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Correlation of the Histopathology of Focal Breast Lesions with Ultrasound Derived Calculation of Strain Ratio

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Introduction

In recent years, the diagnostic confidence of B-mode ultrasound has been strengthened by innovations including tissue Doppler techniques and imaging of tissue elasticity. Elasticity is the ratio of the strain (pressure) required to induce relative elongation or distention (Figure 1). The intrinsic elasticity of biological tissue is altered by physiologic aging and pathologic processes such as inflammation and tumorigenesis. Real-time ultrasound with off-line analysis allows functional tissue elasticity changes to be depicted (Figure 2).

Elastography and Breast Lesions

The incorporation of elastography data improves the specificity of ultrasound diagnosis in the differentiation of focal breast lesions, especially beneficial in the presence of lipomatous glandular parenchyma and discrimination between BI-RADS category 3 and 4 lesions (Thomas A and Fischer T et. al.

2006, 2007 & 2010). Off-line analysis can be used for quantitative evaluation of tissue elasticity expressed as an elasticity quotient derived by means of tissue strain imaging (TSI) or strain ratio (SR) calculation.

Off-line, Independent Determination of Elastography Strain Ratio

The aim of this current investigation was to perform a retrospective evaluation by an independent second reader of B-mode ultrasound, mammography and elastography using subjective scores and calculated SR. Examples of the breast imaging, elastography images, SR determinations and biopsy procedures are depicted in Figures 3, 4, 5 & 6. The analysis by the second independent reader was performed on stored elastography raw data sets obtained in 201 patients with sonographically confirmed focal breast lesions. The elastography raw data and sonographic images where obtained using a

Toshiba Aplio XG ultrasound system. The comparative investigation of Tsukuba scores (for the analysis of elastographic images) and BI-RADS categories (for mammographic and B-mode scan interpretation) contributed to further standardization of the method.

Confirmation of the Value of Elastography SR

The findings in this study support the premise that a second reading of ultrasound data, which is independent of the examiner who performed the sonographic examination, is feasible. The results confirm the inclusion of the elastography derived SR improved lesion detection sensitivity and specificity (95 % / 74 %) compared with B-mode imaging (85 % / 60 %), mammography (78 % / 62 %) and subjective interpretation of elastography images using the Tsukuba elasticity scoring system (85 % / 68 %).
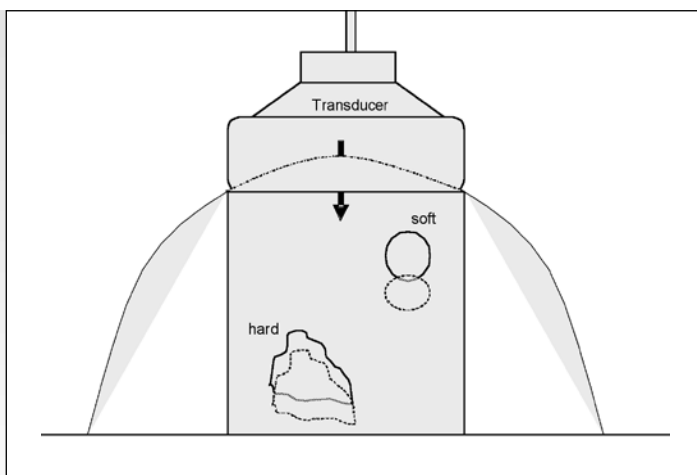

Fig. 1: A schematic depiction of the principle of strain imaging.
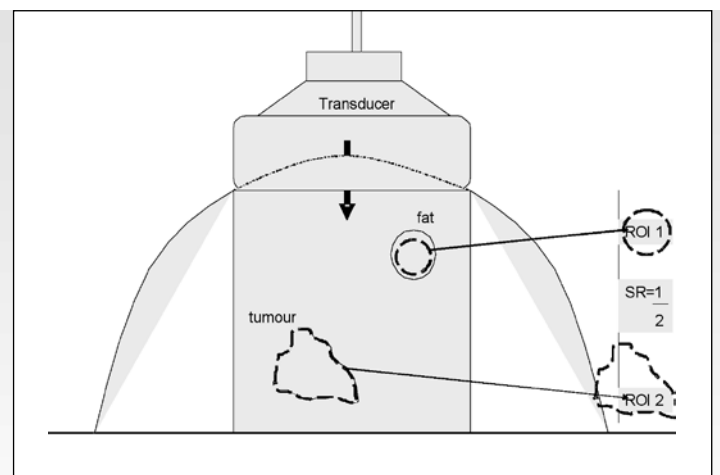

Fig. 2: Regions within the field of view can have their strain measured and a strain ratio (SR) can be calculated.

Figure 7 shows the SR values for the various lesions pathologically determined in this patient cohort. SR calculation allowed reliable differentiation of invasive ductal and lobular carcinomas from fibroadenoma, mastopathy and other benign lesions. Based on this data an SR cutoff value of 2.27 was determined as one which allowed significant differentiation ($p<0.001$) of malignant from benign focal breast lesions. This value agrees with the cutoff value of 2.45 previously published for real-time sonoelastography (Thomas A et al. 2010). Such agreement confirms this as a technique with potential clinical value.

Unfortunately, in this study it was not possible to differentiate carcinomas from scar tissue based on SR value alone. The differentiation of these categories constitute a special situation currently requiring biopsy and histologic confirmation.

Other entities that require special attention are medullary and mucinous carcinomas and precancerous lesions. While the number of such cases in this study was low (n=17), these entities had lower elastography scores (between 3 and 4) and also a relatively low SR (3.3 for the group of medullary carcinomas, n=7). However, this value was still higher than that of benign breast lesions. Such cases require interpretation by the range of available ultrasound techniques, including elastography and SR, B-mode imaging, color Doppler and histological examination when the imaging data are inconclusive.

Conclusion

This study provides evidence that elastography data can be analyzed off-line, independent of the operator who acquired the data. It also supports that the incorporation of the calculated SR increases the sensitivity and specificity for the accurate classification of breast lesions and suggests there maybe prognostic value in an SR in the range of 2.27 – 2.45. Future prospective validation may provide a cutoff value with clinical utility which significantly aids in the confident diagnosis of breast lesions.

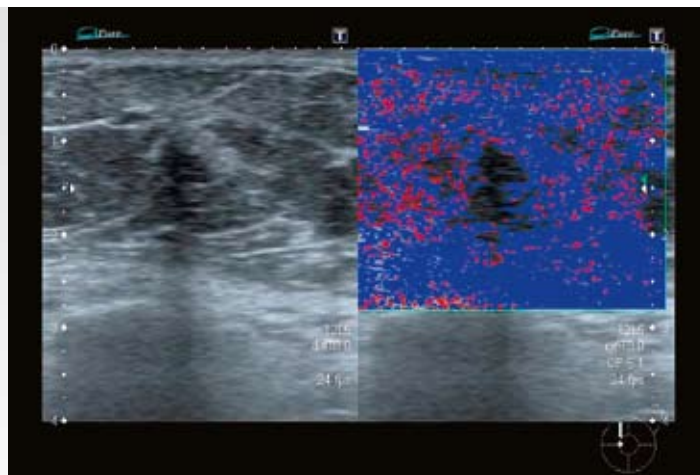Fig. 3: B-mode scan of a breast lesion measuring 11 mm.

Fig. 4: The lesion is suspicious in the B-mode scan and realtime tissue Doppler image obtained without tissue compression.
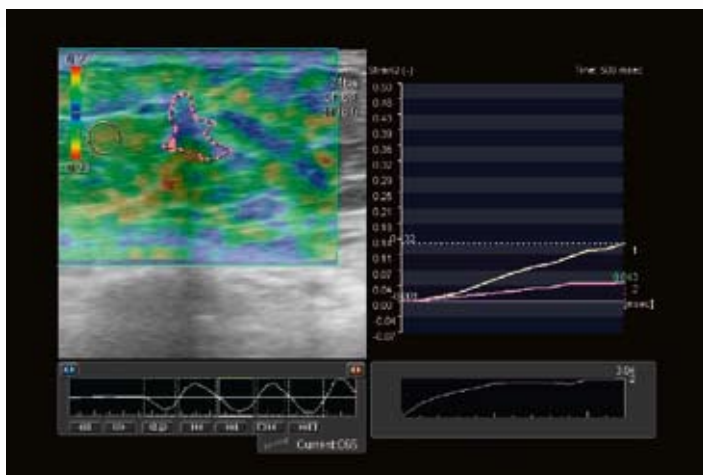

Fig. 5: Elastography shows a larger tumor extent (blue color beyond the tumor border) and a high SR of 3.04 of the entire area.

References

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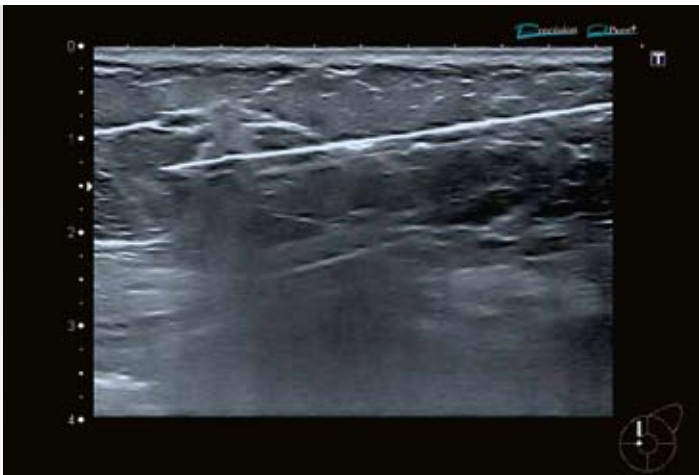
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Fig. 6: Based on the elastography results, a core biopsy was obtained although the lesion had been classified as a BI-RADS 4 lesion. The histological result indicated an invasive lobular carcinoma.
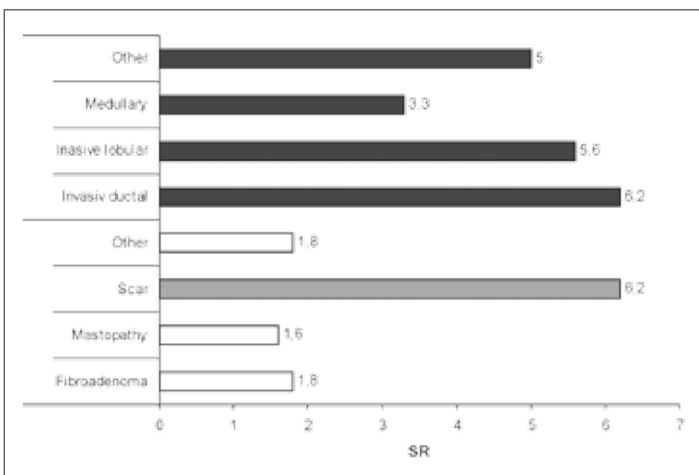

Fig. 7: This bar diagram shows the mean strain ratios (SR) calculated for benign (white bars) and malignant (dark gray bars) focal breast lesions; the scar (light gray) was the only lesion type which could not be differentiated by means of SR.

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