A Helmet Coil with Reduced Out-Of-Volume Sensitivity for Human Brain Imaging at 7 T.

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Introduction

Ultrahigh-field MR scanners operating at 7 T or above typically do not have large volume RF coils (e.g., a body coil) for transmission due to design challenges and the problem of high specific absorption rates (SAR). Even local, head-only coils exhibit unwanted characteristics including inhomogeneity and excessive sensitivity outside of the desired volume. For systems with head-only gradients, this can then result in signal from the shoulder and neck regions infolding into head-only scans [1]. The aim of the current work was to construct and optimize a helmet coil [2] for human brain studies at 7 T, which minimizes RF spillover to regions outside the brain. Its open design also allows for fMRI stimulus presentation.

Coil design

The coil design (Fig.1) was based on 4 strip-type transmission-line (SL) resonators [2]. They consisted of 10-µm thick copper tape separated by a low-loss dielectric substrate (10-mm thick polypropylene) and terminated with capacitors at the end near the neck. The electrical length of the SL-resonators was set to one half wavelength, and the strip width was 50 mm. Upon sinusoidal excitation, standing waves were generated along the SL with a current maximum about 4 cm above the resonator's end. For first tests, opposite SL resonators were connected with 180° phase difference using semi-rigid cable. Each segment was tuned by a parallel capacitance and matched to 50 Ω by two series capacitors. The two crossed sets of resonators could then be used to transmit and receive in quadrature. To suppress common mode currents in the cables, quarter-wave baluns were included between the match capacitor and the hybrid. The coil channels could be tuned and matched without and with load (phantom or human head). No resonance peak split was observed..

Experimental Results and Discussion

To optimize the homogeneity of the radiofrequency (RF) field, the effect of the coil geometry on the distribution of the $\mathbf{B_1}$ field was first investigated numerically using commercial software based on finite-element methods (HFSS 9, Ansoft, Pittsburgh, PA). The final coil design was then tested on a MAGNETOM 7T scanner (Siemens, Erlangen, Germany) using both phantoms and human volunteers (Fig. 3). In-vivo SNR maps were created using gradient echo images (TE 4.1ms, TR 200ms, FOV 220mm, 256×256matrix, 3mm slice, flip angle 20°). The experimental signal distribution observed *in vivo* was consistent with the numerically obtained B_1 maps and indicated minimal pick up of unwanted signal from the neck (Fig. 4). The later two measurements were compared to a 16 rung hybrid birdcage (20 cm long, 28cm in diameter) in the same subject.

References
[1] L. Wald et al. Design Considerations and Coil Comparisons for 7 T Brain Imaging. *Appl. Magn. Reson.* 29: 1 (2005).
[2] W. Driesel et al. A New Helmet Coil Concept Using Strip Lines. *Proc. ISMRM* 13: 948 (2005)

Fig. 1. 7T helmet coil

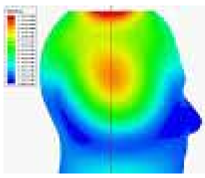

Fig. 2. $\mathbf{B_1}$ field map calculated using HFSS and an unstructured head model.

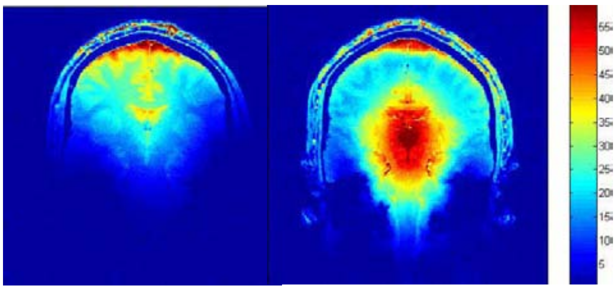

Fig. 3. Comparison of SNR maps from the helmet coil (left) and hybrid birdcage coil (right). While the helmet coil does not exhibit the central brightening of the birdcage coil, SNR in many cortical areas is comparable or greater.

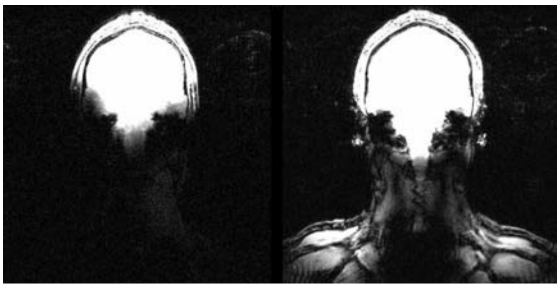

Fig. 4. Comparison of neck and shoulder images from the helmet coil (left) and hybrid birdcage coil (right). Images were individually scaled so that the mean of an ROI over the corpus callosum scaled to 8 times the maximum grey level. Gradient echo images were used (TE 5ms, TR 30ms, FOV 350mm, 256×256matrix interpolated to 512×512, 5mm slice, flip angle 10°)