Comparison of Several 8-element Surface Coil Configurations for Cardiac Imaging using SENSE

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INTRODUCTION

The performance of parallel imaging using sensitivity encoding (SENSE) [1] for accelerated acquisition is highly dependent on the number and geometry of surface coils. The SNR loss due to the noise amplification of the SENSE method is characterized by the g-factor. Arrays optimized for cardiac SENSE application using 6-elements have been previously described [2,3]. We present experimental cardiac imaging results comparing SENSE at various rates acquired with several different 8-element surface coil configurations, as well as a 4-coil cardiac array. SENSE was used to reduce the breath-hold time for acquiring cardiac cine images

METHODS

The coils configurations tested are shown in Fig 1. The 8-element surface coil arrays (Nova Medical Inc, Wakefield, MA, USA) were preamp decoupled with ultra-low impedance pre-amps (Nova Medical) [4,5] to minimize inductive coil-to-coil coupling while maintaining sample noise loading. Additional isolation was achieved by capacitative nulling of the inductive coupling between adjacent elements. The 4-element array was the standard GE cardiac surface coil array product.

The optimum phased array combined SNR (B1-weighted) [5] and SENSE g-factor were computed for various coil geometries and imaging plane orientations based on simulated field maps. Magnetic fields (B1-maps) for each coil were calculated using the Biot-Savart law. The sample noise correlations between coils which are used in calculating the optimum B1-weighted combining and SENSE g-factor [1] were calculated from the magnetic vector potential (A-field).

All experiments were conducted using a GE Signa CV*i* 1.5T MR imaging system which was modified to incorporate a high performance 8-channel digital receiver. Imaging parameters are listed in Table 1. Image reconstruction was performed off-line using MATLAB (The Mathworks, Natick, MA, USA). Several surface coils arrangements were used on a normal healthy volunteer. Care was taken to maintain the same localization for each coil configuration.

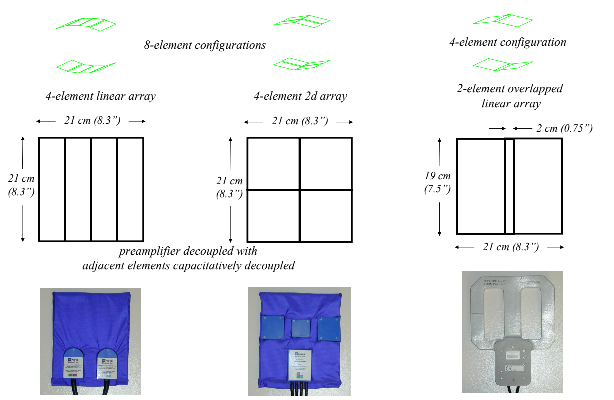

Figure 3. Block diagram showing the phased-array phase-sensitive SENSE accelerated reconstruction of IR image using a separate reference image acquired after magnetization recovery.

Table 1 Cine Imaging Parameters

scanner:	custom modified* GE Signa 1.5T
pulse sequence:	ECG Gated, Segmented SSFP (FISP)
acquisition matrix:	256 freq x 144 phase encodes
FOV:	340 x 255 mm²
Bandwidth:	±125 kHz
spatial resolution:	1.3 x 1.8 mm²
# cardiac phases:	34
TR:	4.1 ms
# lines per segment:	6
breath-hold duration:	24 heart beats
	12 *(R=2 SENSE)*
	9 *(R=3 SENSE)*
	6 *(R=4 SENSE)*

* using GE LX CV/*i* custom modified with 8 digital receivers
Morris, HD, Derbyshire, JA, Kellman, P., Chesnick, AS, Guttman, MA, McVeigh, ER. A Wide-Bandwidth Multi-channel Digital Receiver and Real-Time Reconstruction Engine for use with a Clinical MR Scanner. ISMRM 2002.

RESULTS

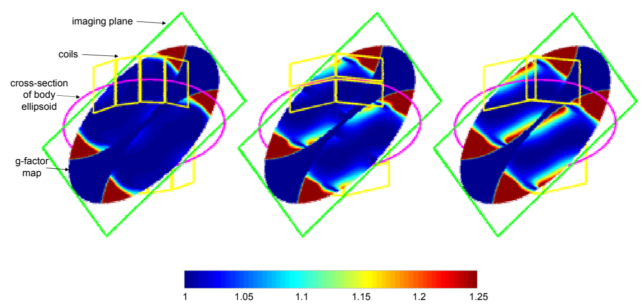

Figure 2. Simulated g-factors for rate *R=2* SENSE with doubly oblique short axis cardiac imaging geometry.

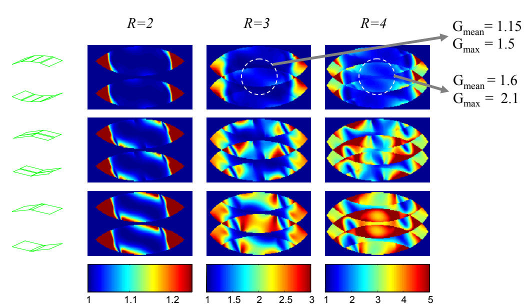

Figure 3. Simulated g-factors for rates *R= 2,3, & 4* SENSE with doubly oblique short axis cardiac imaging geometry.

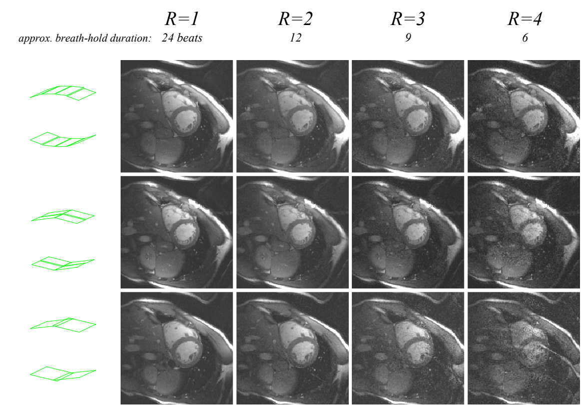

Figure 4. Short axis cardiac images with comparing SENSE, rates R=1 (full *k*-space), 2, 3, & 4 for various surface coil arrays.

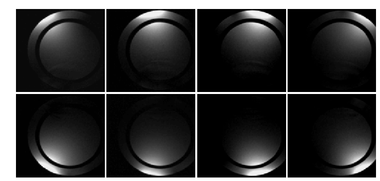

Figure 5. Axial images of cylindrical phantom with 8-element Nova 1x4 linear arrays illustrating low degree of inductive coupling.

CONCLUSIONS

- Overall array performance
  - all arrays tested had same SNR in central region (within 15%)
  - reasonable agreement with simulation
  - good pre-amp decoupling achieved
- Cardiac SENSE performance
  - 8 coils provided reasonable quality up to R=3 acceleration
    - + *increased robustness to differences in coil positioning or slice orientation*
    - + linear array performed slightly better for SAX slice geometries tested
    - + further testing of 2-d array planned
  - 4 coils degraded rapidly for R>2 due to ill-conditioning
    - + *high sensitivity to B1-map errors reduced artifact suppression*

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