Final Report: **MR-Guided High Intensity Focused Ultrasound- Temperature Measurement**

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The Focused Ultrasound Surgery Foundation provided funding to our group starting in the fall of 2007 for a research proposal titled, *MR-GUIDED HIGH-INTENSITY FOCUSED ULTRASOUND – Temperature measurements*. The funds provided covered the salaries of two graduate students and augmented the salaries of two professors working on the project. We are grateful for the support and are pleased to report that significant progress was made on the research project. Here we give a brief description of the work that was done during the time of the FUS Foundation award.

In the area of improving MR temperature measurements, we focused on two topics: making temperature measurements in adipose tissue and improving the temporal resolution of MRI temperature scans. Results for a novel hybrid PRF/T1 pulse sequence were presented in a poster at the ISMRM conference in Toronto in May 2008 and more recent results were shown in a poster at the ISTU conference in Minneapolis in September 2008 (see attached files). The goal is to have enough data for a paper on the hybrid PRF/T1 technique by this fall. A paper titled, *Temporally constrained reconstruction applied to MRI temperature data*, which describes one of our novel reconstruction methods for improving MR temperature scan time has been accepted by the journal Magnetic Resonance in Medicine and is due to be published shortly (see attached proof). The second reconstruction method, Model Predictive Filtering, was first presented as a poster at the ISMRM conference in Toronto in May 2008, further results were presented at a talk given at the FUS Foundation MRgFUS Symposium in October 2008, and the most recent results will be presented in a talk at the ISMRM conference in Hawaii this April (see attached abstracts). This work is being written up into a paper, tentatively titled, *Model Predictive Filtering for Improved Temporal Resolution in MRI Temperature Imaging*, and will be submitted within the month.

We have also worked on perfusion and blood flow measurements, with the goal of integrating real-time repeatable perfusion measurements into the MRgHIFU treatment plan. Work was done to determine the extent of the magnetization transfer effect in arterial spin labeling. The results were presented at the 4th Annual Mountain West Biomedical Engineering Conference in Park City in September 2008. Experiments have been done on ex-vivo kidneys and in-vivo brain using 2D and 3D Turbo-FLASH imaging sequences to measure perfusion and angiography. The results on the 3D high resolution angiography will be presented at the ISMRM conference in Hawaii this April (see attached abstracts). Some preliminary perfusion imaging on breast tissues has been done; more phantom and human studies will be performed in the near future.

Our final area of research concerns HIFU treatment planning and optimization. We have performed simulated treatments on a region of tissue using a finite difference solver with the goal of optimizing the treatment path and focal zone size for minimum treatment time. The conclusions from this work will be presented at the STM conference this April.

Building on this work, we are writing on an NIH proposal to develop MRgHIFU treatment planning by developing methods to measure tissue thermal and acoustic properties and to continue to refine methods of temperature measurements in aqueous and adipose tissue. We will focus initially on the breast, but will also include other organs of interest.

List of Papers, Abstracts, and Grants

- Todd, N., Adluru, G., DiBella, E.V.R., Parker, D. *Temporally constrained reconstruction applied to MRI temperature data*. Magnetic Resonance in Medicine (Accepted for publication).

- Todd, N., Payne, A., Blankespoor, A., Roemer, R., Parker, D.L. *Using thermal model predictions to improve MR temperature imaging time resolution.* Poster presentation, National Center for Image-Guided Therapy workshop 2008, Rockville, MD.
- Todd, N., Niu, R., Skliar, M., Parker, D. *Rapid MR temperature imaging based on model-predictive filtering of undersampled data.* Poster presentation, ISMRM Annual Meeting 2008, Toronto.
- Todd, N., Parker, D. *A hybrid PRF/T1 pulse sequence for rapid, simultaneous temperature tracking in soft and adipose tissues.* Poster presentation, ISMRM Annual Meeting 2008, Toronto.
- Todd, N., Parker, D. *Strategies for MR thermometry in Breast.* Poster presentation, ISTU Annual Meeting 2008, Minneapolis.
- Todd, N., Payne, A., Parker, D. *3-D MR Temperature Imaging with Model Predictive Filtering Reconstruction.* Talk, ISMRM Annual Meeting 2009, Hawaii.
- Blankespoor, A., Payne, A., Todd, N., Skliar, M., Roell, S., Roland, J., Parker, D.L., Romer, R. *Model Predictive Control of HIFU Treatments in 3D for Treatment Time Reduction.* Poster presentation, ISTU Annual Meeting 2008, Minneapolis.
- Payne, A., Vyas, U., Christensen, D., Parker, D. *Optimization of HIFU Treatments for Use in Model Predictive Control.* Talk, ISTU Annual Meeting 2008, Minneapolis.
- Todd, N., Parker, D. *Strategies for Improving the Temporal Resolution of MR Thermometry Scans.* Talk, MRI-guided Focused Ultrasound Surgery International Symposium & Exhibition 2008, Washington D.C.
- Wang, Y., Kim, S., Parker, D. *Magnetization Transfer Effect in Arterial Spin Labeling.* Poster presentation, 4th Annual Mountain West Biomedical Engineering Conference 2008, Park City.
- Roemer, R., Parker, D.L. *Non-Invasive Image-Guided HIFU for Breast Cancer Therapy,* Grant awarded funding by the NIH.
- Wang, Y., Kim, S., Parker, D. *High Resolution 3D MR Angiography using Arterial Spin Labeling.* Talk, ISMRM Annual Meeting 2009, Hawaii.
- Coon, J Payne, A Vyas U Christensen, D Roemer R. *Dose Delivery Time Reduction through Focal Zone (FZ) Size and Shape Optimization in HIFU.* Talk, Society of Thermal Medicine. Tucson, Arizona, 2009.