MR guided HIFU in Cadaver Breasts for Pre-Operative Tumor Localization of Non-Palpable Breast Tumors as an Alternative to Needle Wire Tumor Localization

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Introduction

Breast conservation surgery is an accepted alternative to mastectomy in patients suffering from limited stage breast cancer. Physicians are increasingly confronted with non-palpable breast lesions that are only visible on MRI. Since these tumors are non-palpable, current methods to locate them include pre-operative ultrasound, X-ray mammography, and MRI image-guided wire placement. However, image-guided wire localization lacks precision; positive tumor margins are discovered in 14-57% of patients [1]. A recent study demonstrated the potential of MR guided High Intensity Focused Ultrasound (MRgHIFU) for pre-operative localization of non-palpable breast lesions, as compared to the current wire placement method [2]. MRgHIFU was used to create lesions fully registered with the MRI, circumscribing the tumor, and thus, providing a visible and palpable lesion that the surgeon could use as a guide for excision during breast conservation surgery. While this initial study was performed in chicken breast tissue, a critical issue for the technique has been the performance of the technique in actual breast tissue, with a high percentage of fat. Therefore, the purpose of this study was to examine the visibility and palpability of focused ultrasound lesions in fatty human breast tissue.

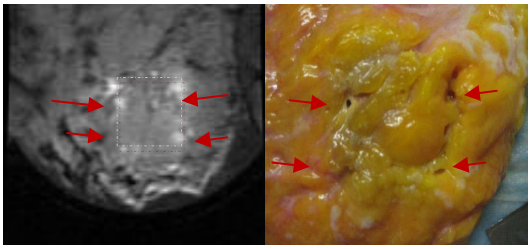

Figure 1. a) MIP of the T1w FSE heating images obtained during ablation subtracted from the non heated reference image. B) Photograph of ex-vivo human breast after MRgHIFU ablation of 24mm square perimeter. Arrows point to square demarcated by voids and tissue darkening.

Materials and Methods

The HIFU localization was performed in a GE 3T scanner using the InSightec ExAblate 2000 system and a 4" circular surface coil designed for MRgHIFU in the breast. In this study 18 sonications (120W acoustic power, 20s) spaced 5mm apart, were made around the perimeter of an arbitrary prescribed "tumor" square, representing a non-palpable tumor area. The ablated area circumscribed a 24 mm x 24 mm square section of the breast, crossing between fibroglandular tissue, as well as fat. Sonications were prescribed in the x-z plane and visualized on TIw FSE (TR=200-400ms, TE=12ms) magnitude images during heating [3]. MR guided Acoustic Radiation Force Imaging (MR-ARFI) data was collected during the same HIFU session. Using MR-ARFI data, displacement maps were obtained to show the difference between the pre and post sonication spots, potentially relating to a change in tissue stiffness. The temperature of the breast was monitored using fiber optic temperature sensors to insure pre and post ablation displacement measurements were evaluated at similar overall tissue temperatures (Luxtron, Inc.).

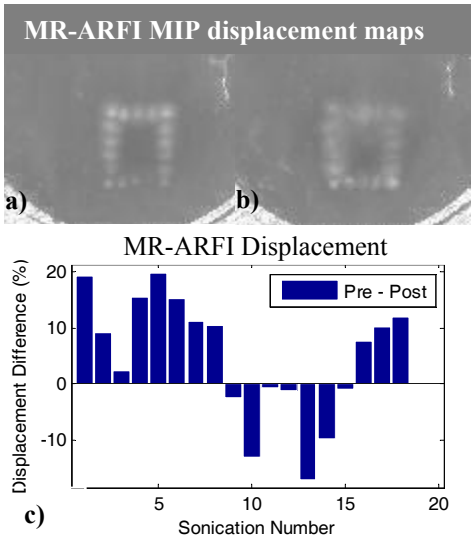

Figure 2. MIP of MR-ARFI displacement maps of pre a) and post b) ablation spots. c) Percent displacement difference between pre and post ablations for sonications 1-18.

Results

T1w FSE images confirmed changes in T1 due to local heating of each sonication spot (Fig 1a). These images also showed a slight structural change during the heating phase of some sonications. The tissue shrank towards the nearest heated fibroglandular tissue in sonications closest to the edge of the breast (along bottom right of square). Stiffening of the tissue, where sonications corresponded with fibroglandular tissue, could be felt upon palpation of the breast at room temperature. Visible changes in the tissue also demarcated the sonication square by creating tissue voids in purely fat sonications, and a darkening of the ablated square perimeter (Fig 1b). Maximum Intensity Projections (MIP) of MR-ARFI maps of the tissue taken pre and post ablation show a reduction in the amount of displacement for most post ablation spots (Fig 2). The reduced displacements are a likely indicator of a stiffer tissue, which is more difficult to displace using the same acoustic power. A greater displacement post ablation in some sonications (along bottom right of square) could be due to the shrinking of the tissue during neighboring ablations. In that case, the displacement measurements would correspond to areas that had not actually been ablated.

Conclusion

This study showed that MRgHIFU treatments in *ex vivo* human cadaver breasts were able to create visual and palpable lesions. ARFI was used to verify tissue displacement changes in sonicated areas, indicating a stiffening of the ablated spot. By creating both visual and palpable lesions that are fully registered with diagnostic MR images surgeons can potentially use this technique for pre-operative localization in breast conservation surgeries.

References

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