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WORKSHOP PRESENTATION Open Access

Motion correction for free breathing quantitative myocardial t_2 mapping: impact on reproducibility and spatial variability

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Background

Quantitative myocardial T_2 mapping is a promising technique for *in-vivo* assessment of inflammation and edema [1]. Free breathing T_2 mapping sequences increase the flexibility in the choice of the number of T_2prep echoes times (TE_{T2P}), but should be combined with respiratory motion correction technique [2]. In this study, we sought to evaluate the performance of the Adaptive Registration of varying Contrast-weighted images for improved TIssue Characterization (ARCTIC) algorithm [3] for in-plane motion correction in T_2 mapping data and its impact on in-vivo reproducibility and spatial variability of myocardial T_2 estimates.

Methods

Seven healthy adult subjects (30±17y, 3male) were imaged using a 1.5 T Phillips scanner. T_2 mapping was performed using either 1) a "T_{2P}4TE" sequence (4 T_2prep echo times=[0, 25, 50, ∞]), or 2) a "T_{2P}20TE" sequence (20 T_2prep echo times=[0, 25, 30, 35, ..., 95, 100, ∞, ∞, ∞]) [4]. $TE_{T2P}=\infty$ was simulated by acquiring an image immediately after a saturation pulse [4]. Each subject was imaged using eight T_2 mapping scans in the following order: 1) breath-held T_{2P}4TE (BH), 2) free breathing T_{2P}4TE *without* respiratory navigator (FB), 3) free breathing T_{2P}4TE *with* respiratory navigator (FB+NAV), and 4) free breathing T_{2P}20TE *with* respiratory navigator (5 repetitions). The same 2D short axis slice was acquired with all scans using single-shot ECG-triggered acquisitions with balanced SSFP imaging readout (TR/TE/α=2.7ms/1.35ms/85°, FOV=240×240mm^2, resolution=2.5×2.5×8mm^3, 10 linear ramp-up pulses, SENSE rate=2, 51 phase encoding lines, linear ordering). Accuracy of in-plane motion correction was evaluated in the first three scans by measurements of the DICE similarity coefficients (DSC) (1: ideal registration, 0: none) and the myocardial boundary error (MBE) with and without using ARCTIC. T_2 mapping reproducibility and spatial variability with and without using ARCTIC was evaluated over the entire myocardium using the 5 repetitions of the T_{2P}20TE sequence and 1) a subset of 4 T_2prep echo times=[0ms, 25ms, 50ms, ∞] (referred to as 4TE) and 2) all 20 T_2prep echo times (referred to as 20TE).

Results

ARCTIC increased DSC in BH data (0.90±0.02 vs. 0.87±0.05, p=0.09), FB data (0.91±0.02 vs. 0.79±0.15, p=0.009), and FB+NAV data (0.90±0.02 vs. 0.86±0.08, p=0.039), and reduced MBE in BH data (0.63±0.09 vs. 0.74±0.12, p=0.049), FB data (0.60±0.12 vs. 1.16±0.71, p=0.007), and FB+NAV data (0.61±0.13 vs. 0.83±0.28, p=0.025). ARCTIC improved the reproducibility (4TE: 5.0±2.3ms vs. 5.9±3.1ms, p=0.011; 20TE: 2.4±1.0ms vs. 4.3±3.9ms, p=0.002) and reduced spatial variability (4TE: 11.1±3.6ms vs. 13.7±4.3ms, p<0.001; 20TE: 7.9±1.8ms vs. 10.6±5.3ms, p=0.001) of in-vivo T_2 mapping.

Conclusions

The ARCTIC technique substantially reduces spatial mis-alignment among T_2-weighted images and improves both the reproducibility and the spatial variability of in-vivo T_2 mapping.

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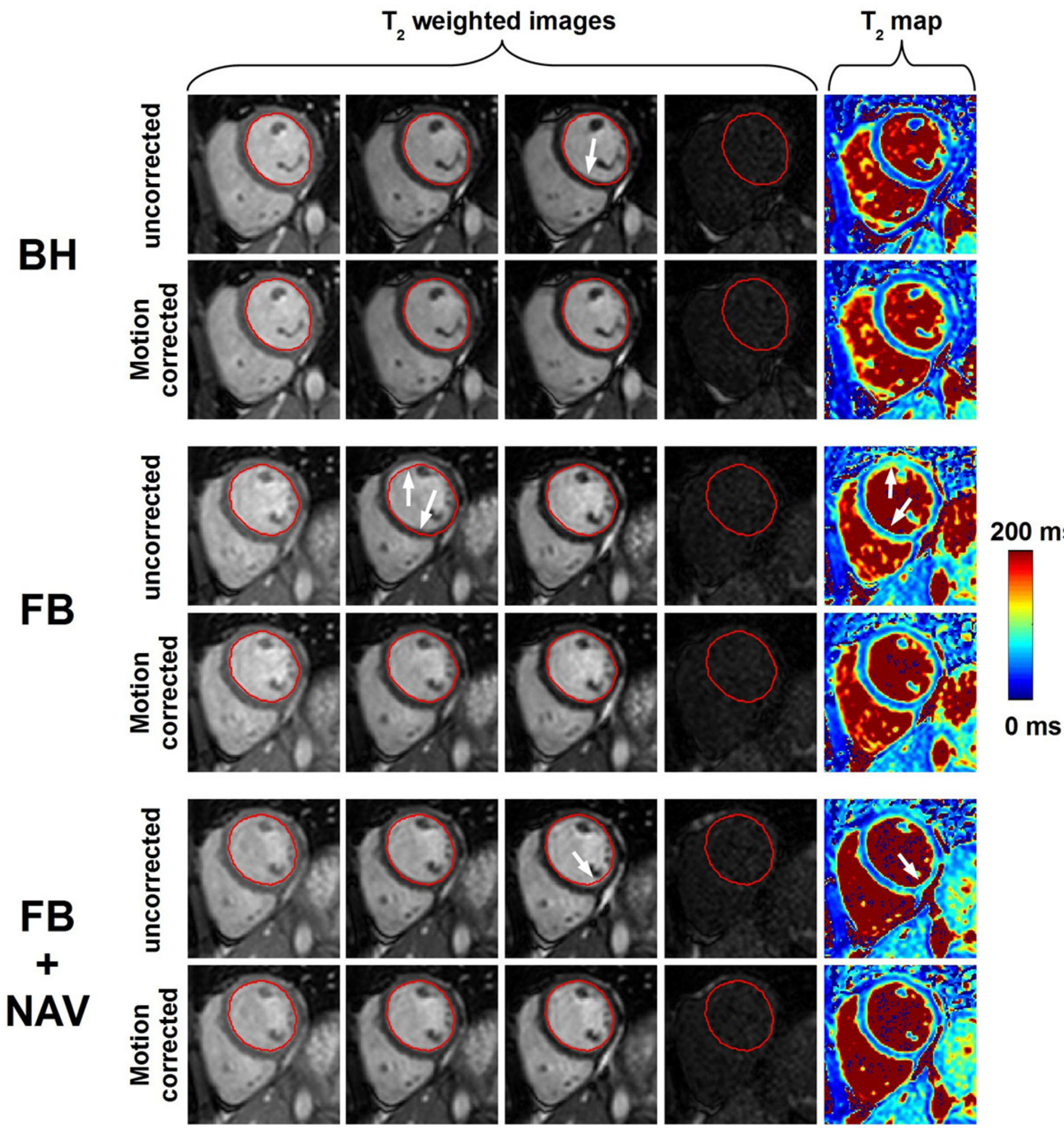

Figure 1 T_2 scans from one subject acquired using the T_{2P}4TE sequence under breath-hold (BH), free breathing (FB), and free breathing with respiratory navigator gating (FB+NAV). Data are shown without (uncorrected) and with (motion corrected) in-plane motion correction. The endocardial contour of the left ventricular (LV) myocardium, drawn on the reference image (1st image) of each scan, is reported in all subsequent T_2-weighted images to facilitate visual motion assessment. Misalignments observed among uncorrected images (white arrows) were substantially reduced after in-plane motion correction using ARCTIC. Furthermore, artifacts in uncorrected T_2 maps (white arrows) were reduced in motion corrected T_2 maps.

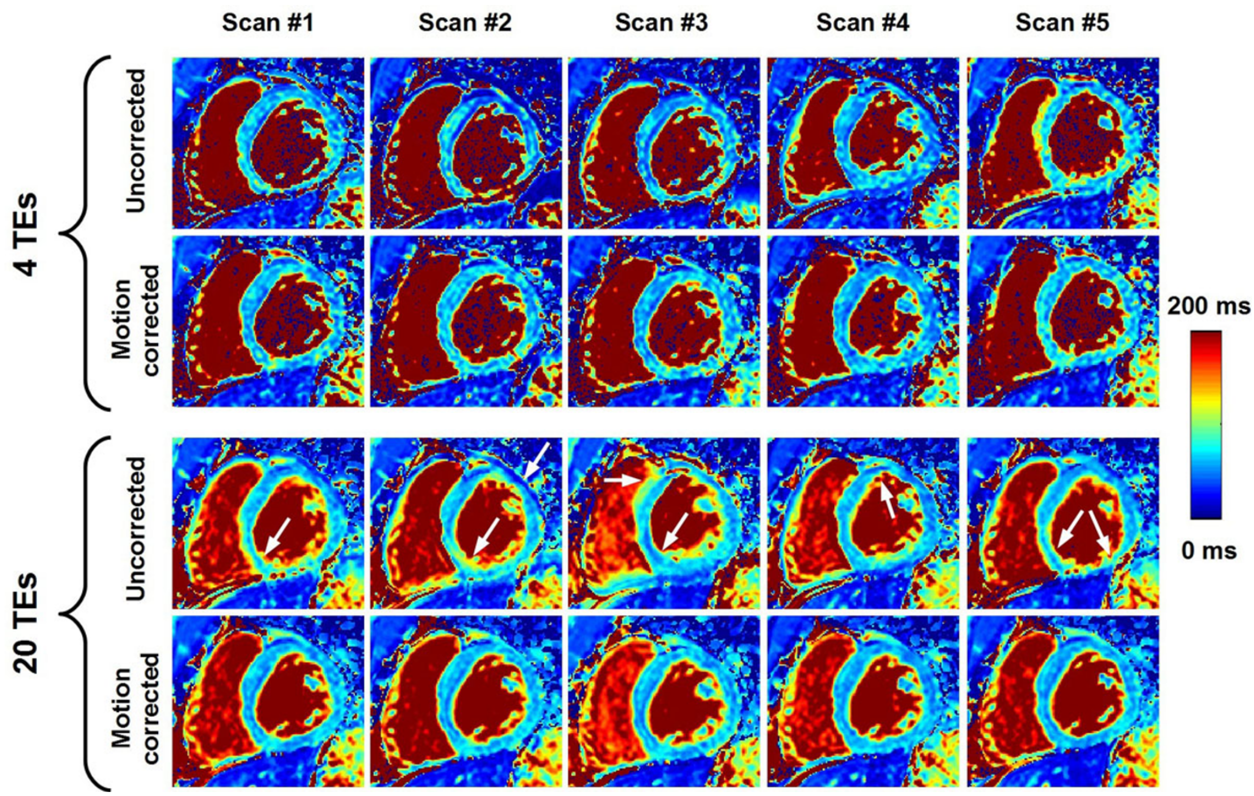

Figure 2 Example of multiple T_2 maps acquired on the same subject using the five repetitions of the T_{2P}20TE sequence acquired under free breathing conditions with respiratory navigator gating. T_2 maps were reconstructed with all T_2prep echo times (20 TEs) or only a subset of the T_2prep echo times (0ms, 25ms, 50ms, ∞) (4 TEs). While the remaining in-plane motion generates artifacts on the directly reconstructed T_2 maps (uncorrected), substantial improvement of T_2 map quality was obtained using in-plane motion correction (motion corrected). As expected, the homogeneity of the T_2 maps greatly improved when using all 20 T_2prep echo times compared to only 4 T_2prep echo times.

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