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

Scott B King[1], Mike J Smith[1], Jarod Matwiy[1], Hung-Yu Lin[1], and Boguslaw Tomanek[2]

[1]*Institute for Biodiagnostics, National Research Council of Canada, Winnipeg, Manitoba, Canada,* [2]*Institute for Biodiagnostics, National Research Council of Canada, Calgary, Alberta, Canada*

Introduction

Most array coils used for body imaging utilize regular shaped rectangular or circular surface coils evenly distributed to cover the entire torso [1,2]. The cardiac region comprises a relatively small volume compared to the entire human torso, therefore, an optimized cardiac array coil should reflect this, to make the best use of a limited number of receivers (32 receivers in our case). We report on a 31-channel array designed specifically for cardiac MRI at 3T, optimized for SNR and parallel imaging performance [3].

Theory/Methods

The anterior array design philosophy was to use smaller elements centered above the heart, to improve SNR and g-factor where needed, and larger elements beyond the targeted ROI for full coverage and maintaining low g-factor in the ROI. Simulations were performed using SEMCAD X (Schmid and Partner Engineering, Zurich). The simulation phantom consisted of a "body" (40cm (L-R) x 24cm (A-P) x 60cm (S-I)) and ellipsoidal "arms" (14.7cm (A-P) x 6.7cm (L-R) x 54cm(S-I)) of uniform tissue ($\sigma = 0.6075 S/m$, $\varepsilon_r = 32.4$), and a 1.5 cm layer of peripheral adipose tissue ($\sigma = 0.07 S/m, \varepsilon_r = 5.1$). The 6-channel anterior benchmark array was modeled after the OEM 6-channel body matrix combined with 6-channels of a OEM spine array (12-Ch OEM), while the 32-channel benchmark array was modeled after Zhu et.al.[1] as 16-anterior elements and 16-posterior elements overlapped in the S-I direction with small gaps in the L-R direction. Our optimized 25-channel anterior array size was 34cm (S-I) x 39cm (L-R), each of the 25 anterior elements tuned to 123.2 MHz included 1-active trap, 1-passive trap, 1-fuse, and a 1.4 Ω input impedance preamp (Hi-Q.A., Carleton Place, ON, Canada). The 25-channel anterior array was combined with 6-channels from the OEM posterior spine array for a total of 31-channels (31-Ch IBD). Simulated and experimental SNR/g-factor analysis was performed using Musaik (Schmid and Partner Engineering, Zurich). Experiments were performed on a 3T TIM TRIO 32-channel MRI system.

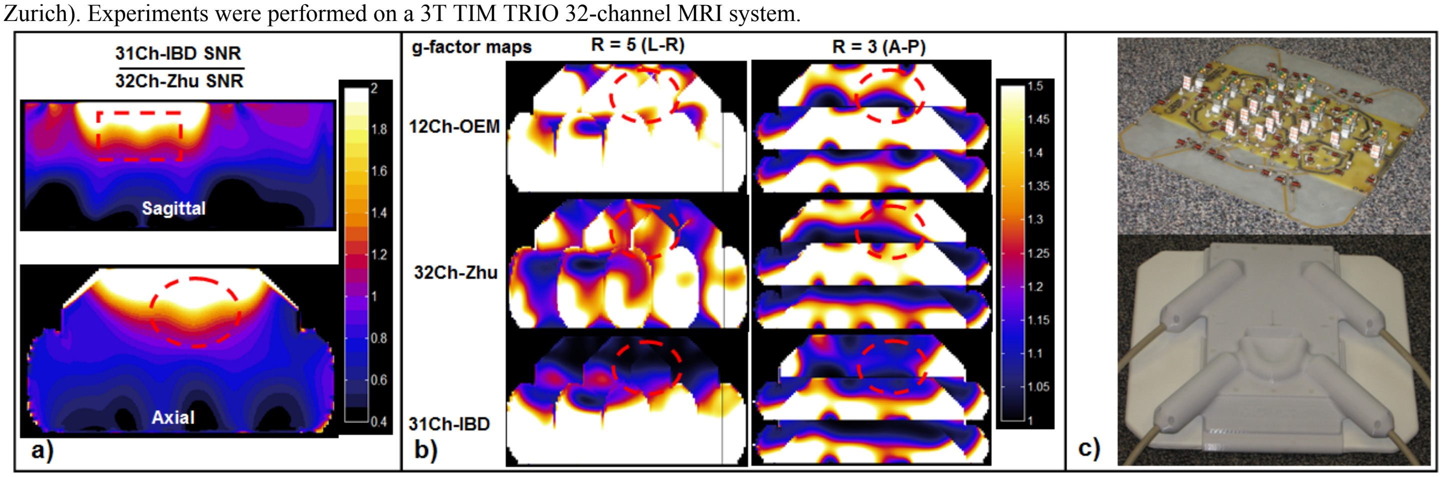

Fig. 1: (a) Simulated SNR Ratio of 31-Ch IBD and 32-Ch benchmark array, **(b)**simulated g-factor map comparison, **(c)**prototype 25-Ch anterior array.

Results/Discussion

Compared to a standard design 32-channel array with 16-channels anterior and 16-channels posterior with evenly distributed elements, the SNR gain for our 31-channel optimized array with 25-channels anterior is expected to be better by up to a factor of 3 in the anterior portion of the heart (*Fig.1a*). The g-factor advantages of this design are shown in *Figure 1b*, where R=5 (L-R) and R=3 (A-P) are achievable only with the optimized design. The constructed 25-Ch anterior array is depicted in *Figure 1c*. In vivo cardiac imaging shows that for R=5 (L-R) a g-factor < 1.5 in the heart is achieved with the optimized array (*Fig.2b*) but not with the 12-Ch OEM array(*Fig.2a*). Figure 2c,d show anterior heart SNR gain of 2.88 (360/125), and posterior heart SNR gain of 1.27 (140/110) for 31-Ch-IBD relative to 12-Ch OEM.

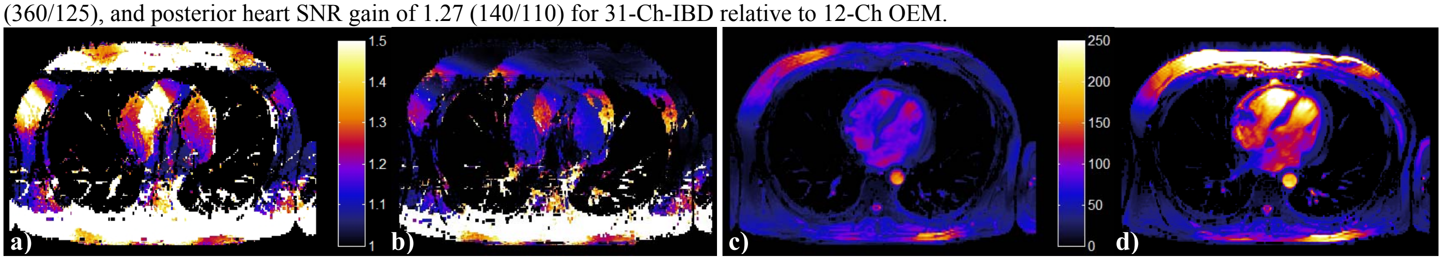

Fig. 2: Cardiac experimental data showing; (a,b) R=5 (L-R) g-factor map and (c,d) SNR map for (a,c)12-Ch OEM Array, (b,d)31-Ch IBD Array.

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 2.88x SNR gains and significant g-factor improvements were achieved within the cardiac region using this anterior design.

References

[1]Zhu et al. MRM 52:869-877 (2004). [2]Hardy et al. MRM 55:1142-1149 (2006). [3]Pruessmann et al. MRM 42:952-962 (1999).

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