Study on a 3T Head Coil: Channel Reduction from 32 to 24

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Introduction

The steadily increasing number of receiver channels available on MRI systems, which have allowed employment of up to 32 channel arrays [1, 2] on clinical MRI scanners and 128 channel arrays on research MRI scanners, has put large demands on the computational requirements for data handling and processing. Besides software-based channel compression methods, hardware-based methods [3, 4] by employing additional circuits before the receiver reduce the number of receive channels thus also lessen the computational burden. A more straightforward method for channel reduction is to optimize the coil layout and reduce the coil elements directly. Through the study on a commercial 32ch coil, we find that the coil element number can be reduced from 32 to 24 without degrading its SNR and parallel imaging performance. Reduced computational efforts of reconstruction, reduced cost and increased stability are then expected.

Method

We compared SNR and parallel imaging performance of three commercial 32ch head coils at 3T, two of them have overlapped elements, and one has gapped elements. Our results show that the gapped-elements design has slightly lower SNR at depth but better g-factor than the other two. This comparison motivates us to look inside the coil layout and think about the coil optimization with reduced coil elements.

We studied a commercial 32ch head coil at 3T. This coil has 2 rows around the head and 16 elements in each row. All the neighbor elements are overlapped for decoupling (see Fig. 1 A1). To avoid dielectric effect, a sphere silicon oil phantom is placed inside the coil, and spin echo images are acquired at axial and sagittal planes. Additional noise images are acquired with RF off for covariance matrix calculation. The raw k-space data were saved and reconstructed offline by MATLAB. Roemer method [5] is then used for SNR calculation.

Result

A 16ch gapped coil was simulated by disabling 16 elements in the 32ch coil (shown in Fig. 1B1). G-map and SNR are acquired. It is interesting that the g-factor values of this 16ch gapped coil are very similar to those of the 32ch coil when the reduction factor is equal or less than 4 (Table 1), but it results in an uneven signal-to-noise ratio distribution near the coil elements compared to overlapped designs. In addition, the central SNR of this 16ch gapped-array coil is slightly lower (see Fig. 1B2 and Fig. 1A2).

It reveals a fact that the parallel imaging performance is mainly contributed by the gapped 16 elements. When the additional 16 elements are added in, they have limited contribution to image acceleration, but are helpful to compensate the non-uniformity at the edge and increase the central SNR. This reminds us to think about the combination of the additional 16 elements into 8 for channel reduction. This combination can be done through signal combiners with proper phase shifts to minimize the phase cancelation, or through coil redesign with 8 larger loops as shown in Fig. 1C1. Those 8 large loops are expected to have deep B1 field penetration, as well as improved B1 homogeneity. The raw data from two nearby loops along S-I direction are linearly combined in k-space domain [6] to simulate the B1 field of the large loop in the 24ch array. The resultant SNR map in Fig. 1C2 and the mean/maximum g-factors in Table 1 demonstrate that the proposed 24ch coil and the original 32ch coil have comparable performance. The 1-D profile of the SNR curves along A-P direction further proves the conclusion (Fig. 2).

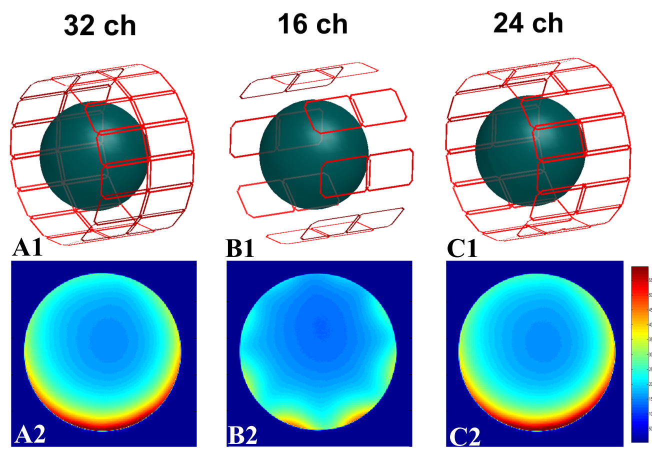

FIGURE 1. 32ch, 16ch and 24ch head coils and their SNR maps.

acceleration direction	R	32ch overlapped mean	32ch overlapped max	16ch under-lapped mean	16ch under-lapped max	24ch overlapped mean	24ch overlapped max
A-P in axial plane	2	1.02	1.1	1.02	1.12	1.02	1.1
	3	1.17	1.48	1.17	1.56	1.17	1.5
	4	1.61	2.54	1.66	3.19	1.61	2.56
	5	2.62	6	2.84	8.1	2.64	6.13
A-P and L-R	2*2	1.04	1.13	1.04	1.16	1.04	1.13
	3*3	1.72	4.07	1.81	6.3	1.74	4.12
S-I in sagittal plane	2	1.01	1.08	1.01	1.09	1.01	1.07

TABLE 1. Mean and maximum G-factor values of the three coils.

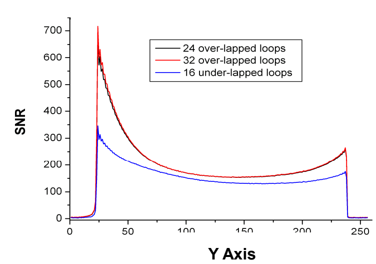

FIGURE 2. 1-D plot of SNR curves alone A-P direction.

Conclusion

The experiment and comparison show that even the channel count is as high as 32 of a head coil, the layout is still critical for its encoding acceleration and SNR performance. Gapped design is superior to others with its g-map but has slightly weaker signal at the depth as we expected. Channels of a high-density overlapped-element coil can be reduced by retaining some gapped elements for parallel imaging requirements and combining the rest of the elements properly.

Acknowledgement

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