In Vivo Evaluation of a Mechanically-Oscillating Dual-Mode Applicator for Ultrasound Imaging and Thermal Ablation

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Introduction

- Technologies for liver tumor ablation
  - Microwave, Laser, Cryotherapy
  - Ultrasound
    - Spatial control
    - Good thermal penetration
    - Rapid coagulation
    - Integrated imaging
Dual-mode ultrasound

- Imaging + treatment
- Low cost, easy to implement
- Pre-tx positioning
- Monitoring during tx
- Post-tx lesion verification
Objectives

• Verify performance of dual-mode US device \textit{in vivo}

• Image tissue

• Induce coagulative necrosis in perfused porcine liver

• Investigate lesion detection and monitoring with US imaging
Methods

- Prototype construction
- Device characterization
- Acoustic and thermal simulation
- *In vivo* experimentation
Device configuration

Dual modes of ultrasound device

Rotational scanning

Tx/imaging cycle
Characterization

- Therapy mode
- Acoustic efficiency
- Imaging mode
- Impulse response
- Frequency response
- Image resolution
Characterization

Electro-acoustic efficiency

Imaging bandwidth

Image resolution
Acoustic and thermal simulation

Acoustic field calculation
Field II Simulation Program

Thermal simulation
MatLab
120 s therapy
Lesion evaluation

Pre-tx

Post-tx

Simulated lesion depth

Actual lesion depth

Intra-therapy
Lesion evaluation

Post-therapy 120 s sonication

**TABLE 1**

<table>
<thead>
<tr>
<th>Test</th>
<th>Surface Intensity W/cm²</th>
<th>Measured Lesion Depth mm</th>
<th>Estimated Lesion Depth mm</th>
<th>Error mm</th>
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Conclusions

- Dual mode operation was feasible for creating and visualizing thermal lesions *in vivo*
- Grayscale intensity changes in US images can be used for lesion depth estimation
- Dividing the US array into a higher number of elements would improve therapy control and more sophisticated imaging