Correlation of T1-weighted and Diffusion-weighted Imaging after MR-guided High Intensity Focused Ultrasound Treatment

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INTRODUCTION: Non-invasive treatment of tumors is highly desirable and provides an alternative to surgery, one such method under active research is high intensity focused ultrasound, in particular, the treatment of uterine fibroids. The energy from the HIFUS can accurately be focused and induce heating of the desired tissue and induce cell death and/or necrosis. Recent publications have demonstrated the use of diffusion weighted imaging (DWI) for identification of treated tissue [1-2] and non-treated uterine tissue[3]. Currently, the "gold standard" is contrast T1-weighted imaging (cT1WI) to assess the treatment of uterine fibroids with HIFUS[4]. However, cT1WI doesn't give functional information about the treated tissue, whereas, DWI does. But, a question is how do the different treatment areas defined by imaging correlate? Therefore, the correlations of treatment areas defined by DWI and T1-weighted maps were investigated after treatment of uterine fibroids with MRg-FUS ablation.

METHODS: Eleven patients (mean age=45.3$\pm$3.8yrs) with uterine fibroids (mean size 32.7$\pm$16.7cm^2) were treated with MR imaging guided HIFUS ablation under conscious sedation monitored by a physician. Ultrasound treatment was performed using a modified HIFUS system (InSightec, Haifa, Israel) coupled with a GE 1.5 T system. The procedure consisted of treatment planning, calibration of images, and acquisition of T2-weighted (T2WI) images. T1 FSPGR phase sensitive images were acquired after each sonication by HIFUS. Each sonication lasted for aprox 30s followed by a 30s cooling period where the temperature was monitored by the T1-PS. Total HIFUS treatment time was in the range of 1-4 hrs for all patients. After treatment, DWI (TR/TE=5000/90ms, b=0,500-1000) and T1 FSPGR pre and post contrast images were acquired for verification of the ablated tissue. Trace ADC maps were constructed for quantitative analysis. Areas of treated tissue were defined by the cT1WI and localized to the DWI hyperintensity. Volumes were segmented using a semi-supervised segmentation method termed the Eigenimage filter[5] Quantitative statistics were obtained from pre, post, and non-treated uterine tissue. Statistical analysis was performed using Regression analysis.

RESULTS: All the patients exhibited increased DWI signal intensity localized in the treated fibroid or fibroids region. Fig. 1 shows typical MR results after treatment on a 47 y/o pt. The top row consists of the pre MRg-FUS treatment MR images: a) T1 post contrast, b) DWI, c) T2WI, d) ADC map. Similarly, the bottom row shows post MRg-FUS treatment MR and segmented region overlaid on a summed cT1WI. The regression analysis of normalized data for T1WI and DWI segmented areas are significantly correlated (r^2=0.84, $p<0.05$) with the equation, (cT1WI)=0.9(DWI)-0.001 for this study (Fig 2).

DISCUSSION: We have demonstrated that the area defined by DWI and cT1WI are highly correlated after treatment of uterine fibroids by MRg-FUS. The experimental data indicate that the combination of DWI and cT1WI can effectively be used in the assessment of the treatment of uterine fibroids by MRg-FUS ablation and the areas are highly matched. However, further studies are needed to further validate this finding.

REFERENCES:

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Figure 1: 47y/o patient A.) before, B.) after, and C) comparison between the cT1WI and DWI areas.

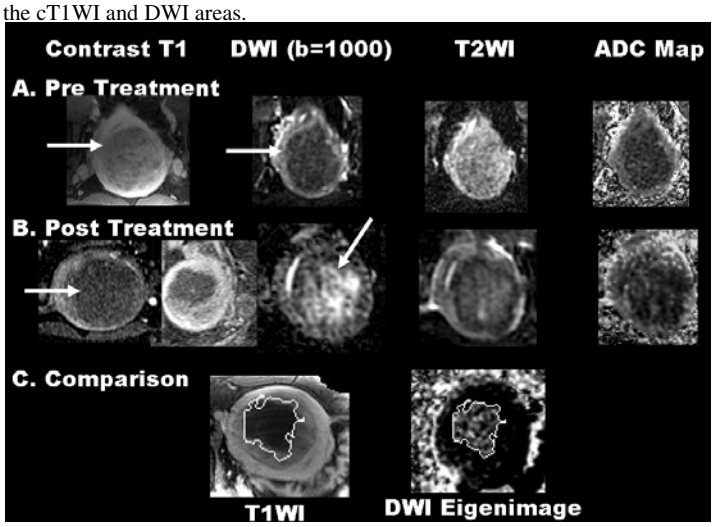

Figure 2: Regression Graph of cT1WI vs DWI