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Title: Automatic Motion Correction of Free-Breathing Delayed Enhancement using Non-rigid Registration

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Introduction:

Single-shot imaging with inversion recovery true-FISP readout may be conducted during free-breathing (1-2). This provides an alternative to segmented, breath-held turbo-FLASH for cases where patients cannot tolerate breath-holding and is also an attractive protocol for reducing scan time. Single-shot true-FISP inversion recovery has been validated against conventional inversion recovery segmented turbo-FLASH for assessment of myocardial infarction (MI).

Respiratory motion corrected averaging of multiple images acquired while free-breathing may be used to substantially improve the image SNR. Fully automatic, non-rigid registration was compared with previously validated rigid body registration that required user interaction (2). The proposed technique provides improved performance across the full field-of-view as compared to the rigid body method.

Purpose:

To develop and test an automatic free-breathing, delayed enhancement imaging method with improved image signal-to-noise ratio.

Methods:

Free-breathing infarct images were acquired for multiple repetitions of a single-shot IR trueFISP sequence and averaged to enhance SNR following respiratory motion correction based on non-rigid body image registration. The performance between rigid (3) and non-rigid (4) methods was compared using the measured variance of edge positions in intensity profiles through the MI enhanced region and through the RV wall.

The imaging sequence (2) was ECG triggered, with 2 R-R intervals between inversions. Typical parameters were: bandwidth=977 Hz/pixel, TE/TR=1.2/2.7 ms, flip angle=50°, image matrix=256x128. Parallel imaging (rate=2) was used to obtain the full resolution with 64 phase encodes acquired in a single heartbeat. A phase-sensitive reconstruction (PSIR) method was used. Images were acquired on a Siemens Sonata 1.5T scanner.

Results:

Short-axis images (Fig 1) of the heart for a patient with anteroseptal MI were compared with and without motion corrected averaging. The non-rigid registration compensated the motion over the full field of view resulting in a sharper definition of the right ventricular wall and the MI compared with non-registered or rigid body registered images. Signal intensity profiles (Fig 2) through each image in the free-breathing dataset allow assessment of the adequacy of registration for different parts of the heart. The left ventricle and myocardial infarction area are correctly aligned when either registration method is used, however, alignment is better through the full heart area using non-rigid registration, and a great improvement is achieved in the right ventricular area.

Measured variation of edge positions (N=6 patients) in intensity profiles showed significant improvement ($P< 0.005$) at the RV edge where the standard deviation was 2.06+/-0.56 mm (mean+/-SD) for rigid body and 0.59+/-0.22 mm for non-rigid registration. Improvement in MI region was observed in 2 cases (Fig 2c) but was not statistically significant; measured variation of MI was 1.16+/-0.71 mm for rigid body and 1.08+/-0.76 mm for non-rigid registration.

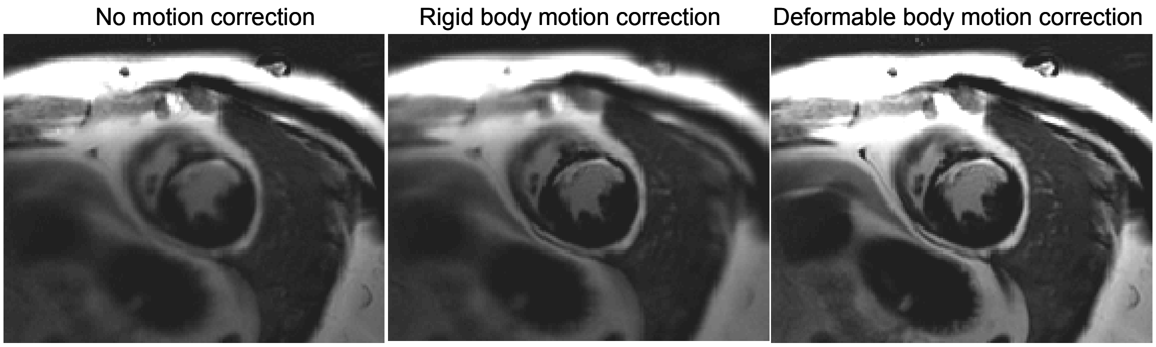

Figure 1. Average of 30 images acquired during free breathing. Rigid body motion correction uses a user defined bounding region around the LV to optimize image registration. Non-rigid body motion correction is automatically performed over the full FOV without any user defined input.

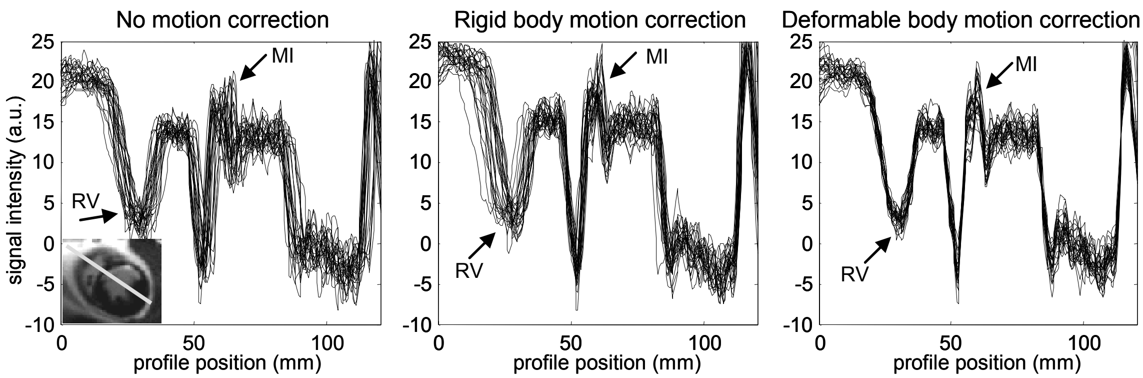

Figure 2. Signal intensity profiles through the heart along line shown in inset image. Profiles for 30 images acquired during free-breathing are shown overlayed. The intensity profiles are well aligned across the full heart using non-rigid motion correction but have significant motion in RV using rigid body correction.

Conclusions:

The proposed approach achieved delayed enhancement images with high resolution and SNR without requiring a breath-hold. Motion correction of free-breathing delayed enhancement imaging using non-rigid image registration was implemented in a fully automatic fashion and performed uniformly well across the full FOV.

References:

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