WHOLE-HEART CORONARY MRA USING 2D SELF-NAVIGATION

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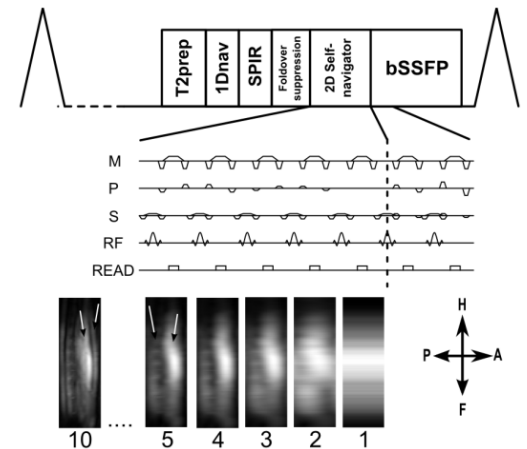
Introduction: Several self-navigation techniques have been proposed to improve respiratory motion compensation in CMRA [1-3]. Compared to diaphragmatic navigators self-navigating methods do not require the use of a heart-diaphragm motion model as they allow direct measurement of cardiac motion. Motion estimation is, however, often impeded by static structures within the excited volume. In this work we implemented a 2D self-navigation method by using the dummy profiles of a whole-heart balanced Steady-State Free Precession (bSSFP) sequence, which are primarily used to catalyze the magnetization towards the steady-state. To create 2D self-navigation images (2DSN), we added phase encoding (PE) gradients during the dummy profiles. With this approach we calculated foot-head (FH) and anterior-posterior (AP) motion and performed retrospective translational motion correction.

Material and Methods: The proposed sequence is shown in Figure 1 with the 2DSN image resolution in PE direction being a function of the number of dummy profiles. The 3D image volume was oriented in the sagittal plane with PE in anterior-posterior direction and read-out in foot-head direction. Half Fourier acquisition, with a factor of 0.6, was performed in PE direction to increase the 2DSN resolution. No PE was performed in slice selection direction and thus 2DSN images are projections of the field-of-view (FOV) in this direction. The bSSFP imaging parameters for the volunteer experiments included FOV = 200×200×100 mm, resolution = 1×1×1 mm, TE/TR=5.0/2.5 ms and FA=70°. Ten dummy profiles were acquired in each shot to create a 2DSN image with a resolution of 1×12×100mm. A 1D pencil beam navigator (1Dnav) was placed on the diaphragm and used for respiratory gating (10mm). A template matching algorithm was used to extract FH and AP motion from the 2DSN images offline (Figure 2b). For the proposed 2DSN method correction was performed in FH and AP direction. This was compared to conventional 1D self-navigation (1DSN) methods with FH correction by only considering the ky_0-profile, shown in Figure 2a. FH correction was also performed with the 1Dnav using a tracking factor of 0.6. Four healthy subjects were scanned on a Philips 1.5T Achieva scanner (Philips Healthcare, Best, NL).

Figure 1. CMRA sequence using dummy profiles to create 2D self-navigator. Increasing numbers of dummy profiles improve spatial resolution of the navigator and separation of moving from static structures (arrows). The 2DSN images shown are reconstructed with the same recon matrix size.
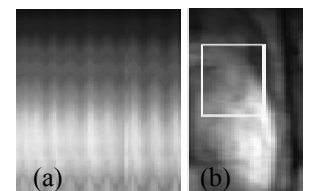
Results: Reformatted CMRA images of two subjects with motion corrected with the 1Dnav (a, d), 1DSN (b, e) and 2DSN (c, f) are shown in Figure 3. Self-navigated motion correction performed better compared to the 1Dnav, particularly for the distal segments of the coronaries. Additional improvements were observed with the 2DSN in example 2 for the distal RCA segment and proximal left coronary artery branch (Figure 3 f).

Discussion and Conclusion: The initial results with the proposed 2D self-navigation method are very promising as it provides a model-free motion correction method, which comes at no "expense" as the navigator is extracted from the dummy profiles used for magnetization preparation. Compared to other self-gating methods the main advantage of the proposed approach is the improved spatial separation of moving (heart) and static (chest wall) structures. Future work will explore the use of motion correction with more degrees of freedom, e.g. affine, which is possible as the self-navigating method spatially encodes in 2D.
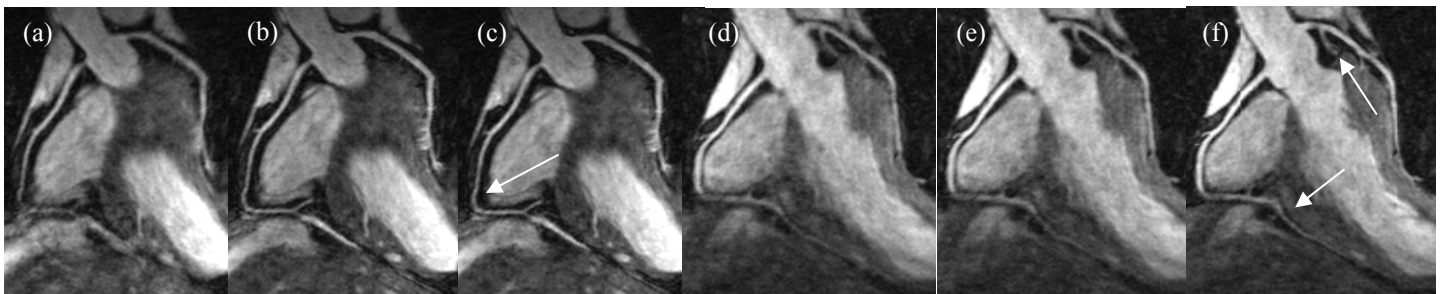

Figure 2. Time-series of 1D self-navigation images using the ky_0-profile (a). 2D self-navigation image using all phase encoding data (b). White box shows the template used for image registration.

References: [1] TD Nguyen et al MRM 2003 50:2 235-241 [2] C Stehning et al MRM 2005 54:2 476-480 [3] P Lai et al MRM 2009 62:3 731-738

Figure 3. CMRA images of 2 subjects (a-c & d-f) using different navigators during reconstruction; 1Dnav with tracking factor of 0.6 (a, d), 1DSN (b, e), and 2DSN (c, f).