

3D-QALAS: Full 3D myocardial T1 and T2 quantification in a single breath-hold

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Target audience

MR-physicists, cardiovascular researchers and cardiologists will benefit from the information given in this abstract.

Purpose

Objective measurement of physical parameters is important in diagnosis and monitoring of cardiac diseases. A number of magnetic resonance methods are currently available for detection of myocardial T1 and T2 relaxation times. Generally, however, these methods acquire a single slice in a breath-hold and hence many breath-holds are required to cover a volume. The purpose of this work was to develop a single breath-hold 3D T1 and T2 quantification method that covers the myocardial volume.

Methods

The sequence is a segmented, cardiac-triggered 3D spoiled gradient echo acquisition named 3D-QALAS (3D-Quantification using an interleaved Look-Locker Acquisition Sequence with T2-preparation). It consists of 5 consecutive acquisitions where the first is preceded by a T2-preparation pulse and the second by an inversion pulse, see Fig. 1. The acquisition time is restricted to 230 ms during end-diastole. This scheme is repeated three times (a total of 15 cardiac cycles) for 13 slices with 2x2x6 mm resolution.

Validation was performed using a Philips Ingenia 3T system on phantoms with various T1 and T2 relaxation times and on healthy volunteers using comparison with inversion recovery and multi-echo acquisitions. The effect of different heart rates and pulse flip angles on 3D-QALAS was investigated. Cardiac arrhythmia was simulated both as random variations around a mean heart rate and as an occasional irregular RR-interval. Post-processing was implemented into an adapted version of SyMRI 7.0 (SyntheticMR).

Results

A good correlation between 3D-QALAS and the reference methods was observed with $R^2 = 0.999$ for T1- inversion recovery and $R^2 = 0.960$ for T2-multi-echo. No significant dependence was observed under various heart-rates 40-80 bpm, flip angle 4-8 degrees, random heart-rates up to 15% around the mean and up to three irregular RR-intervals during acquisition. Preliminary in-vivo results on a healthy volunteer are shown in Fig. 2.

Discussion and conclusions

The proposed acquisition method enables 3D myocardial T1 and T2 relaxation measurements within one breath-hold, which may facilitate practical application of quantitative MRI on a broader spectrum of cardiovascular diseases. Further developments are aimed at increasing the resolution using more advanced k-space trajectories or profile sharing. In-vivo validation, including the MOLLI technique for T1 relaxation time measurements is on-going.

Fig. 1. Schematic overview of the proposed acquisition kernel. Five cardiac-triggered acquisitions (Acq1- Acq5) are performed during end-diastole. Prior to the first acquisition a T₂-sensitizing phase decreases the M_z magnetization proportional to the T₂ relaxation. Prior to the second acquisition a T₁-sensitizing phase is applied to decrease the M_z magnetization. No sensitizing phases are applied before the other acquisitions. The typical M_z magnetization evolution is displayed as the dotted line.

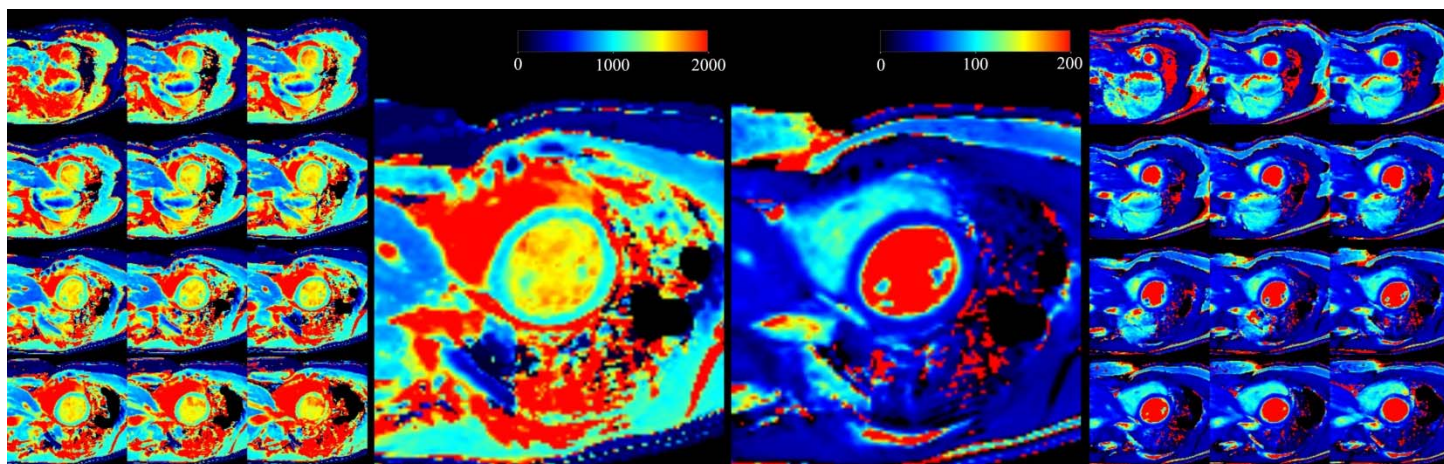
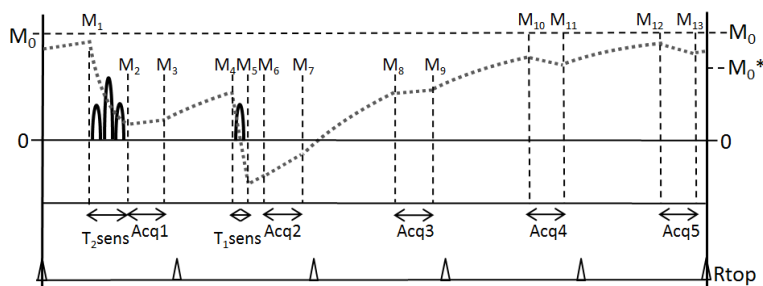


Fig. 2. Example of myocardial T1 relaxation maps (left) and T2 relaxation time maps (right) of a healthy volunteer, acquired by the proposed method in one breath-hold of 15 heart beats.