An eight-channel, non-overlapping phased array coil with capacitive decoupling for high resolution MRSI and parallel DWI of the brain at 3.0 T

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Introduction

Increased SNR available from smaller phased array coils can be used to dramatically improve spatial resolution in the brain, particularly in the cortical gray matter. This improvement is particularly useful for high resolution MR spectroscopic imaging, where voxel size is limited by the available SNR of the spectra. In addition, parallel imaging using small phased array coils can provide critical susceptibility artifact mitigation for EPI-based high-field DWI acquisitions[1]. Here we describe a 3.0 T eight-channel phased array receiver coil that is designed to achieve these objectives.

Materials and Methods

Eight receiver loops were mounted, four per side, into bilateral plastic paddles curved to fit the typical head (Figure 1). The loop dimensions were 4 cm by 10 cm, with a 1.7 cm gap between elements. A non-overlapping row configuration was selected in order to boost the peripheral SNR beyond that of an equivalent overlapping design, and also to minimize the noise inflation due to acceleration along the AP and RL directions (ie. the g-factor)[2]. To reduce crosstalk due to the heavy inductive coupling inherent to this design ($k_m = .047$), two capacitors were placed between adjacent loops. A three-receiver (five-loop) mesh current model programmed in Matlab predicted to 20% tolerance the capacitor values required to decouple the receivers, as well as the different tuning adjustments required for the inner and outer loops. After tuning and decoupling, the isolation achieved was 14.0 dB ($|S_{21}|$) for nearest-neighbors and > 25 dB for next-nearest neighbors. To minimize the effect of reactive coupling using the system's standard low input impedance preamplifiers, the 50 Ω coaxial connection length was set to a half- wavelength. To assess the performance of the coil in vivo, high resolution spectra (0.22 cc, 8x8x8 PRESS with CHESS and VSS suppression, TE = 35 ms, 9 minutes) were obtained from five healthy volunteers on a GE 3T MR scanner. In addition, high angular resolution diffusion imaging (55-direction HARDI) using SENSE-EPI (R=2) was performed with the coil and compared to results obtained with a commercial 8-channel head coil.

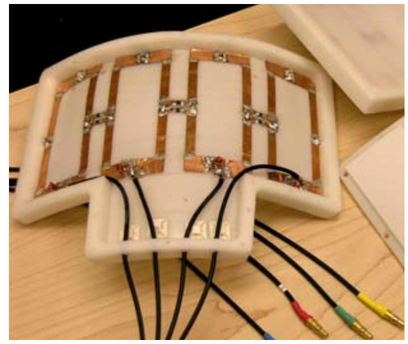

Figure 1 – Non-overlapping phased array coil with capacitive decoupling

Results and Discussion

Anatomical images from individual coils showed negligible levels of inter-element reactive coupling, demonstrating the adequate decoupling achieved by the combination of our capacitive bridging method and the standard system preamps. Figures 2-4 show typical experimental results, illustrating the anticipated improvement in SNR of this design. Figure 2 shows an example high resolution FSE anatomical image (sum of squares with filter intensity correction). In the 0.22 cc MRSI data, the SNR reached a maximum value of 20.7 for the NAA in cortical gray matter (figure 2). The average maximum SNR achieved for the NAA among the exams was 18.6 ± 1.3. In the HARDI data, the SNR in several important structures was markedly increased over the corresponding data from the commercial coil. For example, the SNR in the temporal stem and the forceps minor rose 56% and 48%, respectively. The processed data shown in figure 4 demonstrates the capability of the HARDI acquisition to identify fiber tract anatomy, when adequate SNR is available. Due to the parallel encoding, the images are largely free from geometric distortions and signal dropouts due to susceptibility variation. The good accelerated SNR performance agreed with our numerical simulations of the SENSE reconstruction (based on a quasi-static EM model). We computed the average g-factor over the sample to be very low at 1.01, with a peak value of 1.17. We expect the SNR improvement over other coils to become even more dramatic at higher reduction factors, due to the non-overlapping geometry.

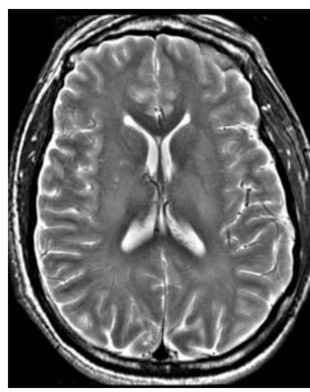

Figure 2 – Axial T2-weighted FSE image (384x384, 24 cm FOV, 8 slices 5 mm thick, 3.5 min)

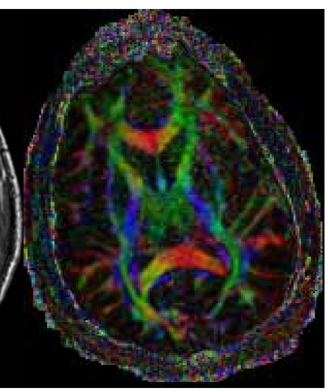

Figure 4 – Processed EPI-SENSE HARDI data

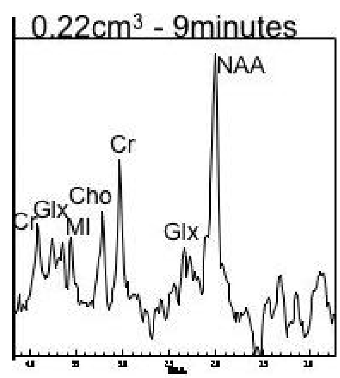

Figure 3 – MRSI voxel with SNR of 20.7 for NAA

References

1. Jaermann T. et al. MRM. 51(2):230-36 (2004).
2. Weiger M. et al. MRM. 45(3):495-504 (2001).