Differentiation of benign and malignant breast lesions on the basis of strain ratio cut-off value calculation by breast sonoelastography

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Aims and objectives

Breast cancer is the top cancer of women in the world, 5-year relative survival rate is over 80%, as a consequence early detection has a critical role in the management of the disease [1]. Although B-mode sonography is commonly used method for morphological characterization of breast masses, it has a high sensitivity but a low specificity in differentiating malignant and benign lesions in breast [2]. Sonoelastography, a new noninvasive method, used to define stiffness of the tissues or displacement in response to an external force which can reveal histological characteristics of lesions [3]. In general benign lesions is softer than malignant lesions and as a result in harder tissues elasticity coefficient is greater [4]. The strain ratio (SR) value which is calculated by dividing the mean strain of the adjacent fatty tissue by the mean strain within the lesion, is a semi-quantitative method. Recent studies have shown a significant difference between the average strain ratio of benign and malignant breast lesions [5, 6]. In this study we aimed to evaluate the effectiveness of sonoelastography to determine whether the calculation of SR and a cutoff value can further improve the differentiation of malignant and benign breast lesions.

Methods and materials

Patients

This prospective study was approved by our institutional ethics committee and written informed consent was obtained from each patient. A total of 81 patients, 80 women and 1 man (age range 19-85, mean age 51.3) with breast lesions on clinical examination and B-mode sonography were enrolled from February 2013 through June 2014. Patients with other systemic disease, with a story of breast surgery before, under the age of 18 and with mental retardation were excluded.

Imaging Techniques

B-mode sonography and elastography were performed with a Siemens Acuson S3000 US system (Siemens Medical Solutions, Erlangen, Germany) with a linear probe (9L4, Siemens Medical Solutions) in the same session by one operator with 15 years' experience in breast imaging. The sonographer was trained by equipment supplier. All images were digitally stored on the ultrasound unit.
At first, B mode sonography images were displayed in transverse and longitudinal scans. The lesions was described by using the American College of Radiology (ACR) Breast Imaging Reporting and Data System (BI-RADS) lexicon of ultrasonographic descriptors of mass shape, orientation, calcification, margin, echo pattern, boundary, posterior acoustic features[7]. Elastographic images were generated with an appropriate compression while the screen was in real time, coupled B mode and elastographic images were included on the screen. For a stable image when the probe pressed on the breast, a Quantification factor value, the standard numeric value for Siemens elastography systems was 55 or over and it was calculated at the bottom of the screen. The vertical amplitude of the probe was between 1 or 2 mm and mean speed of probe movement was once or twice per second during the compression. The calculations of SR was based on a comparison of the average strain measured in the lesion and adjacent fatty or normal tissue at the same depth and was measured on a static image. First ROI including lesion was selected then second ROI including the reference surrounding normal tissue was selected depending on the lesion size for each case. The SR was automatically obtained.

True-cut and surgical biopsy results of the lesions were taken as a gold standard to compare the diagnostic efficacy of SR measurements.

Statistics

Statistical analysis were performed by Statistical Package for the Social Sciences (SPSS version 15.0, Chi, IL, USA). The definitive statistics were frequencies, percentage frequencies of categorical factors, mean, median minimum, maximum and standard deviations of continuous variables. The diagnostic performance of strain ratio was evaluated by receiver operating characteristic (ROC) curve and the best cut-off value was analyzed when achieving the maximal sum of the sensitivity and specificity of SR in diagnosing benign and malignant breast lesions. Sensitivity, specificity, positive and negative predictive values were calculated at cut-off value. P values less than 0.05 were considered to be significant.

Results

Pathologic diagnoses
Of the 81 breast lesions, 43 were benign and 38 were malignant depending on the pathological reports. The pathologic diagnoses of these lesions are shown in table I. The most common malignant and benign tumors were intraductal invasive carcinoma (n=33) and fibroadenoma (n=16), respectively. The dimensions of all lesions ranged from 3-70 mm along the long axis (mean 16.3mm)

_Sonoelastography results_

Mean SR values were calculated as 4.3 +/- 1.5 for malignant lesions (range 1.6-7.3) (Fig.1) and 1.8 +/- 0.9 for benign lesions (range 0.5-4.9) (Fig.2). The area under the ROC curve value was 0.927 for SR which was statistically significant (Fig.3). The best cutoff value for SR was calculated as 2.84 when the maximal sum of the sensitivity and specificity was obtained in SR method. Among 38 malignant lesions 30(78.9%) were correctly diagnosed by SR method. The false positive lesions which SR value were calculated over the cutoff value 2.84, histopathologic diagnosis of two were sclerozan adenosis and two were fibroadenomas. Among 43 benign lesions 39(90.7%) were correctly diagnosed by SR. The 8 false negative lesions by SR were 6 invasive ductal carcinomas, 1 medullary carcinoma and 1 ductal carcinoma in situ.

_Images for this section:_
Invasive Ductal Carcinoma (Sr: 5.38)
Reference: Department of Radiology, Baskent University Hospital Ankara/Turkey

Fig. 1

Fibroadenoma (Sr: 1.20)
Reference: Department of Radiology, Baskent University Hospital Ankara/Turkey
Fig. 2

![ROC Curve](image)

**Table 1**

<table>
<thead>
<tr>
<th>Benign lesion (n=43)</th>
<th>Malignant lesion (n=38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibroadenoma</td>
<td>Invasive ductal carcinoma</td>
</tr>
<tr>
<td>16</td>
<td>33</td>
</tr>
<tr>
<td>Sclerozan adenosis</td>
<td>Invasive lobular carcinoma</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Fibrocystic changes</td>
<td>Micropapillary carcinoma</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
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<tr>
<td>Granulomatous mastitis</td>
<td>Medullary carcinoma</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Fat necrosis</td>
<td>Ductal carcinoma in situ</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Atypic ductal hyperplasia</td>
<td></td>
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<tr>
<td>1</td>
<td></td>
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<tr>
<td>Ductal epithelial hyperplasia</td>
<td></td>
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</table>
Conclusion

In our study, we found that SR, was different between benign and malignant lesions. In this study, the best cutoff value was calculated as 2.84, and the sensitivity and specificity were 78.9% and 90.7% respectively. Some of recent studies have shown that unless the SR value of the lesion is under 3, the lesion should be diagnosed malignant[8, 9]. Thomas et al.(2006) and Itoh et al.(2006) have shown similar sensitivity and specificity values in their studies as 77.6%, 91.5% and 89.3%, respectively[10, 11]. Due to 4 false positive and 8 false negative results, positive predictivity and negative predictivity were calculated as 88.2% and 82.9%, respectively. False negative and positive results might be due to overlapping elasticity coefficient for different tissues. Hemorrhage in a malignant lesion or a cystic component, and medullary like carcinomas in which central necrosis mostly seen causing softening in the lesions, can cause similar SR values like benign lesions[12](Fig. 4). Also surgical scars and subcutaneous edema can affect the strain ratio[9]. In the same way, calcifications, central fibrosis and rich tumoral cellularity can affect the strain ratio[9]. In our study benign lesions like sclerozan adenosis and fibroadenoma with high strain ratio because of the rich cellularity and central fibrosis were defined as false positive whereas malignant lesions like invasive carcinoma, medullary carcinoma and ductal carcinoma in situ with low strain ratio because of central necrosis were defined as false negative.

Our study had several limitations. First, all B mode sonography and SR evaluations were performed by one radiologist. Then, our study included a low number and limited variety of malignant lesions. Finally other confounding factors like lesion depth, breast thickness, histological grade, lymph node involvement, age and fatty tissue were not performed in this study[14, 15].

In conclusion sonoelastography, as a fast, simple, noninvasive method improves specificity of conventional ultrasound examination in the differentiation of malignant and benign breast lesions by using a cutoff value 2.84.

Images for this section:
Invasive Medullary Carcinoma (Sr: 1.80)
Reference: Department of Radiology, Baskent University Hospital Ankara/Turkey

Fig. 4

Fibroadenoma (Sr: 3.34)
Reference: Department of Radiology, Baskent University Hospital Ankara/Turkey
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References


