Prospective projection-based respiratory whole-heart coronary MRI with patient-specific tracking factor

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Introduction: Respiratory motion compensation in coronary artery MRI is challenging. Commonly, a pencil-beam navigator positioned on the right hemidiaphragm is used with a fixed slice tracking factor of 0.6 [1]. However, this scale factor varies among different patients [2, 3]. Respiratory self-gated navigator techniques have been introduced to directly measure the respiratory induced motion of heart [4]. The estimated motion is then utilized to *retrospectively* eliminate the motion artifacts [5-7]. In this study, we have investigated a *prospective* projection-based respiratory self-gating navigator with the patient specific scale factor determined during a training phase and utilized in the subsequent image acquisition.

Methods: Fig. 1 shows the schematic of the proposed technique. Two projection-based navigators are used to track the positions of diaphragm edge (Proj.A) and center of heart (Proj.B), and to compute the slice tracking factor which is subsequently used in the imaging. The Fourier transform of the measured navigator signal provides a projection profile of the navigator volume along the superior-inferior (SI) direction. The cross-correlation between the most recently acquired profile and the first projection profile is used to estimate the diaphragm or heart motion. The computed heart displacement can then be employed for prospectively gating and tracking the respiratory induced heart motion. The heart motion acquired in the preparation phase is used to compute a patient-dependent scale factor, as shown in Fig. 1a. Images are then acquired using the projection-based navigator (Proj.A) positioned on the hemidiaphragm with the calculated scale factor, though pencil beam could have been used.

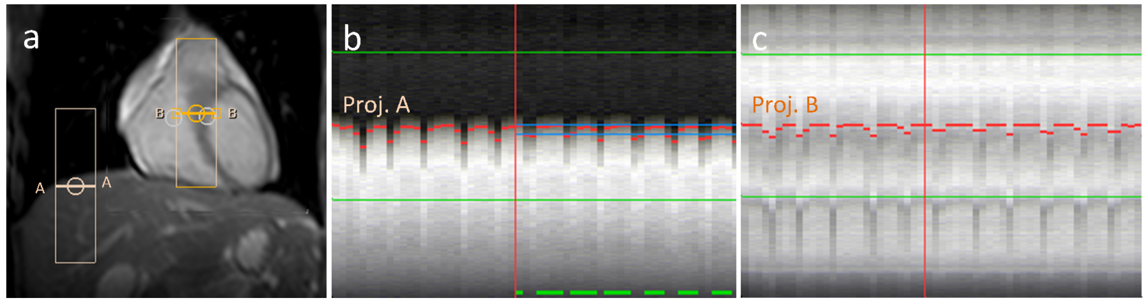

Fig. 1: *Example of projection-based navigators' locations and profiles; a) schematic of projection-based navigators' position; with corresponding profiles in b and c.*

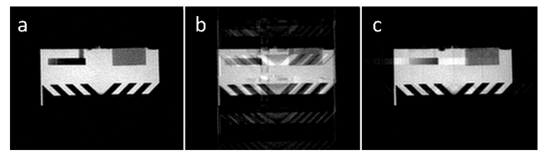

Fig. 2: *Example of prospective tracking of motion using projection-based navigator; motion free (a); motion corrupted (b); and corrected (c) images.*

Phantom Validation: A two dimensional ECG-triggered SSFP (TE/TR/α=1.5/3/90˚, spatial resolution =1×1×10mm^3) sequence was employed for acquiring a multi-shot axial slice of a phantom. In each shot, the phantom was semi-periodically moved along the slice-encoding direction. The projection-based navigator, positioned at the edge of the phantom, was then used to track and correct the phantom's displacements in real-time immediately before imaging. As reference, the same experiment was performed without motion compensation. Whole Heart Coronary MRI: Whole heart coronary MRI was acquired on a 1.5T clinical MR scanner (Philips Healthcare, Best, Netherlands) in four healthy subjects. Images were acquired using the proposed projection-based navigator and compared with the pencil beam navigator. A free-breathing ECG-triggered SSFP sequence (TE/TR/α=2.4/4.8/90˚, spatial resolution = 1.3×1.3×1.5mm^3) was used for imaging [8]. In imaging, only Proj.A was used for gating (8mm gating window) and tracking (with the computed scale factor). Images were scored by two experts (4=excellent, 1=poor) to evaluate motion compensation. SNR and blood-myocardium CNR measurements were also measured.

Results: Fig. 1b and 1.c display the projection-based navigators that follow the lung-liver interface and displacement pattern of heart. Fig. 2 shows that the projection-based navigator can effectively correct the motion along SI direction. Fig. 3 depicts different slices of a whole heart data set reconstructed by the conventional pencil beam (a_c, b_c, c_c) and projection-based (a_p, b_p, c_p) navigators, respectively. The subjective scores were 2.2 vs. 3.1 for pencil beam vs. the proposed projection-based method. There were no statistically significant difference between CNR and SNR.

Discussions and Conclusions: We demonstrated improvement in respiratory motion correction in whole-heart coronary MRI by using two projection-based navigators to accurately calculate the tracking factor for each patient. This can be combined with the pencil beam navigator for improving respiratory compensations or the cases where projection of heart cannot be used for gating such as rapid signal variations caused by infusion of contrast agents.

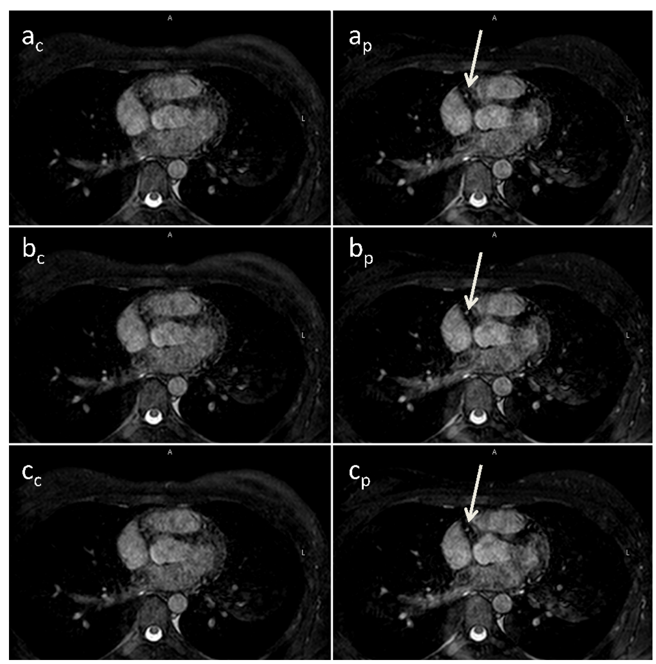

Fig. 3: *Consecutive slices of whole-heart MRI reconstructed by conventional pencil beam (a_c,b_c,c_c), and projection-based (a_p, b_p,c_p) navigators. Arrows indicate RCA better visualized in images reconstructed by projection-based navigator.*

Acknowledgements: The authors wish to acknowledge grant support from NSERC-PDF-357920-08, NIH R01EB008743-01A2, AHA SDG-0730339N, and Catalyst (Harvard Clinical and Translational Science Center).

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