

OPEN ACCESS 3-CHANNEL RECEIVE-ONLY COIL FOR INTERVENTIONAL BRAIN IMAGING.

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INTRODUCTION: The purpose of this work was to design a coil that allowed for open access to the cranium for interventional MRI. The goal was to provide high SNR in the brain, while simultaneously keeping the majority of the coil circuitry away from the top of the head. With thin wires or traces, such a coil could ultimately be used in transcranial MRI guided high intensity focused ultrasound (MRgHIFU) systems.

METHODS: A 3-channel phased array coil design was chosen (Figure 1). Each of the coil channels were capacitive decoupled from their neighbors. The channels were triangular-like and each shared a leg with the other two channels. The number of channels was kept small and the loops were not overlapped to reduce obstructions to the head. To verify that the coil could be used in a MRgHIFU setup, single shot heating was done in a homogeneous phantom without and with a single copper/kapton trace of the type used in this coil. All experiments were performed in a Siemens TIM Trio 3T MRI scanner (Erlangen, Germany). SNR scans were obtained for three different coil set-ups; the body coil, a 12-channel commercial head coil, and this 3-channel brain coil (Figure 2). For SNR comparisons, a gradient echo sequence was used with $(1 \text{ mm})^3$ isotropic spatial resolution, TR/TE 500/4.12 ms and 25° flip angle. To compare the relative temperature precision of the different coils, the standard deviation of the phase-based proton resonant frequency (PRF) temperature for each point in the image through time was calculated for the body coil and the 3-channel brain coil (Figure 3). The body coil was compared to the 3-channel coil because it is the setup with the most access to the cranium in MRgHIFU systems and the 12-channel coil was compared because it is available at many MR imaging sites. The sequence used for the standard deviation scans was a series of nineteen 2D gradient echo (GRE) with $1.3 \times 1.3 \times 3 \text{ mm}$ spatial resolution, TR/TE 40/10 ms and 20° flip angle.

RESULTS: Single shot heating through the coil trace showed negligible effects on the ultrasound beam when heating a tissue-mimicking phantom. The SNR plots showed a 332% and 41.2% increase in SNR at the cranium for the 3-channel coil compared to the body and 12-channel commercial head coil, respectively. The standard deviation of the temperature measurements over time showed that there is precision using the MRgHIFU brain coil. The average temperature error for a small region of interest in the middle of the brain 3 cm / 9 cm from the top of the head was $1.8 \text{ }^{\circ}\text{C} / 1.6 \text{ }^{\circ}\text{C}$ for the body coil and $0.67 \text{ }^{\circ}\text{C} / 0.98 \text{ }^{\circ}\text{C}$ for the three-channel brain coil.

DISCUSSION: The 3-channel brain coil gave good SNR throughout the brain area of interest compared to the body and 12-channel commercial coil. The temperature standard deviation maps for a non-heating sequence showed there would be less temperature error when using the 3-channel phased array brain coil. The increased SNR translates directly to reduced temperature error and better anatomy recognition.

CONCLUSION: This design could be used to improve many interventional MR techniques were traditionally the body coil is used. This is due to the coil's open design where all circuitry except coil traces are found on the side of the head. Some of these techniques include: MR guided high intensity focused ultrasound, RF ablation; and MR guided surgical procedures in the brain.

References: ¹ Jevtic J. 2001. Proceedings of ISMRM; p 1434. ² Roemer PB, et al. 1990. Magn Reson Med 16: 192-225. ³ Jolesz FA, et al. 1994. Magn Reson Q 10(2):85-96.

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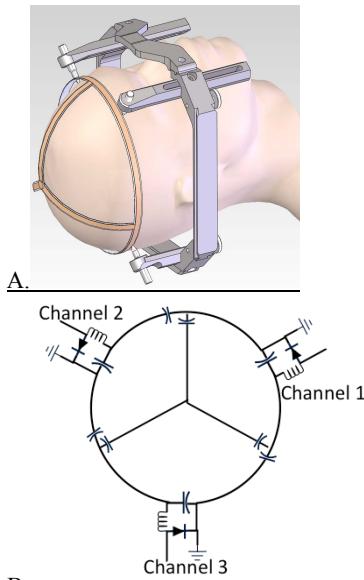


Figure 1. A: SolidWorks rendering of the 3-channel brain coil. B: Top view of circuit diagram of 3-channel brain coil.

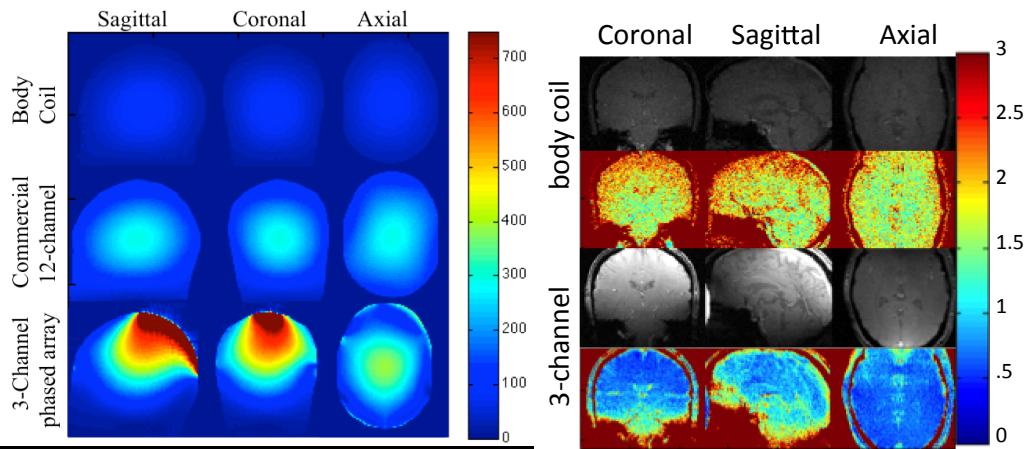


Figure 2. SNR scans using three different coils. 1st row: Body coil. 2nd row: 12-channel commercial coil. 3rd row: 3-channel brain coil.

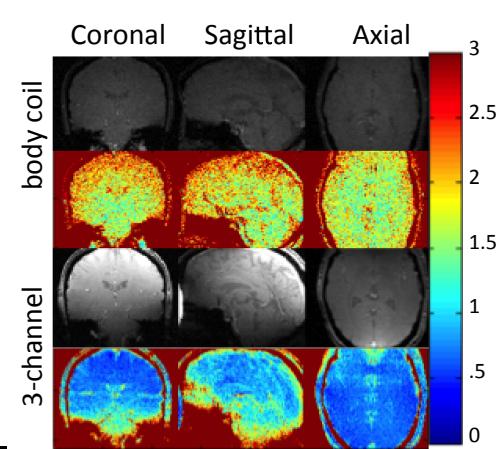


Figure 3. Non-heating standard deviation plots corresponding to the SNR scans. The columns are labeled Coronal, Sagittal, and Axial. The rows are labeled body coil, 3-channel, and 3-Channel phased array. The standard deviation shows the temperature error for the different coils.