A 6-CHANNEL BRAIN COIL FOR MR GUIDED HIGH INTENSITY ULTRASOUND.

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INTRODUCTION: The purpose of this work was to design and validate a magnetic resonance radio frequency (RF) coil for operation within a standard stereotactic frame for imaging the brain with increased SNR. In addition to improved temperature measurement accuracy, lesion visualization, and tissue characterization for patients undergoing transcranial MR guided high intensity focused ultra-sound (MRgHIFU) procedures, this coil will improve MRI image quality for patients being imaged in a frame for any general application.

METHODS: The stereo-tactic frame compatible coil was designed as a ladder phased array that is wrapped around the head (**Figure 1**). The design requirements were to fit around the stereotactic head device and be out of the way of the US beam in the transcranial MRgHIFU system (**Figure 2**). The total circumference of the coil was 56 cm with a 10 cm height. The coil channels each shared a leg with its neighbor and the channels were capacitive decoupled. All experiments were performed in a Siemens TIM Trio 3T MRI scanner (Siemens Healthcare, Erlangen, Germany). SNR comparisons were made with the body coil, the 12-channel commercial head coil, and this 6-channel phased array brain coil (**Figure 3**). For SNR comparisons, a gradient echo sequence was used with $(1\ mm)^3$ isotropic spatial resolution, TR/TE 500/4.12 ms and 25° flip angle. To assess relative temperature measurement precision, a human volunteer was scanned with a series of nineteen 2D gradient echo (GRE) volumes with 1.3 x 1.3 x 3 mm spatial resolution, TR/TE 40/10 ms and 20° flip angle. The standard deviation of the temperature obtained from the phase of the image sequence was calculated for each point in the image for the body coil and the 6-channel phased array brain coil (**Figure 4)**.

RESULTS: The 6-channel phased array brain coil was easy to implement and could allow for more access to the head for attaching the stereo tactic head device. The SNR comparisons show an increase of SNR in the center of the brain by 245% over the body coil and 34.5% over the 12-channel commercial coil. The temperature standard deviation from the temporal sequence showed that there is less temperature error using this 6-channel brain coil. The average temperature error for a small region of interest in the middle of the brain 9 cm from the top of the head was 1.6° C for the body coil and 0.69° C for the 6-channel phased array brain coil.

DISCUSSION: The 6-channel phased array brain coil gave good SNR within the coil sensitive volume. The temperature standard deviation maps for a non-heating sequence showed there would be less temperature error when using the 6-channel phased array brain coil. The increased SNR translates directly to reduced temperature error and better anatomy recognition.

CONCLUSION: Use of the 6-channel phased array brain coil should provide improved visualization of the brain and increased diagnostic capability of brain imaging in the MRgHIFU system. If successful, RF coils that have significantly more SNR than the body coil could change patient treatment by improving the accuracy temperature mapping during HIFU treatment. This would allow for better targeting and monitoring of tissue ablation and reduce unnecessary heating in healthy brain tissue and the cranium.

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.

Acknowledgements: This work is supported by NIH R01 EB013433, the Ben B. and Iris M. Margolis Foundation, The Mark H. Huntsman chair, and the Focused Ultrasound Surgery Foundation, Siemens Healthcare.

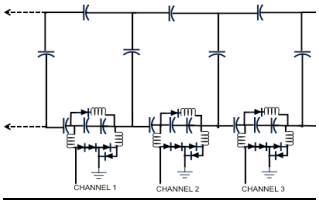

Figure 1. Circuit diagram of 3 channels of the 6-channel phased array brain coil.

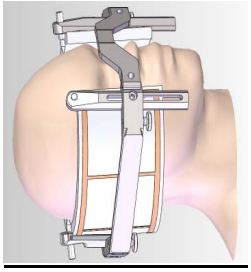

Figure 2. Solid works design of the 6-channel phased array brain coil, with the stereotactic head device.

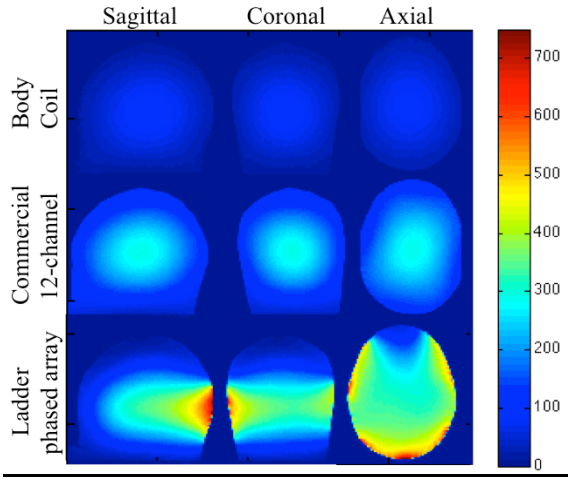

Figure 3. SNR maps obtained with three different coils. 1st row: Body coil. 2nd row: 12-channel commercial coil. 3rd row: 6-channel phased array brain coil.

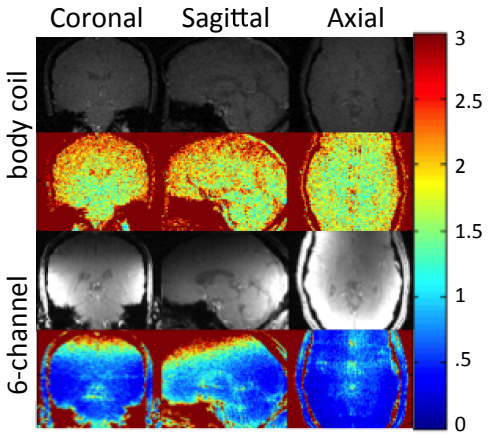

Figure 4. Non-heating standard deviation plots corresponding anatomy images (same window/level) with the body coil compared to the 6-channel phased array brain coil. The standard deviation shows the temperature error for the different coils.