Exploiting the Signal Gain of 3 Tesla to Accelerate Cardiac SSFP Imaging using SENSE

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INTRODUCTION:

Cardiac imaging procedures at 1.5T are increasingly based on balanced steady-state free precession (SSFP) techniques [1]. These sequences offer a high contrast-to-noise ratio (CNR) between myocardial muscle and oxygenated blood at a high signal-to-noise ratio (SNR). Concurrently with the success of SSFP imaging, parallel imaging techniques such as sensitivity encoding (SENSE) [2, 3] have emerged as major tools for speeding up data acquisition. With respect to cardiac examinations, SENSE may be applied to improve temporal/spatial resolution and/or shorten long scan durations. The gain in speed/resolution is traded for a reduced SNR according to [2]:

$$SNR^{SENSE} = \frac{SNR^{full}}{g\sqrt{R}},$$

where R denotes the reduction or acceleration factor and g reflects coil sensitivities, receiver noise correlation and the degree of reduction. The SNR loss with SENSE might be compensated by the inherent gain in SNR at the higher static field strength.

METHODS:

Cardiac SSFP imaging was performed in healthy volunteers on a 3.0T Intera whole body MR system (Philips Medical Systems, Best, The Netherlands) using a six-element cardiac array coil. Volunteers were placed in supine position. For cardiac triggering a vector-ECG [4] was connected. Prior to the actual measurement localized 2nd order shimming parameters were determined using B_0-mapping. Furthermore, a low resolution SENSE reference scan was acquired to determine coil sensitivities.

For SSFP breath-held functional cine imaging the following parameters were used: acquisition matrix 160x214, FOV: 264x330 mm^2, slice thickness: 8 mm, flip angle: 40°, TR: 3.8 ms, TE: 1.9 ms, temporal resolution: 38 ms (heart rate of 70 beats per minute). Without SENSE the scan duration was 16 s, and with SENSE reduction factor 2 and 3, scan duration was two- and three-fold shorter, respectively.

The parameters for 3D SSFP coronary angiography were: acquisition matrix 272x260, FOV: 270x258 mm^2, 10 slices, slice thickness: 3 mm, flip angle: 80°, TR: 7.7 ms, TE: 3.6 ms, T2prep, α-half and 10 startups. Without SENSE the scan duration was 4:30 min, and with two-fold SENSE reduction 2:15 min assuming a respiratory gating efficiency of 50%.

RESULTS:

Selected time frames of short-axis and long-axis views obtained from a volunteer measured with SENSE reductions factors 1, 2, and 3 are shown in Fig. 1.

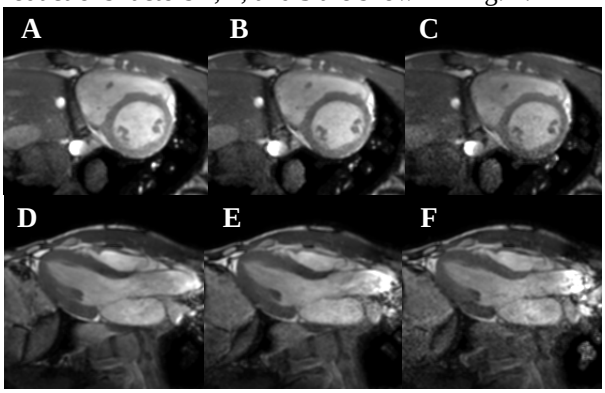

Figure 1: Short-axis views at end-diastole (A-C) and long-axis views at end-systole (D-F) measured with SENSE reduction factors 1 (A, D), 2 (B, E), and 3 (C, F). Breath hold durations were 16, 10, and 5s, for reduction factors 1, 2 and 3, respectively.

In-vivo coronary angiograms acquired with and without SENSE are presented in Fig. 2.

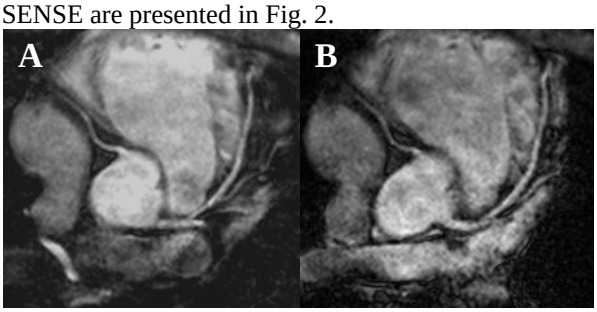

Figure 2: Multiplanar reformatted images of the left anterior descending coronary artery (LAD) and portions of the right coronary artery (RCA) acquired without SENSE (A) and with a reduction factor of 2 (B).

DISCUSSION:

Parallel imaging allows significant reduction of scan times in both cardiac SSFP cine and coronary artery imaging without significant loss in image quality.

REFERENCES:

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[3] Weiger M et al., MRM 2000, **43** p. 177-184
[4] Fischer SE et al., ISMRM 2001, p. 1826