

Initial results with free-breathing self-navigated, post-contrast, 3D isotropic high-spatial-resolution MRI of the heart

Piccini D^{1,2}, Schwitter J³, Littmann A⁴, Zenge M⁴, Krueger G^{1,2}, Stuber M^{2,3}

¹ Siemens Schweiz AG, Healthcare Sector, Lausanne, Switzerland, ²Center for Biomedical Imaging (CIBM), Lausanne, Switzerland, ³University Hospital of Lausanne (CHUV), Lausanne, Switzerland, ⁴MR Application & Workflow Development, Siemens AG, Healthcare Sector, Erlangen, Germany

Introduction: Free-breathing whole-heart MR imaging with high isotropic spatial resolution may be a valuable tool to assess information on both myocardium and coronary anatomy in one single scan. However, current navigator-gated techniques [1] require extensive acquisition planning and suffer from limited scan efficiency, thus resulting in prolonged examination times. Conversely, self-navigation [2,3] allows for respiratory motion correction without navigators, while motion estimation is directly extracted from the image data. Not only does this technique require minimal planning, but also achieves 100% scan efficiency, such that the only physiological determinant of the duration of the scan is the heart rate of the examined subject. Self-navigated protocols can therefore be easily integrated into a complete clinical cardiac MR routine exam with minimum impact on the total examination time. Since the performance of self-navigation hinges on myocardium-blood contrast, and provided that there is often a time gap between perfusion imaging and late gadolinium enhancement (LGE) imaging in clinical protocols, high-resolution 3D whole-heart inversion-recovery imaging may be integrated to simultaneously obtain information about coronary anatomy and delayed hyperenhancement [4]. In this preliminary work, a self-navigated inversion-recovery 3D whole-heart radial imaging technique was integrated into a clinical routine protocol and preliminary results are reported.

Methods: Examinations were performed in 5 patients on a 1.5T clinical MRI scanner (MAGNETOM Aera, Siemens AG, Healthcare Sector, Erlangen, Germany). A total of 30 elements of the anterior and posterior phased-array coils were activated for signal reception. Data acquisition was performed with a 3D radial trajectory implementing the spiral phyllotaxis pattern, adapted to self-navigation [3]. All measurements were segmented and ECG-triggered. A non-selective inversion-recovery pulse (inversion time between 180 and 250 ms) was added before each segment to the fat-saturated bSSFP imaging sequence. The 3D self-navigated acquisition started roughly 5 minutes after injection and imaging was performed with the following parameters: TR/TE 3.1/1.56 ms, FOV (220mm)³, matrix 192³, acquired voxel size (1.15mm)³, flip angle 70°, and receiver bandwidth 898 Hz/Px. A total of 11,687 radial readouts were acquired in 377 heartbeats, resulting in an overall sampling ratio of 20%, with respect to the Nyquist limit. The effectiveness of the self-navigation module was assessed during acquisition, using the inline display, as described in [3] and total acquisition time was recorded. A qualitative assessment of SNR and CNR was performed for all datasets. The 3D datasets were compared to the standard 2D LGE for scar tissue detection in the myocardium. Furthermore, reformat of the right coronary artery (RCA) was performed using CoronaViz (Work in Progress software, SCR, Princeton, NJ, USA).

Results: In all acquisitions, a bright structure representing the blood pool could be segmented by the self-navigation algorithm. The scan time for the self-navigated sequence was always less than 8 min and could always fit into the expected waiting time before 2D LGE. Blurring artifacts were observed in all final datasets, which demonstrated lower SNR and CNR than expected. However, a clear assessment of the general cardiac anatomy was possible in all cases and the 3D self-navigated datasets showed good agreement with the standard 2D LGE (Fig.1). In three cases it was possible to segment the proximal section of the RCA (Fig.2). Unsuppressed fat signal is visible around the coronaries.

Discussion: 3D whole-heart datasets could be obtained in all cases with the proposed self-navigated sequence after contrast injection. Analysis of these datasets led to several suggested improvements. Phantom experiments will support the design of a more effective fat saturation strategy for the specific application. Moreover, the wash-in / wash-out effect of the contrast agent during prolonged data acquisition and its consequences on the self-navigation as well as on the general image quality needs to be systematically investigated. Imaging after a longer waiting time post injection may be useful, but would come at the cost of an increased examination time. However, this has to be considered under the aspect that 2D LGE imaging may entirely be replaced by the self-navigation method in the future. **In conclusion**, this first experience with post-contrast self-navigated 3D whole-heart inversion-recovery imaging showed that the proposed technique potentially makes it possible to assess both the myocardial scar tissue in 3D as well as the anatomy of the coronaries in one single acquisition with high isotropic resolution at no extra cost in scanning time.

References: [1] Nguyen TD, et al, MRI 2009;27:807–814 ; [2] Stehning C, et al, MRM 2005, 54:476-480 ; [3].Piccini D, et al, MRM 2012, in press; [4] Peters et al, Radiology 2007, 243:690-695

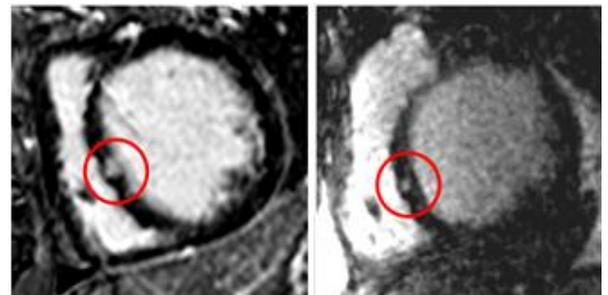


Figure 1. Comparison between 2D LGE (left) and 3D self-navigated isotropic acquisition (right). The same small scar could be detected.

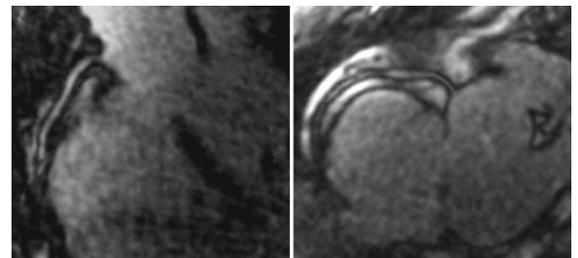


Figure 2. Examples of reformats of the RCA

1. My preferred presentation type is:

Oral

2. Keywords:

Self-navigation, 3D whole-heart coronary imaging, late gadolinium enhancement

3. I am eligible for the Potchen Award

YES