3D strain imaging in volumetric breast ultrasound scanners to improve breast cancer detection: an in-vivo validation study

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Background, Motivation and Objective

The automated breast volume scanner (ABVS) is an operator-independent 3D ultrasound imaging system to detect breast cancer also in women with dense breast. The ABVS has a high sensitivity, but low specificity resulting in high recall rates and unnecessary biopsies. The addition of strain imaging may improve the specificity as malignant lesions are often stiffer compared to benign lesions. In a previous phantom study, we demonstrated that it was feasible to implement 3D strain imaging on an ABVS. The aim of this study was to verify whether 3D strain imaging in a clinically-used ABVS discriminates between benign and malignant breast lesions.

Statement of Contribution/Methods

Volumetric ultrasound RF datasets were acquired by the ABVS (Acuson S2000, Siemens Medical Solutions, Mountain View, CA) in 31 patients: 16 normal, and 15 presenting 16 abnormalities. RF datasets were obtained before and after automated transducer lifting (1 mm) to obtain different levels of deformation while patients held their breath during the two subsequent scans (15 seconds). Displacements were calculated using 3D coarse-to-fine block matching. The 3D strain tensor was estimated using a least-squares strain estimator. From this strain tensor the largest principal strain component was determined, since the applied strain was not purely in axial direction due to breathing in-between scans. Finally, strain ratios were calculated by dividing the median strain of the subcutaneous fat layer and median strain in the annotated lesion.

Results/Discussion

Biopsy and regular breast exams revealed 2 invasive ductal carcinoma (IDC), 2 ductal carcinoma in situ (DCIS), 1 phyllodes tumor (PT), 3 fibroadenoma (FA) and 8 cysts. Examples of B-mode and strain images of an IDC can be found in Fig. 1. The strain ratios were 2.8 and 3.5 (IDC); 0.9 and 1.8 (DCIS); 1.3 (PT); 0.4, 0.7 and 1.6 (FA). The strain ratios in IDCs and in one DCIS were increased compared to the benign lesions (FA). As expected for healthy tissue, the strain ratios (1.3±0.8; median± iqr) were close to 1 in the 11 subjects without a lesion. These results suggest that 3D strain imaging has the potential to improve discrimination between benign (FA) and malignant lesions (IDC, DCIS). To conclude, it seems feasible to implement 3D strain imaging on a clinically used ABVS, to obtain, visualize and analyze in-vivo strain images in 3D.

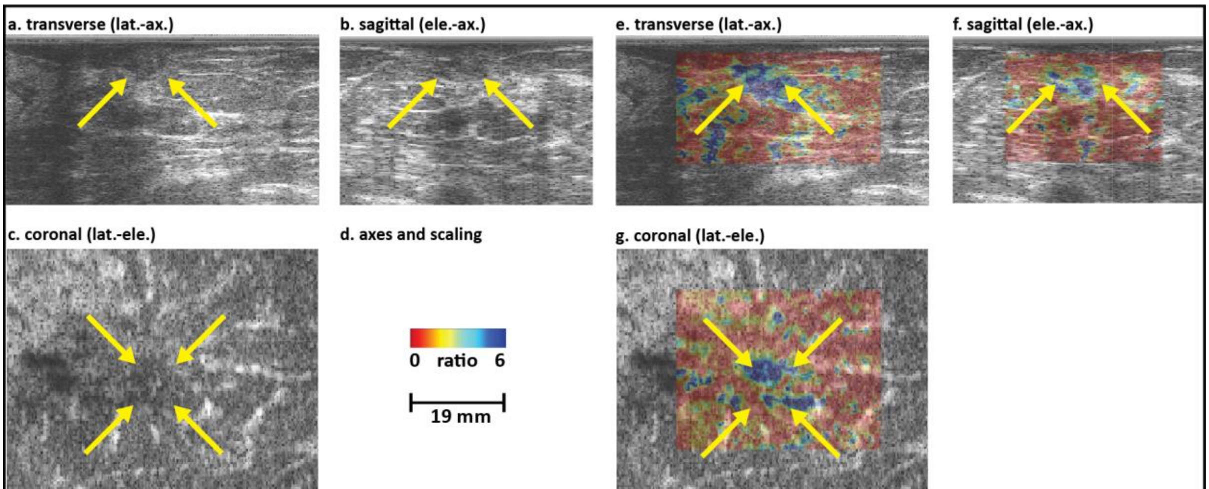

Fig. 1 *B-mode (a-c) and strain ratio images (e-f) of an IDC visualized in the transverse (a,e), sagital (b,f) and coronal planes (c,g) cutting through the center of the lesion. The lesion is indicated by yellow arrows and the color axis and scaling can be found in (d).*