Clinical T1 mapping in the heart - improved T1 map image quality by automated motion correction for Modified Look-Locker Inversion-recovery (MOLLI)

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Background: T1 mapping is emerging as a tool for quantitative assessment of myocardial disease. Quantitative T1 mapping can be undertaken using a Modified Look-Locker Inversion-recovery (MOLLI) sequence (Messroghli, 2007, JMRI). The MOLLI sequence acquires multiple single-shot steady-state free precession images in the same slice, in late diastole, during different heart beats, and at different inversion times during inversion-recovery, and is a breath-hold protocol. Thus, these images can be combined to generate a T1 map by fitting the T1 for each pixel in the image. However, accurate T1 mapping necessitates that all images are optimally registered, which may be challenging in clinical patients who may have heart rate variability or difficulties holding their breath consistently. Although motion-correction algorithms exist, existing algorithms cannot be readily applied to inversion-recovery image series due to the greatly varying signal intensities in the different images. We developed a novel fully automated motion-correction algorithm for MOLLI images and hypothesized that it would improve the quality of T1 maps in clinical patients.

Methods: Patients (n=178) were randomly selected from a cohort of consecutive patients clinically referred for cardiac MRI and who were imaged at 1.5T (Siemens) using a MOLLI sequence that acquired 8 images in an 11 heartbeat breath-hold. Patients were instructed to hold their breath at end-expiration for the duration of the respective scans. Imaging was undertaken in a long-axis slice and a mid-ventricular short-axis slice at pre-contrast and approximately 15 minutes after a 0.15 mmol/kg intravenous dose of Gd-DTPA. For each pre- and post-contrast image series, a T1 map was generated using the uncorrected MOLLI images, and a separate T1 map was generated using the automated motion-corrected MOLLI images. The uncorrected and the motion-corrected T1 maps were compared with regards to image quality by a physician with 10 years experience in cardiac MRI. The evaluation was focused on the left ventricular myocardium and based on assessment of edge sharpness, distortion of shape and homogeneity of T1 values.

Results: 649 paired T1 map comparisons were assessed. 52% were pre-contrast and 48% were post-contrast. 596/649 cases (91.8%) had no change in T1 map image quality after motion correction. When compared to the uncorrected T1 map, the motion-corrected T1 map had better image quality in 49/649 cases (7.6%) and worse image quality in 4/649 cases (0.6%). Among the cases improved by motion-correction, 19/49 (39%) were post-contrast. Among the four cases which were worsened by motion-correction, three were post-contrast.

Conclusions: Automated motion correction in MOLLI imaging improves the T1 map image quality of both pre-contrast and post-contrast T1 maps of the heart in clinical patients.

Discussion: The observation that 7.6% of the T1 maps had better image quality may be modulated by the duration of the breath hold in our protocol. We acquired our images during 11 heart beats compared to standard 17 heart beats in order to reduce motion artifacts. It remains to be determined if motion correction methods might allow acquisition of additional inversion times or even non-breath hold acquisition.

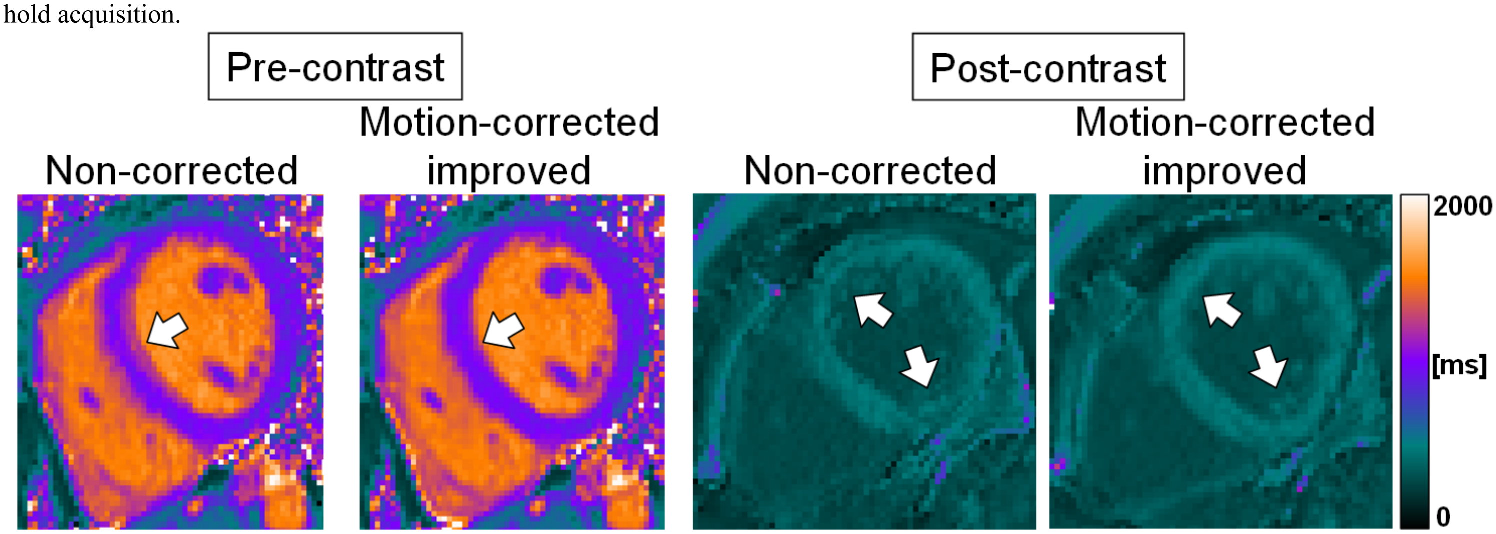

Figure: Uncorrected and motion-corrected T1 maps in two different patients with improved image quality by motion-correction in a pre-contrast T1 map (left) and a post-contrast T1 map (right). The same color scale is used for both image sets.