Whole-heart coronary MRA using a 32 channel coil array in combination with 2D-SENSE

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Introduction

Recently, a “whole-heart” imaging protocol for coronary MRA, which covers the entire heart with a large non-angulated 3D measurement volume, has been proposed [1]. In this protocol, scan time is reduced using sensitivity encoding (SENSE) [2] along one phase-encoding direction. The objective of the present work was to investigate “whole-heart” coronary imaging using 2D-SENSE [3] and a 32 channel coil array [4]. Local noise amplification in the volume of interest was assessed by means of the g-factor metric for different reduction factors. Exemplary in-vivo data of the coronary arteries measured in a healthy volunteer are demonstrated.

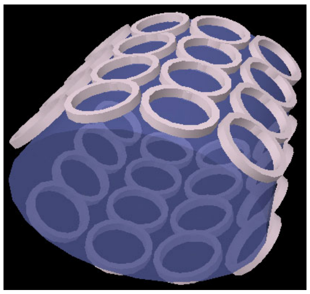

Figure 1: Cardiac coil array with 32 independent channels consisting of an anterior and a posterior array.

Methods

In parallel imaging, the signal-to-noise ratio (SNR) depends on a spatially varying function g(r) (g-factor), given by: $SNR(r)^{SENSE} = SNR^{full} / (g(r) * R^{1/2})$ with r denoting a positional vector, R: reduction factor, SNR^{full} =SNR without SENSE) [3]. Therefore, in an optimized coil setup, the g-factor on the heart should be as small as possible.

For g-factor calculation a coil array with 32 independent circular elements was used, arranged in a symmetric way with 16 elements each in the front and in the back of the object (Figure 1). A low resolution SENSE reference scan was acquired with following parameters: FOV=370x370mm^2, 20 slices, voxel-size: 7.7x7.7x8mm^3, TR=8ms; TE=1.6ms; flip angle=5°.. Afterwards a region of interest (ROI), including the heart, was manually selected and the average g-factor inside the ROI was calculated for different acceleration factors. The reduction directions were chosen as anterior-posterior (AP) and right-left (RL) and the reduction factors along these two directions were set to identical values. Accordingly, reduction factors were $R_{AP} = R_{RL} = \sqrt{R_{tot}}$, (R_* denotes the reduction factor along one phase encoding direction, R_{tot} is the total reduction factor).

For coronary imaging a steady-state-free-precession sequence (TR=5.6ms, TE=2.6ms, flip angle=140°, 16 RF excitations/cardiac cycle) with real-time respiratory motion correction was used. A 3D volume with 120 coronal slices (slice thickness=1.5mm, reconstructed to 0.75mm, FOV=240x240mm^2, resolution=1x1mm^2) was acquired. All measurements were performed on a 1.5T Philips Intera system (Philips Medical Systems, Best, The Netherlands).

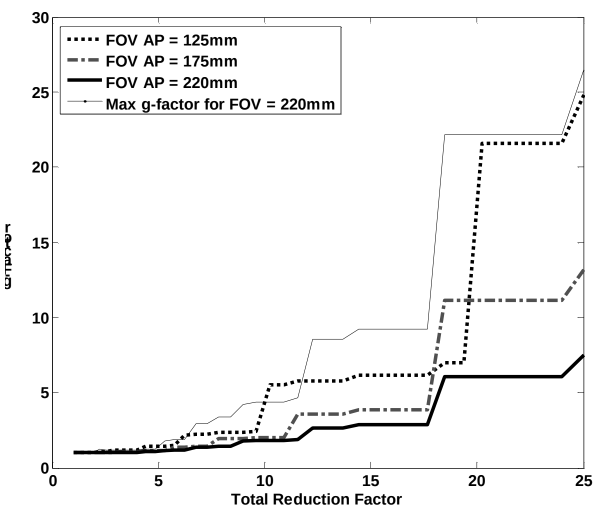

Figure 2: Mean g-factor on the heart as a function of the total reduction factor, plotted for three different FOV’s in AP direction. Also shown are the peak g-values on the Heart for a FOV of 220mm.

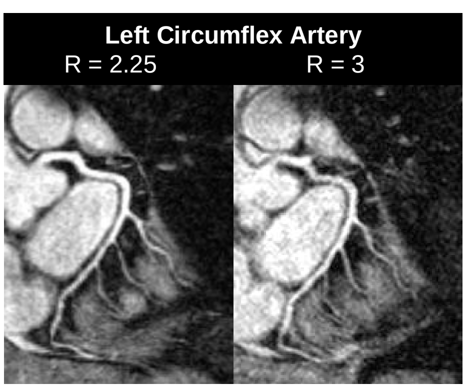

Figure 4: Two in-vivo angiograms of the LCX. Excellent image quality is obtained at 2.25- and 3-fold acceleration using 2D-SENSE.

Results

The g-factor dependency on reduction factor and field of view (FOV) in AP direction is illustrated in Figure 2. The g-factor increases considerably beyond a reduction factor of 7 for a field-of-view of 175mm in AP direction. There is a strong dependency of the g factor on the FOV in AP direction, especially for higher reduction factors. Exemplary g factor maps for different acceleration factors together with the anatomy image are shown in Figure 3. A high spatial dependency of the g-factor especially at high reduction factors is observed. For simplicity of display, g-factors greater than 5 were clipped. In-vivo data are presented in Figure 4 showing reformatted views of the left circumflex (LCX) acquired with total reduction factors of 2.25 and 3, respectively.

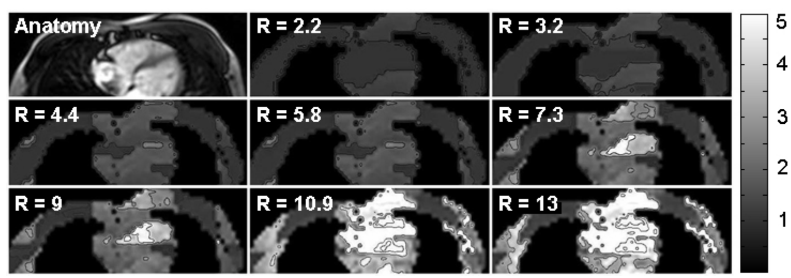

Figure 3: The g-maps at eight different reduction factors for a FOV of 125mm in AP direction. The anatomic image is given as reference.

Discussion

Simulations of g-factor maps based on measured coil sensitivity data from a 32 channel cardiac coil array revealed acceptable g-values on the heart up to a total reduction factor of 7 for 2D-SENSE This suggests that “whole-heart” coronary imaging using 2D-SENSE may be possible up to a factor of 5-7 in future settings depending on SNR considerations. In this study, in-vivo feasibility of “whole-heart” coronary imaging at reduction factors of 2.25 and 3 could be tested only. Excellent image quality was obtained for deep regions as for instance along the path of the LCX. It remains a subject of future work to explore the feasibility of the “hole-heart” protocol at even higher reduction factors.

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References:

[1] Weber O.M. et al., JCMR **5**: 23-24 (2003)
[2] Pruessmann K.P. et al., MRM **42**:952-62 (1999)
[3] Weiger M, et al., MAGMA **14**: 10-19 (2002)
[4] Niendorf T, et al., ISMRM 2004, Abstract NR 703 (2004)