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In vivo validation of a theory-based single-point T_1 mapping pulse sequence for quantitative first-pass cardiac perfusion MRI

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Introduction

In quantitative analysis of first-pass contrast-enhanced cardiac perfusion MRI, the signal-time curves must be converted to contrast agent (gadolinium-DTPA) concentration-time curves. A theory-based single-point T_1 measurement method has been proposed and validated in phantoms at 1.5 T [1,2] and 3 T (unpublished).

Purpose

To validate *in vivo* the accuracy of the proposed single-point T_1 mapping pulse sequence against a reference pulse sequence.

Methods

Two healthy volunteers were imaged in a short-axis plane of the heart on a 3 T whole-body MR scanner (Tim-Trio, Siemens) at 9 time points: pre-contrast, 5, 10, 15, and 20 min post first injection (0.1 mmol/kg, Magnevist) of Gd-DTPA, and 5, 10, 15, and 20 min post second injection of Gd-DTPA. A saturation-recovery TurboFLASH sequence was implemented with the following parameters: FOV = 320 mm × 262 mm, slice thickness = 8 mm, matrix = 144 × 94, TE/TR = 1.24 ms/2.4 ms, flip angle = 10°, T-SENSE-factor = 2, centric k-space trajectory, effective saturation pulse [3] with delay time (TD) = 50 ms, and total image acquisition time = 176 ms. The effective longitudinal magnetization in the center of k-space was calculated using the Bloch equation. A proton density-weighted image was acquired in the first heartbeat, without the saturation pulse, in order to normalize the image signal, and obtain a theoretical relationship between the signal and T_1(Fig. 1a). Contours for the myocardium and left ventricular (LV) cavity were drawn manually (Fig 1b).

Reference T_1 measurements were performed with a multi-point saturation recovery TurboFLASH sequence with variable TD and a centric k-space trajectory. A varying trigger delay was introduced to acquire in mid-to-late-diastole, 550 ms after QRS detection. A least square linear regression was used to fit the experimental 6-point-curve (no saturation pulse - TD = 200-300-400-500-550 ms). The single-point and reference T_1 measurement pulse sequences were performed during separate breathholds of 8 s and 6 s respectively. Measured T_1s were converted to

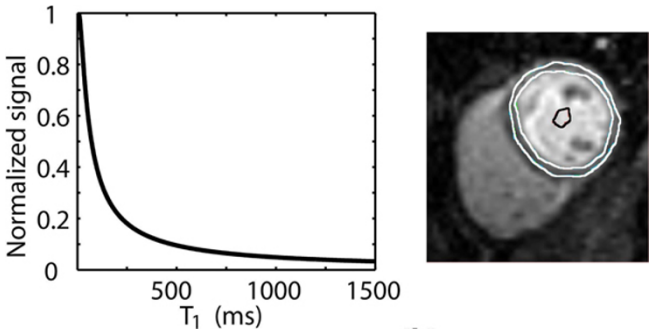

Figure 1
a) Theoretical normalized signal intensity vs T_1 (calculated for the sequence parameters)/b) Representative LV cavity (black) and wall (white) ROIs.

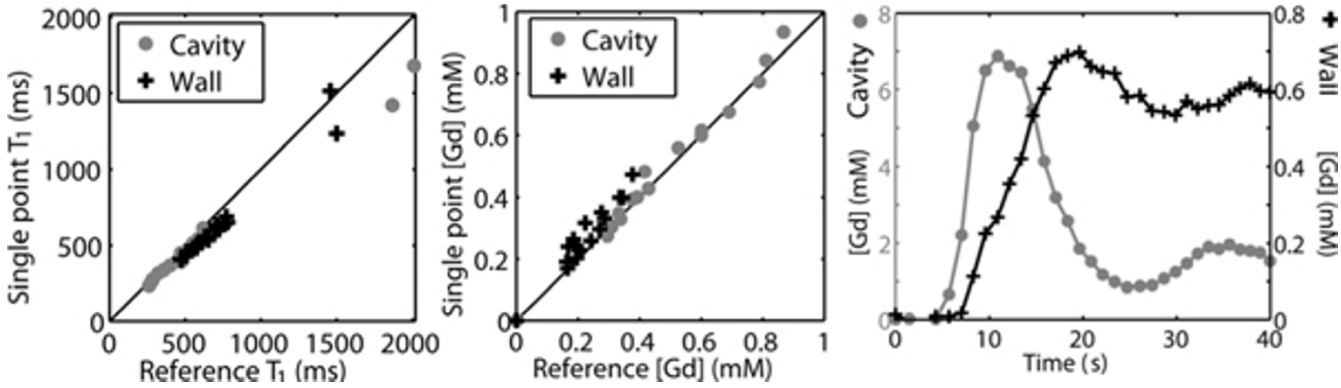

Figure 2
a) Linear correlation bw. single-point and reference T_1. b) Linear correlation bw. single-point and references Gd-DTPA concentrations. c) LV cavity and wall GD-time curve of a cardiac first-pass perfusion, calculated from the single-point T1 method.

Gd-concentrations ([Gd]) assuming fast water exchange condition [4] and T_1 relaxivity of 3.8 L/mmol/s [5,6].

Results

Figure 2a/b show respectively the single point T_1/[Gd] plotted against the reference T_1/[Gd] in the LV cavity and the myocardium. A strong linear correlation was found for all curves (Pearson correlation coefficient = 0.98; $p < 0.001$). Representatives LV cavity and wall [Gd]-time curves calculated from data acquired during first passage of Gd-DTPA are shown in (fig. 2c).

Conclusion

The study shows that our theory-based single-point T_1 measurement method and the multi-point T_1 measurement method produce quantitatively equivalent [Gd] values. Future studies include in vivo validation in patients.

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