Joint myocardial T1 and T2 mapping

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Joint myocardial T_1 and T_2 mapping

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Background

Recent studies suggest that quantitative myocardial T_1 mapping allows assessment of focal and diffuse fibrosis in the myocardium [1]. Quantitative T_2 mapping has also been proposed to overcome challenges associated with T_2 weighted imaging [2]. These maps are traditionally acquired with different sequences, necessitating image registration to evaluate them jointly. A sequence that can jointly estimate T_1 and T_2 maps has been proposed [3], but it requires multiple relaxation cycles, which necessitates a lengthy free-breathing acquisition. In [4], an alternative joint estimation sequence was proposed based on the inversion-recovery SSFP curve. In this study, we sought to develop a saturation-recovery

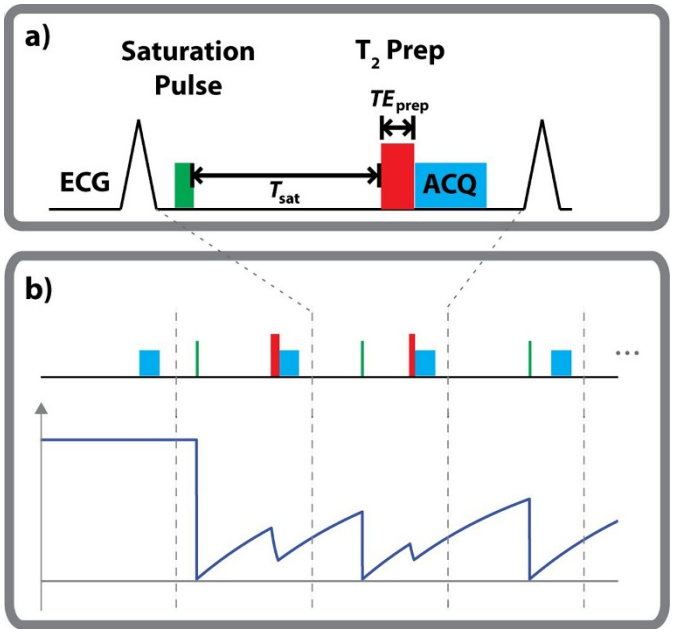

Figure 1 a) The sequence diagram for the proposed technique. A saturation pulse is applied in every R-R interval to eliminate the magnetization history. The longitudinal magnetization then recovers for T_{sat}. Subsequently a T_2-prep with echo length TE_{prep} is applied to generate the additional T_2 weighting, after which a single shot SSFP image is acquired. b) The mapping sequence acquires the first image with no magnetization preparation (corresponding to $T_{sat} = \infty$ and $TE_{prep} = 0$), followed by 12 images (3 are shown) acquired with different T_{sat} and TE_{prep} values. The major characteristics of the longitudinal magnetization signal curve are depicted under the pulse sequence diagram.

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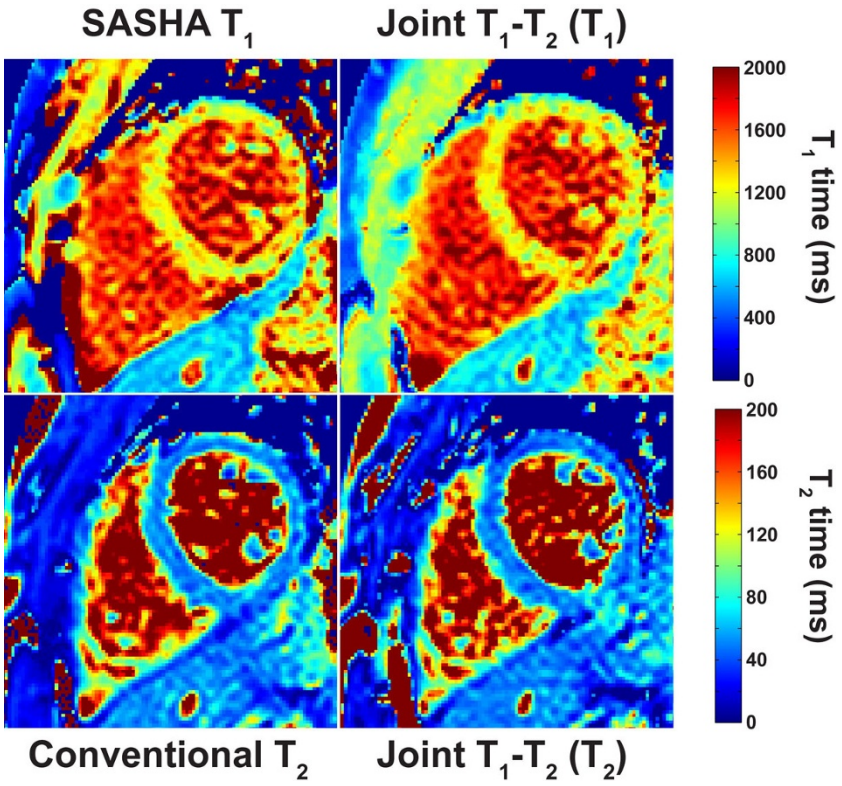

Figure 2 T_1 and T maps from a healthy subject, acquired using the proposed technique, as well as SASHA T_1 mapping, and conventional T_2 mapping using 4 T_2prep echo times. Both the T_1 and T_2 maps generated jointly with the proposed method are similar to the individual maps with similar magnetization preparations. The myocardial T_1 and T_2 values in the septum were 1211 ± 82 ms (SASHA T_1), 1210 ± 92 ms (Joint T_1-T_2), 49.0 ± 5.8 ms (conventional T_2) and 47.3 ± 6.5 ms (Joint T_1-T_2) for each technique. The methods generated with the proposed method were acquired in the same time as each individual map, and are jointly registered by design.

based heart-rate independent sequence that can be acquired in a breath-hold and that allows for simultaneous estimation of quantitative T_1 and T_2 maps.

Methods

The sequence diagram is depicted in Figure 1. At every heartbeat, a saturation pulse is applied to eliminate the magnetization history. The longitudinal magnetization then recovers for T_{sat} based on the T_1 value. Subsequently a T_2-prep pulse [5] with echo length TE_{prep} is applied to generate the additional T_2 weighting, after which a single shot SSFP image is acquired. The process is repeated for 13 heartbeats with various (T_{sat}^k, TE_{prep}^k) corresponding to heartbeat *k*, to sample different T_1-T_2 weighted images. The first heartbeat is acquired with no magnetization preparation.

The T_1 and T_2 maps were estimated jointly by voxel-wise least squares fitting to a 4-parameter signal model, $A\ (1- \exp(-T_{sat}^k/T_1))\ \exp(-TE_{prep}^k/T_2) + B$. Phantom imaging of 14 vials with different T_1/T_2 values were performed and compared to inversion-recovery and CPMG spin-echo references, respectively. Breath-held in-vivo imaging was performed on 5 healthy adult subjects, and the maps were compared to SASHA T_1 maps [6] and to T_2 maps [7].

Results

Phantom imaging resulted in T_1 and T_2 values not significantly different than the references (P = 0.481 and 0.479 respectively). Example in-vivo T_1 and T_2 maps are depicted in Figure 2, comparing various techniques. The T_1 and T_2 values were in good agreement (1211 ± 82 ms vs. 1210 ± 92 ms for T_1; 49.0 ± 5.8 ms and 47.3 ± 6.5 ms for T_2).

Conclusions

The proposed sequence allows for the simultaneous estimation of accurate and jointly registered quantitative T_1 and T_2 maps with similar accuracy and precision to saturation-based T_1 mapping and to T_2 mapping of same duration.

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