Ex vivo and *in vivo* human breast tumor comparison study using Harmonic Motion Imaging

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Background, Motivation and Objective

Harmonic motion imaging (HMI) is an elasticity imaging technique that estimates the viscoelastic properties of the underlying tissue. Our group showed promising results in differentiating breast tumors based on relative stiffness in post-surgical breast specimens. We also previously applied HMI to clinical applications to characterize *in vivo* human breast tumors. However, validation of *in vivo* HMI measurements is essential to increase the specificity of the technique. In this study, in order to verify our clinical findings, we estimated HMI displacements in post-surgical mastectomy specimens from the same subjects and compared them against the *in vivo* estimations.

Statement of Contribution/Methods

The HMI setup consists of 2 transducers: a 4-MHz focused one to generate an amplitude-modulated (f_{AM}: 25 Hz) acoustic radiation force and a confocally aligned 2.5-MHz imaging one to estimate the induced displacements. A robotic arm performing a 1-D mechanical raster scanning of the transducers was used to acquire sets of HMI images. Each image was formed by 80 RF frames acquired with a Verasonics Vantage system at a 1 kHz pulse repetition frequency after an 80-ms pulse excitation. The axial displacements were estimated offline from the RF lines using 1-D cross correlation with a 0.98 mm window and 95% overlap. Similar setup and parameters were used for data acquisition and processing in both the *in vivo* and *ex vivo* studies. Patients diagnosed with invasive ductal carcinoma (IDC) and lobular carcinoma (n=2 resp. n=1) and their post-surgical specimens were imaged in this study.

Results/Discussion

B-mode images and displacement maps for a 54-year-old IDC patient are illustrated in Fig.1 A-D. We estimated HMI displacements *in vivo* as 0.9 ± 0.2 µm vs. 6.0 ± 2.4 µm and *ex vivo* as 1.7 ± 0.9 µm vs. 7.7 ± 1.2 µm in the malignant tumor and surrounding tissue respectively *(n=3),* within a manually selected 5-mm-diameter circular region of interest (Fig.1 E). Our findings indicate that HMI successfully differentiated tumors from the surrounding tissue in both *ex vivo* and *in vivo* conditions with higher reliability *ex vivo* due to lack of respiratory and motion artifacts. Ongoing studies focus on analyzing the factors resulting in differences of *ex vivo* and *in vivo* acquisitions such as change in the boundary conditions, geometry and motion artifacts, as well as further optimization of the clinical setup.

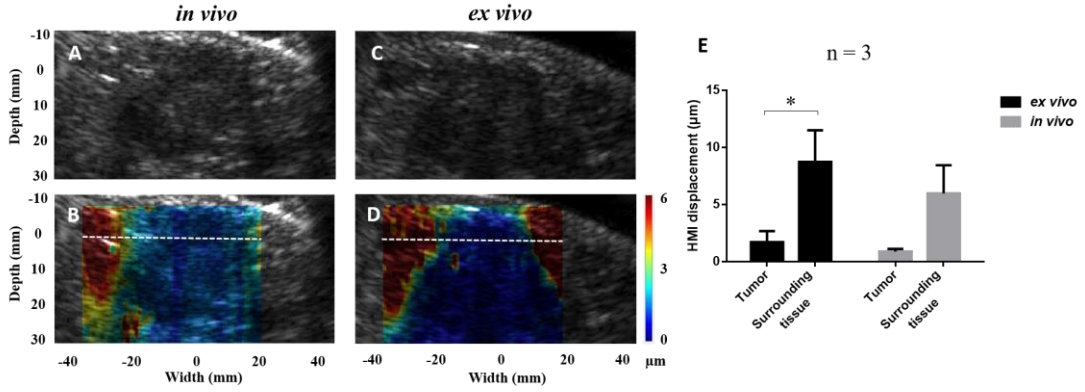

Fig. 1. HMI displacement estimation in human breast *in vivo* and in post-surgical breast tissue *ex vivo* (A) B-mode image of a female patient with a 4-cm breast tumor diagnosed as invasive ductal carcinoma. (B) Reconstructed HMI displacement map from peak-to-peak amplitude of the HMI displacements, overlaid on the B-mode image of the in vivo breast tumor. (C) B-mode image of the post-surgical mastectomy specimen from the same patient. (D) Reconstructed HMI displacement map overlaid on the B-mode image of the breast specimen. The displacements are coded with red as soft and blue as stiff in the colormap. The dashed line indicates the location of the focus of the FUS transducer during the 1-D raster scan. (E) HMI displacement map in a 5-mm-diameter region of interest estimated in vivo and ex vivo in human breast (n=3) .