Initial in vivo evaluation of a breast-specific MRgHIFU system

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INTRODUCTION:

Magnetic resonance guided high intensity focused ultrasound (MRgHIFU) has the potential to become an effective tool in the treatment and management of breast cancer. A laterally-shooting breast-specific MRgHIFU system with an integrated 11-channel RF-coil system has recently been developed [1]. This design integrates several features intended to improve the treatment efficacy and safety of MRgHIFU in the breast. The features of this system include an increased acoustic window providing greater access to breast tissues, flexibility in treatment steering, repeatability of the system's energy delivery and improved signal sensitivity resulting in increased temperature measurement accuracy. Previous studies have evaluated the breast-specific MRgHIFU system in homogenous phantoms and *ex vivo* tissue [1,2]. This work presents the first *in vivo* testing performed with this MRgHIFU system.

METHODS:

A white New Zealand rabbit was used as a first *in vivo* model in the breast-specific MRgHIFU system. The system incorporates a 17-cm diameter treatment cylinder (Figure 1) that houses a laterally-shooting phased array transducer (1 MHz, 256 elements, spherically curved) mounted outside the treatment cylinder and an 11-channel phased-array RF coil comprised of a 10-channel ladder array that surrounds the cylinder and a 16.5-cm single loop that surrounds the top of the cylinder. The anesthetized rabbit (2.9 kg) with hind legs secured next to the body was suspended in the MRgHIFU system such that the hind legs of the rabbit and the lumbar muscles were submerged in the treatment cylinder (Figure 2). MR temperature imaging was used to monitor the rabbit during the experiment with the imaging slab oriented along the axis of ultrasound propagation (3D segmented-EPI, TR=35ms, TE=10ms, t_{acq}=4.9s, 2x2x2mm, FA=10°, EPI=9, 16 slices, fat sat. used). All experiments were performed in a Siemens TIM Trio 3T MRI (Erlangen, Germany) with an MR compatible power generator system driving the ultrasound transducer (Image Guided Therapy, Bordeaux, France). Several single point sonications were applied to the rabbit's right lumbar muscles to localize the focal spot (56 acoustic W, 30s) followed by a 4x4 point trajectory (2-mm spacing, 10s/point, 105 acoustic W). Pre- and post-treatment T2w images were obtained (3D seg-EPI, TR=200ms, TE=25ms). This procedure was repeated in the left lumbar muscle. Gross histological analysis was performed at the completion of the study. The institutional animal care and use committee approved all experiments.

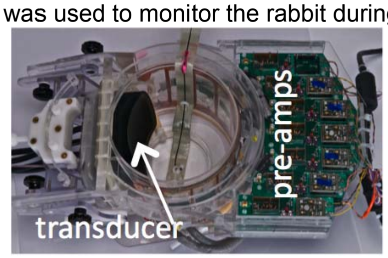

***Figure 1**: Breast-specific MRgHIFU treatment cylinder.*

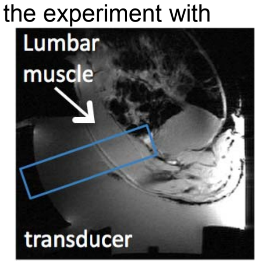

***Figure 2**: Rabbit setup. Imaging slab shown.*

RESULTS & CONCLUSIONS:

The thermal dose accumulated in the right lumbar muscle as a result of the 160-second 4x4 single plane trajectory is shown in Figure 3. The ablated volume (≥ 240CEM43°C) is approximately 0.75 cm^3. An oblique coronal slice of the post-treatment T2w image is shown in Figure 4. While most heating occurred in the lumbar muscle, some off-focus heating did occur near the spine, as indicated by the white arrow seen in Figure 3(a). This heating is due to the wide aperture of the transducer that while beneficial in the breast is a disadvantage when the target is smaller with absorbing materials in the acoustic path. The gross histological analysis of the lumbar muscle (Figure 5) shows qualitative agreement with the ablated volume seen in Figures 3 and 4. The initial results presented here show the ability to ablate *in vivo* tissue effectively at a rate of approximately 0.3 cm^3/min using this new breast-specific MRgHIFU device. These results suggest that this new device may be suitable for MRgHIFU treatment of breast lesions.

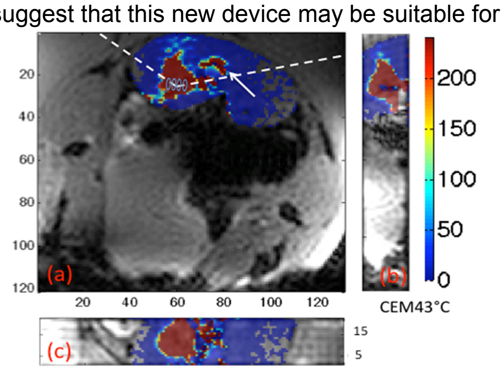

***Figure 3:** Thermal dose in oblique (a) coronal, (b) sagittal and (c) axial planes. White arrow indicates off-focus heating of spinal column. Beam path and focal spot locations are indicated. Distance in mm.*

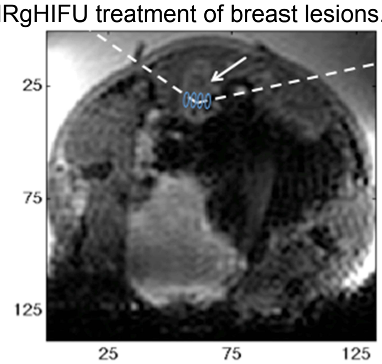

***Figure 4:** Post-treatment oblique coronal T2w image of ablation. White arrow indicates ablation zone. Beam path and focal spot locations are indicated. Distance in mm.*

***Figure 5:** Gross histology of ablated right lumbar muscle. Off focus spine heating seen in the lower right of the muscle. Ruler in cm.*

REFERENCES:

1. Payne et al., FUS Foundation Symposium, 2010. , 2. Minalga et al., ISMRM, 2011, p. 1726.

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