SELF-GUIDED RETROSPECTIVE MOTION CORRECTION (SEGMO) FOR FREE-BREATHING WHOLE-HEART CORONARY MRA WITH 100% ACQUISITION EFFICIENCY

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Introduction

Free-breathing whole heart coronary MRA is a promising noninvasive method of detecting coronary artery disease [1]. Conventional diaphragm navigator schemes suffer from the need for time-consuming and exquisite setup of the navigator, prolonged imaging time due to low gating efficiency, and inaccuracy in motion detection due to the nonlinear relationship between diaphragm and heart motion. In this work, a respiratory motion correction scheme is proposed with an affine motion model for accurate estimation of respiratory motion, and uses 1D projections of the imaging volume to detect respiratory phase and segment 3D radial data into respiratory bins.

Methods

A dual-echo self-guiding module is added prior to each imaging segment which effectively suppresses static chest wall signal [2]. Respiratory superior – inferior translations are derived from 1D heart profiles using a cross-correlation method, which are subsequently used to segment 3DPR data into respiratory bins similar to the work in [3]. From each bin a low-resolution image is reconstructed. Next, to estimate the motion in the image domain, affine motion registration is performed between each moving bin and an end-expiratory reference bin, followed by motion correction using the estimated affine motion parameters. Finally, all corrected k-space data is combined to give a high-resolution image, free of motion artifacts.

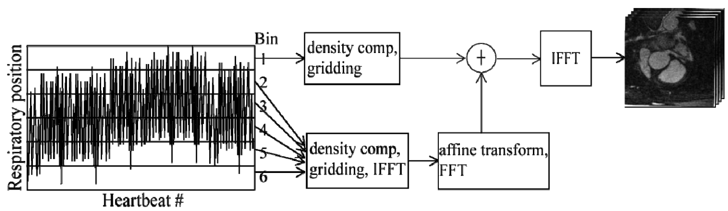

Fig. 1 Workflow of SEGMO

Fig. 2 Reformatted images: without correction (left), with navigator binning (middle), and with SEGMO (right)

Twelve healthy volunteer scans were performed on a clinical 1.5T scanner (MAGNETOM Espree, Siemens AG Healthcare, Erlangen, Germany) with IRB approval and written consent obtained before each scan. MR data was acquired using an ECG-gated, T2-prepared, fat-saturated bSSFP pulse sequence with 3DPR trajectory (TR/TE=3.2ms/1.6ms, FOV=260mm^3, matrix size=256^3, voxel size=1.0mm^3, flip angle=90°, readout bandwidth=781Hz/pixel, total number of views=16000 to 16800,Scan time=7.6±1.5min) Three 3D images were reconstructed from each dataset: one without motion correction (NO), one corrected with navigator binning and motion correction (NAV), and one with the proposed SEGMO method. Diaphragmatic navigators were set up but were only used in the NAV reconstruction (not SEGMO). Off-line reconstruction program is coded in MATLAB (The Mathworks, Natick, MA). Images were reformatted and measured using CoronaViz software (Siemens Corporate Research, Princeton, NJ).

Results

Quantitative comparisons of LAD, LCX and RCA length and sharpness are performed between the three reconstructions. Both SG and NAV perform significantly better ($p<0.05$) than NO, and show no significant difference between each other. Qualitative image scoring yielded similar results.

	LCX				LAD				RCA				Overall image quality score
	Length	Sharpness	Max Diam.	Min Diam.	Length	Sharpness	Max Diam.	Min Diam.	Length	Sharpness	Max Diam.	Min Diam.	
NO, NAV	***0.0008***	***0.0051***	0.3554	0.4145	***0.0006***	***0.0001***	0.7818	0.4781	***0.0063***	***0.0263***	0.7090	0.6178	***0.0000***
NO, SEGMO	***0.0012***	***0.0233***	0.3793	0.9711	***0.0008***	***0.0008***	0.7712	0.8985	***0.0071***	***0.0231***	0.3291	0.9647	***0.0000***
NAV, SEGMO	0.5950	0.1687	0.9136	0.3436	0.7087	0.7997	0.1631	0.3347	0.3144	0.4841	0.4008	0.6504	0.4678

Table 1: Paired t-test results comparing the three reconstructions. Statistically significant results are shown in bold and italic ($p<0.05$).

Discussion and Conclusions

The proposed motion correction method eliminates the need for a diaphragm navigator, reduces imaging preparation time, and is more accurate in respiratory motion detection as the motion information is derived directly from the imaging volume. The inherent 100% gating efficiency ensures not only a shorter but also a more fixed scan time compared to conventional navigator gated schemes. Using an affine model provides realistic motion estimation and thus minimizes residual motion artifacts. The current reconstruction takes about two hours. However, parallel computing and code optimization will greatly accelerate the reconstruction and hence will make the method feasible for clinical practice.

References

[1] Weber OM et al, Magn Reson Med 2003;50:1223– 8. [2] Lai P et al, J Magn Reson Imaging 2008;28:612– 620. [3] Bhat H et al, Magn Reson Med 2011;65:1269–1277.