described

as [2]: $I_{Tk} \propto \exp(-t_k / T_1^*) \prod_{j=1}^{k-1} \cos(a_j) \sin(a_k)$; with t_k denoting

the time after tagging preparation and $a_1\dots a_k$: variable flip angles. By using an optimized flip angle train, a constant tagging signal throughout the cardiac cycle can be obtained for one tissue type with known T₁ [2,4]. However, for tissues with a different T₁ value, a change in signal amplitude is still observed over the cardiac cycle (Fig. 1).

After dividing I_{Tk} by $\prod_{j=1}^{k-1} \cos(a_j) \sin(a_k)$, the T₁*-value of any

imaged tissue can be calculated using a two-parameter fit according to: $I = A \exp(-t_k / T_1^*)$. In order to use signal intensities from the same (moving) tissue points, HARP-tracking [5] needs to be applied prior to T₁*-calculation.

To obtain sufficient spatial resolution of the T₁-maps, a TFEPI-sequence as described in [6] was used and phase-cycling of the first tagging RF-pulse was incorporated to separate the harmonic peaks ('3-SPAMM', [3]). Furthermore, RF phase cycling was implemented in the acquisition to suppress coherent transversal signal across heart phases. Slice-following tagging images with a tag-line distance of 8mm were acquired in two navigator controlled breath-holds on a 1.5T Scanner (Philips Medical Systems, Best, NL): FOV:320x272mm², matrix:160x84 (recon. 320x320), EPI-factor:7, TFE-factor:2, flip angle train adjusted for T₁=870ms, flip angle for last heart phase:20°, cardiac phases:20, temporal resolution:30ms, total scan time:38s.

Experimental data were acquired in a phantom containing a range of Gd concentrations (Figure 1) and the obtained T₁*-values were compared with the results from an interleaved spin-echo and inversion recovery sequence as reference.

To test in-vivo feasibility a healthy volunteer was scanned and a T₁-map as well as the circumferential shortening of a mid-wall contour was calculated from the same data set.

Results: The obtained T₁*-map from the phantom experiment is shown in Figure 2. The measured T₁*-values corresponded well with the reference values (Table 1). For the in-vivo data circumferential shortening of the tracked mid-wall contour is plotted for six different sectors in Figure 3 and the T₁*-map calculated from the same data set is shown in Figure 4.

Discussion: T₁*-values obtained from the phantom measurements showed good agreement with the reference values. Initial in-vivo results demonstrated the feasibility to quantify both cardiac deformation and T1-relaxation in a single scan.

Deviations in T₁*-values along the circumference of the myocardial wall can partly be attributed to motion induced B₀ field variations. Further to this, work is required to evaluate the method in a larger cohort of subjects in particular under post-contrast conditions to correlate T₁*-values with functional manifestations.

References: [1] Messroghli DR, et al., 2004, MRM 52: 141-6. [2] Fischer SE, et al., 1993, MRM 30: 191-200. [3] Tsao J, et al., 2005, Proc. ISMRM: 273. [4] Stuber M, et al., 1999, MRM 9: 85-91. [5] Osman N, et al., 1999, MRM 42: 1048-60. [6] Ryf S, et al., 2005, JCMR 7:693-703.

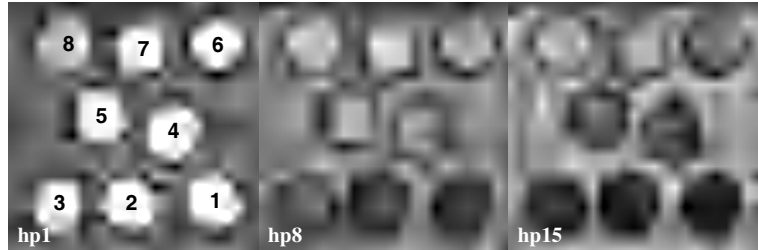


Figure 1: 3-SPAMM magnitude images for different heart phases acquired in a phantom with different Gd concentrations. The flip angle train was optimized for T₁=870ms.

Phantom	T1* [ms]	
	Ref. Scan	Tagging
1	141	161
2	176	199
3	232	251
4	304	305
5	352	356
6	422	406
7	502	522
8	752	741

Table 1: T₁*-values in the phantom using the reference (=Ref. Scan) and the tagging based approach.

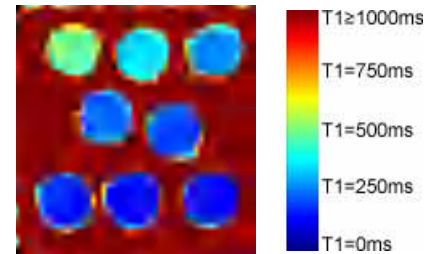


Figure 2: T₁*-maps calculated from tagging data acquired in the phantom.

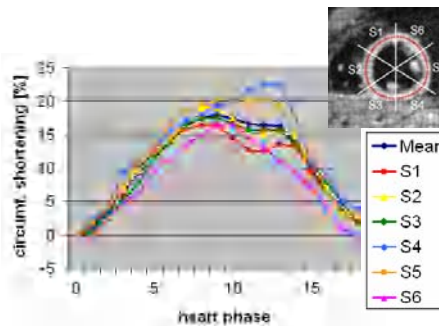


Figure 3: Circumferential shortening of six sectors over the cardiac cycle.

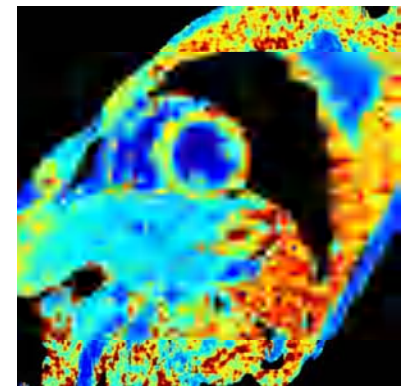


Figure 4: In vivo T₁*-map (with the same color encoding as used in Figure 2) calculated from 3-SPAMM tagging data.