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Meeting abstract

1096 Simultaneous B0- and B1-map acquisition in a breath-hold for localized shim, frequency and RF power determination

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Introduction

Cardiac MR at 3 T is challenged by the increased inhomogeneity of the static magnetic field B0, especially when using balanced steady-state free precession sequences. One solution is to determine localized second order shim corrections and a localized on-resonance frequency F0 based on an acquired B0-map [1]. Furthermore, both numerical simulations [2] and measurements [3] have shown that also the transmit radiofrequency (RF) field B1 in the heart is more inhomogeneous at 3 T as compared to 1.5 T. Conventional methods to measure B1-maps, such as the dual-TR method [4], are rather lengthy. Recently, the saturated double angle method (SDAM) to acquire a B1-map covering the heart within a single breath-hold was introduced [5]. Applying SDAM, Sung et al reported a flip angle distribution from 34° to 63° across the entire left ventricle (LV) for a nominal flip angle of 60° [6]. This suggests that not only the B1 field over the LV is inhomogeneous by ± 30%, but that the average flip angle (power setting) is about 20% lower than the requested 60°. However, inadequate power settings may lead to signal reduction, changes in contrast, and eventually to biased quantitative measures.

Purpose

To combine the acquisition of the B0- and the B1-map into one single breath-hold for fast determination of localized shim values, F0, and RF power settings.

Methods

The SDAM B1-map acquisition method was adapted to additionally acquire a second image for each slice with a longer echo time to simultaneously generate a B0-map (Figure 1).

As the measured signal in a multi-slice acquisition depends on the excitation profile of the applied pulse shape as well as on the RF excitation angle, the integral of the signal along the excitation profile was simulated based on Bloch-equation simulations of two different pulse shapes (sinc-Gaussian SG100 (tBW = 2.14) and Optex1 (tBW = 9.56)) and for a range of RF excitation angles from 0°–180°. This was used to calculate a correction lookup table to determine the local B1-field.

The proposed method was tested in a phantom, in the head and the heart of a volunteer. For verification purposes a regular B0-map and a dual-TR B1-map were acquired in the phantom and the head scans. The dual-TR B1-map acquisition took 14 minutes and cannot be triggered for a cardiac scan.

The following parameters were used for the phantom and head acquisitions: TR/TE = 14.4/2.3 ms (20.4/4.6 ms) using the SG100 (Optex1) pulse shape, $\alpha = 60°$, 6 slices, 10 mm slice thickness, 10 mm gap, FOV = $(400\ \text{mm})^2$, matrix = 80^2, 9 spiral interleaves, 7.5 ms readout, T_{SR} = 600 ms. For the cardiac acquisition along the short axis orientation, the SG100 pulse shape was applied with a

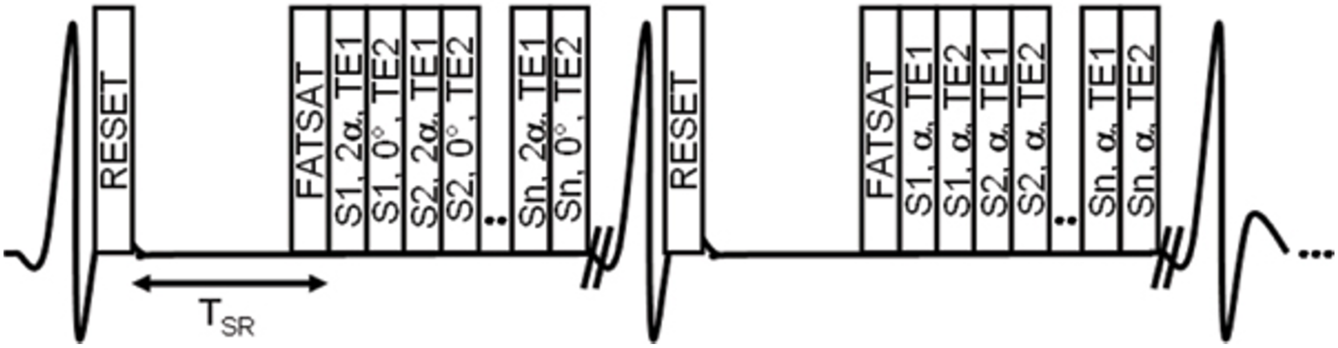

Figure 1

Schematic of the combined B0- and B1-map sequence. The multi-slice acquisition is cardiac triggered, the magnetization is reset with an 8 ms 90° BIR-4 pulse, relaxed during T_{SR}, and acquired with spiral readouts after a frequency selective fat saturation pulse. Each acquisition box in the figure denotes slice (S1-Sn), excitation angle (0°, α, or 2α), and TE (TE1 or TE2). The two shown cardiac cycles will be repeated according to how many spiral interleaves are acquired. This leads to four images per slice with all combinations of flip angles α and 2α, and echo time TE1 and TE2. α-TE1 amd α-TE2 are used to calculate the B1-map [5], whereas α-TE1 and α-TE2 are used to calculate the B0-map [1]. To reduce the deposited RD power, the flip angle of the 2α-TE2 acquisition was set to zero as this image is not used.

reduced slice thickness (5 mm) and acquisition window (3 ms) leading to a breath-hold duration of 18 heart beats.

Results

Profiles of the measured B1-maps of the phantom and the head are shown in Figure 2. Calculated shim terms from the combined acquisition in the phantom and the head corresponded well with terms calculated from the conventional B0-map (mean difference of linear (second order) terms was 0.0015 mT/m (0.0276 mT/m^2).

The simultaneously acquired cardiac B0- and B1-map are shown in Figure 3.

Discussion

The proposed method allows simultaneous acquisition of a B0- and a B1-map in the heart within one breath-hold only, enabling fast localized shim, F0 and RF power setting determination. While optimized RF power settings should improve the imaging performance, actual B1-shimming, using a multi-channel transmit system, will likely be superior. The proposed slice profile correction for the B1-map is necessary, and may explain why others

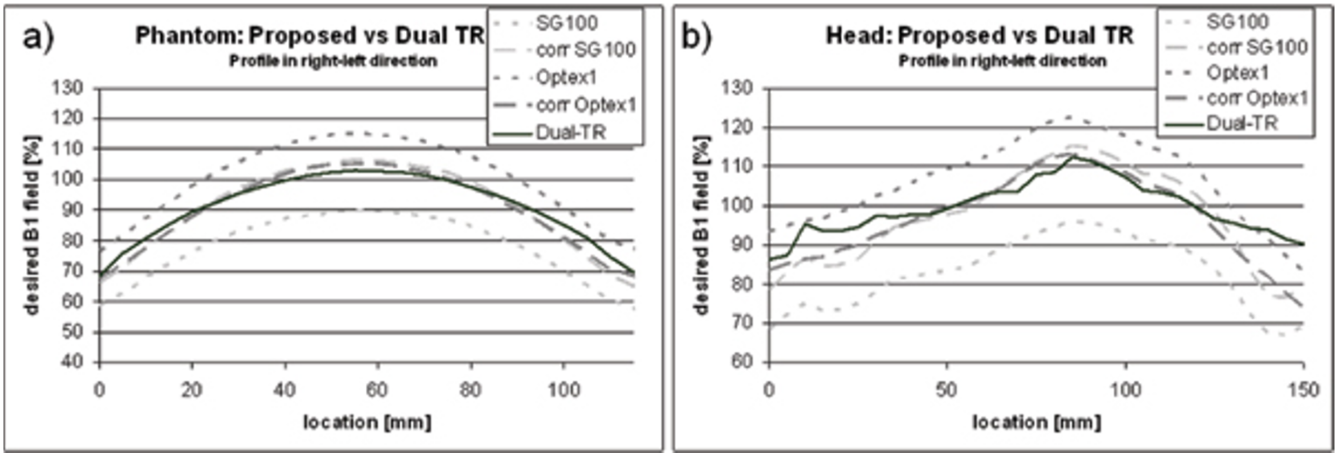

Figure 2

Profile of the B1-map along the right-left direction in a phantom (a) and the head of a volunteer (b) as percentage of the desired B1 field strength. Shown are the results of the proposed method with (dashed) and without (dotted) the excitation profile correction for the SG100 (light gray) and the Optex1 (dark grey) excitation pulse shape, and of the dual-TR method (solid black) as a reference.

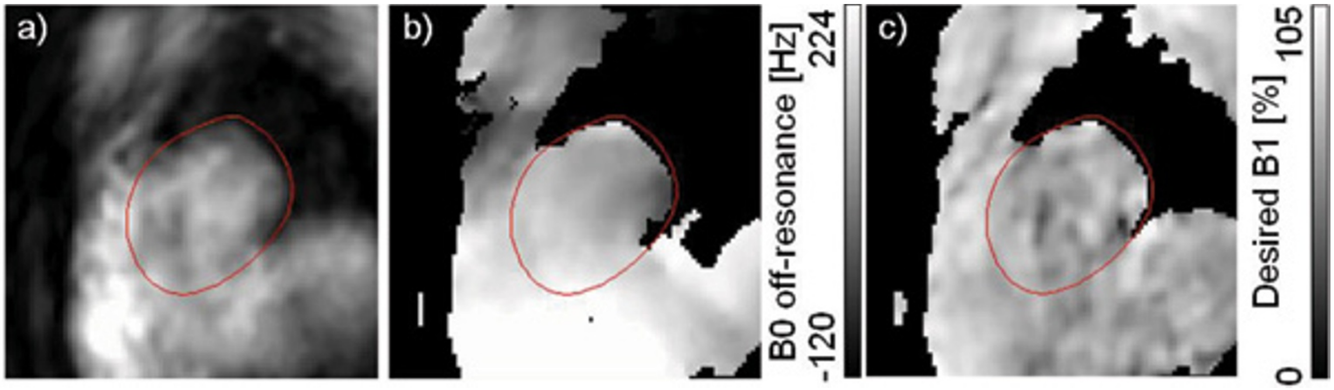

Figure 3
Simultaneously acquired B0-map (b) and B1-map (c) of a mid-short axis slice (slice 4), (a) is showing the magnitude image. Shim, F0 and RF power settings were optimized across the entire heart and applied in a second acquisition: The peak-to-peak off-resonance over the enture heart was improved from 302 Hz to 194 Hz, and the average desired B1 field strength improved from 70% to 107%.

[4,5] reported a much lower average flip angle than the one requested.

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