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TITLE: Compact Modular MR-Guided HIFU System for Treatment of Liver Cancer

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ABSTRACT BODY:

OBJECTIVES: A prototype MR-guided HIFU system is developed for treatment of human liver tumors. The system is compact and portable, allowing the patient support/applicator module to be easily installed on and removed from a MR Table.

METHODS: The HIFU system was used with a Siemens Magnetom Trio a Tim SystemTM 3T scanner, with software (SW) exploiting and extending the utility of the Interactive Front EndTM and TMAPTM (MR thermometry) SW prototype packages. The applicator has a high power (>2 KWac), high element count (>18,000) HIFU array capable of significant electronic steering. The beamforming electronics are embedded in the array, enabling the low profile patient support platform. A base module has power and control electronics, and a fluid system delivering pressure-and flow-controlled degassed water to the applicator. The SW allows dosing strategies (focal scanning patterns, dose power and time) to either be selected from those recommended by the system, or manually input. Targeting is confirmed via low energy shots and thermometry, or by MR ARFI images. HIFU is delivered through a subcostal acoustic window with the patient prone, tilted toward the left lateral decubitus position. As part of treatment planning, the operator designates an "acoustic tunnel" within which the energy is confined to avoid critical structures. Temperatures are monitored via multi-planar PRFS MR thermometry (interleaved with HIFU transmission and synchronized with breathing), and dose histories and peak tissue temperatures are stored, guiding treatment assessment and subsequent dosing.

RESULTS: System attributes, treatment planning, control and workflow are discussed. Data is presented on ablation in ex vivo liver phantoms including respiratory motion demonstrator, and on MR compatibility (passive and active). Significant HIFU steering flexibility is confirmed. Magnetic susceptibility imaging artifacts are minimal, enabling mm-accuracy in spatial registration of the device in the MR coordinate frames based on 3D high resolution imaging. Therapeutic beamforming integrity is maintained in spite of the array electronics being in the magnet bore.

CONCLUSIONS: The hardware and software components for a newly developed compact MR-guided HIFU system is described. Phantom experiments demonstrated satisfying system performance, clinical workflow and MR compatibility.