SNR and g-Factor Optimized 16-Channel Anterior Cardiac Array for 3T

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Introduction

Array coils specifically designed for parallel imaging must be optimized for a particular region and depth of interest. Initially, array coil designs incorporated overlap for inductively decoupling nearest neighbors [1], but underlap has been recently proposed for improved g-factor maps in parallel imaging [2][3]. Disadvantages of underlap include SNR loss between elements [4] and reduced signal isolation between adjacent loops, establishing a tradeoff to be considered for performance optimization of designs with many elements. The cardiac region comprises a relatively small volume compared to the entire human torso, as such, an optimized cardiac array coil should reflect this. Previous work [5][6] utilized regular shaped rectangular or circular surface coils evenly distributed to cover the entire torso. In the design constructed here, we utilized FDTD field computations for designing a 16-channel anterior array specifically targeted for cardiac MRI at 3T, optimized for SNR and parallel imaging performance (SENSE [7]). The prototype was evaluated against other 16-channel anterior designs and benchmarked to a 6-channel OEM cardiac coil.

Theory/Methods

The design was partitioned into an 8-element section placed directly above the heart with small FOV SNR optimized geometry, and an 8-element section for improved parallel imaging performance and depth penetration, having outermost dimensions 14cm by 14cm and 36cm by 28cm respectively. The form-fitting design curves underneath the shoulder for complete cardiac coverage. Simulations were performed using xFDTDv6.3 (Remcom, USA) with a 120x84x148 sized mesh on a rounded human torso cardiac model sized 40cm by 26cm by 64cm long, composed of adipose, cardiac and inner averaged tissue. The 16-channel array was constructed using 1.8Ω input impedance pre-amps, and tuned to 123.2MHz on a gel phantom of dimensions 28cm by 25cm by 37cm long. Pre-amps and traps were mounted vertically and system interfacing involved two 8-channel cables to a 3T TIM TRIO 32-channel MRI system. Standard FLASH images were collected with our anterior array for SNR and parallel imaging comparisons to the OEM 6-channel anterior cardiac array. In all setups, a 3 x 3 OEM posterior spine array was utilized for posterior performance.

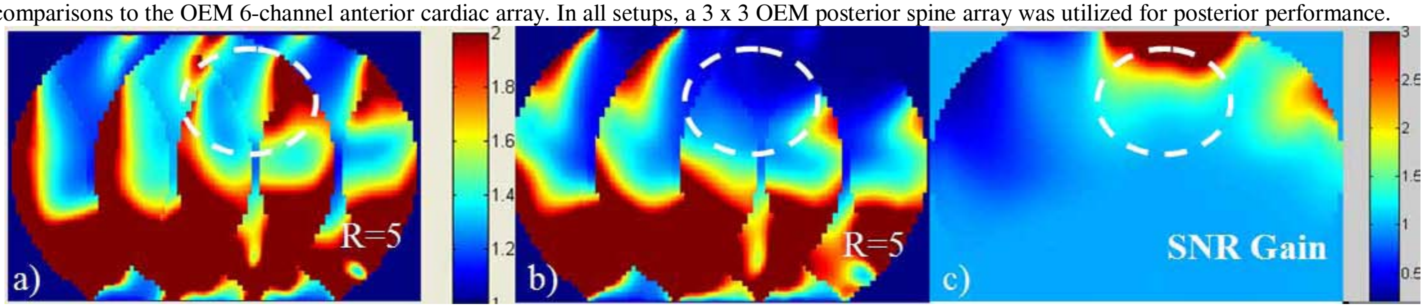

Fig. 1: Simulated L-R phase encoding axial plane g-factor maps for: a) the standard 16-channel anterior cardiac array by [5] for R=5; b) the optimized design for R=5; c) The SNR gain of the optimized anterior array relative the standard 16-channel anterior array by [5].

Results/Discussion

Element underlap between the two sections was employed for enhanced parallel performance of L-R phase encoded axial slices. Otherwise, element overlap was applied for signal isolation between channels. For comparisons of calculated g-factor performance and SNR improvements relative a standard anterior cardiac array [5], refer to Fig. 1. The dashed cardiac region indicates higher reduction factors are achievable and SNR gains up to 200% for the anterior coronary arteries. The posterior OEM spine array elements used for all designs were only useful for improving A-P phase encoded g-factor maps. The designed trace layout and final fabricated coil are depicted in Fig. 2. A GRAPPA reconstruction of R=4, using 16 reference lines for a 320x240 original image shows good image quality in the cardiac region in Fig. 2c). Higher g-factor maps relative to computations can be attributed to reduced L-R FOV (40cm down to 28cm), not accounting for the non-uniform transmit field in sensitivity maps and different array placement when acquiring experimental results. The SNR gains of Fig. 2e) relative the 6-channel OEM anterior cardiac array matched very well to computations, providing validation of the modeling environment.

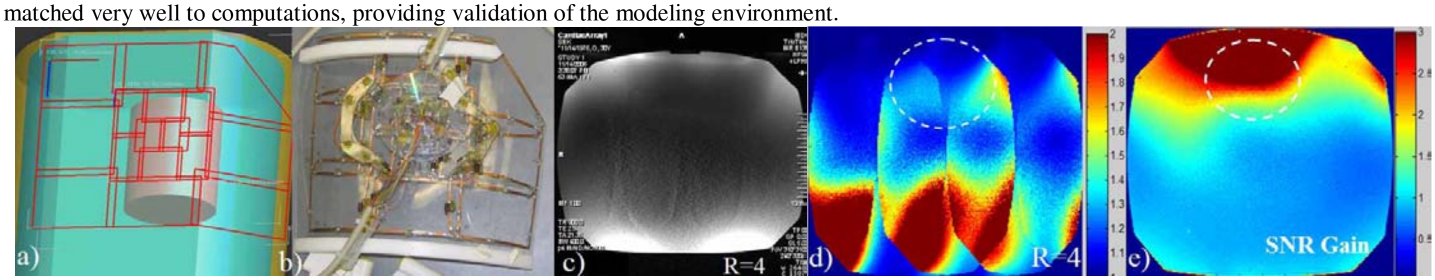

Fig. 2: a) 16-channel optimized anterior array design traces; b) Electrically isolated complete 16-channel anterior cardiac array; c) Experimental GRAPPA reconstruction from R=4; d) Experimental L-R phase encoding g-factor maps for R=4; e) Experimental SNR gain over 6-channel OEM cardiac array.

Conclusions

By relaxing performance benefits outside the cardiac region, we designed a coil better suited to cardiac imaging compared to symmetrical, pattern based designs. Up to 200% SNR gains and significant g-factor improvements were achieved within the cardiac region using this anterior design.

References

[1]Roemer PB et al. MRM 16:192-225 (1990). [2]Weiger M et al. MRM 45:495-504 (2001). [3]de Zwart JA et al. MRM 47:1218-1227 (2002). [4]Hardy CJ et al. MRM 52:878-884 (2004). [5]Zhu Y et al. MRM 52:869-877 (2004). [6]Hardy CJ et al. MRM 55:1142-1149 (2006). [7]Pruessmann KP et al. MRM 42:952-962 (1999).

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