Design and Testing of a 9-Channel Phased Array Coil for Magnetic Resonance Guided Focused Ultrasound Treatment of the Abdominal Region in Large Animal Models.

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PURPOSE

Signal to noise ratio (SNR) is critical in magnetic resonance guide focused ultrasound (MRgFUS) treatments. Higher SNR can result in faster, more accurate temperature measurements. However, the system geometry makes engineering coils in the MRgFUS environment challenging. This abstract presents a coil design for the MRgFUS environment that allows better SNR in the abdomen of a large animal model during the planning and execution of MRgFUS treatments. **Target Audience:** Physicists and clinicians who are interested in achieving better SNR throughout the imaging volume in MRgFUS treatments.

METHODS

The MRgFUS phased array coil has 9-channels. Five of the channels are located on a semi-cylindrical shaped support with a hole for US propagation. These five coil elements are non-overlapping and capacitively decoupled in a common leg. The central coil (ch 1) is a shoot-through coil of 17 cm diameter. The other channels (ch 2-5) are 12cm x 4 cm rectangular coils, two placed symmetrically to each side of the shoot-through coil in a ladder arrangement. The remaining four channels (ch 6-9) are located in two 2-channel paddles that are placed on the top of the animal. None of the coil channels interfere with the US beam. (**Fig. 1**)

Experiments were performed in a Siemens TIM Trio 3T MRI scanner (Erlangen, Germany) to compare the 9-ch MRgFUS coil with two other coil configurations: A. the body coil because of its homogenous profile covering the entire animal, and B. the single shoot-through-only coil, which is typical configuration for MRgFUS abdominal treatments. Three separate evaluations were performed:

Exp 1) Relative SNR (rSNR) maps (highest value normalized to 10) were obtained in a homogeneous phantom with a standard 2D GRE pulse sequence (TR/TE 500/4.21ms, 1.5x1.5x3mm^3 spatial resolution, 90° flip angle) with the three different coil setups. Both the rSNR in the ROI and the noise correlation were measured.

Exp 2) Anatomy images were obtained in a porcine model with the shoot-through-only coil and the 9-ch MRgFUS coil using a 2D GRE sequence (TR/TE 4.21/1.94ms, 1x1x3mm^3 spatial resolution, 9° flip angle).

Exp 3) Relative temperature measurement performance of the coils were compared using a 2D MR thermometry sequence under non-heating conditions (2D GRE, TR/TE 75/11ms, 2x2x5mm^3 spatial resolution, 20° flip angle, EPI factor=9, 19 acquisitions) in a porcine model using a shoot-through-only coil and 9-ch MRgFUS coil.

RESULTS

Exp1) Mean rSNR values in the animal model center where the US focal spot would be located was 1.11, 2.52, and 4.03, using the body coil, shoot-through-only coil, and 9-ch MRgFUS coil, respectively. Thus the rSNR in the porcine model tissue surrounding the kidney was 1.60 times greater using the 9-ch MRgFUS coil over the shoot-through-only coil and 3.60 times greater than the body coil. (**Fig. 2**) The maximum noise coupling between any two channels in the 9-ch MRgFUS coil was 0.425.

Exp 2) Anatomy images (**Fig. 3)** show more uniform intensity throughout the entire animal with the 9-ch MRgFUS coil than the shoot-through-only coil allowing better tissue visualization for treatment planning and healthy tissue monitoring.

Exp 3) Temperature standard deviation (STDev) over time was lower for the 9-ch MRgFUS coil than the shoot-through-only coil (**Fig. 4**). The mean temperature STDev for a small ROI (~9cm^2) in the psoas muscle at a depth 8cm from the dorsal side was 1.12°C for the shoot-through-only coil, and 0.68°C for the 9-ch MRgFUS coil.

DISCUSSION AND CONCLUSION

The 9-channel coil significantly improved the SNR in the central abdominal region compared to the shoot-through-only coil resulting in better anatomy visualization and temperature accuracy. This increased SNR allows for improved MRgFUS treatments by providing improved temperature monitoring in target tissue and safety for healthy tissue in large animal abdominal MRgFUS treatments.

ACKNOWLEDGEMENTS: Funding provided by the Joe W. & Dorothy Dorsett Brown Foundation.

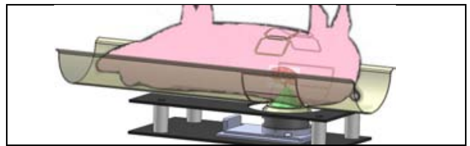

Figure 1. Solidworks schematics of the MRgFUS abdominal system showing the US transducer, animal support, and 9-ch MRgFUS coil.

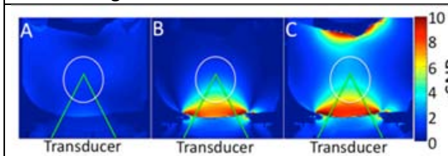

Figure 2. Sagittal rSNR maps using three different coil setups. A. Body coil B. Shoot-through-only coil C. 9-ch MRgFUS coil. The green lines show the US cone and the white circle shows the available treatment volume with electronic and mechanical steering.

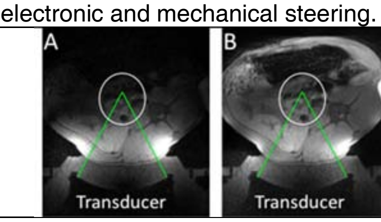

Figure 3. Axial anatomy images. A. Shoot-through-only coil. B. 9-ch MRgFUS coil. The green lines show the US cone and the white circle shows the available treatment volume with electronic and mechanical steering.

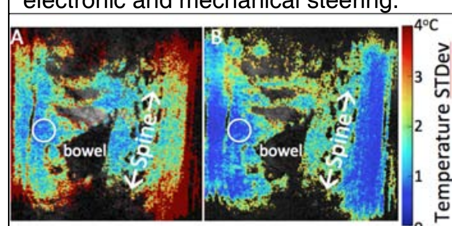

Figure 4. Temperature STDev over time for non-heating coronal scan through the target ROI with the respective anatomy scan underlayed. A. Shoot-through-only coil B. 9-ch MRgFUS coil. White circles are the ROIs used to find the mean STDev in the center of the pig. STDev is not shown in the bone and the bowels. US Transducer pointing into page.