Detectability of breast cancer in the specimen during breast-conserving surgery: digital mammography versus digital breast tomosynthesis

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Aims and objectives

Breast-conserving surgery (BCS) followed by irradiation is a well-established standard care for ductal carcinomas in situ (DCISs) and early-stage invasive breast carcinomas. Obtaining tumor-negative margins during BCS is important to prevent local recurrence and second operation [1]. Although specimen radiography (SR) using digital mammography (DM) is one of the strategies for intraoperative resection margin determination during BCS, it has been reported that the diagnostic accuracy, sensitivity, and specificity were relatively low, being 60 - 84%, 55 - 60 % and 60 - 92 %, respectively [1-3].

Because conventional mammographic images are 2-dimensional radiographic views, the presence of overlapping dense breast tissue substantially reduces the conspicuity of some breast lesions [4]. Digital breast tomosynthesis (DBT) uses conventional X-rays and a digital detector to obtain multi-directional projection data and creates thin-slice cross-sectional images through the breast by using reconstruction algorithms similar to computed tomography (CT) [5]. These images are expected to reduce overlapping dense breast tissue and to improve detectability of breast cancer. The purpose of our study was to compare the diagnostic ability of SR using DM and DBT for detecting breast cancer and evaluating its extension in the intraoperative specimen.
Methods and materials

Patients

The local institutional review board approved the study, and informed consent was obtained from all patients before the examination. During a 7-month period (April to October 2013), we obtained 39 specimens during BCS from 39 women (median, 64 years; range, 34-86). Patients who had undergone neoadjuvant chemotherapy were excluded from this study. All patients underwent US core needle biopsy or stereotactic vacuum-assisted biopsy and were histologically diagnosed with breast cancer before surgery.

The final histopathological diagnoses of the patients were DCISs in 7 (18%) and invasive carcinomas in 32 (82%). Among the latter, 28 were invasive ductal carcinomas (IDCs), one was invasive lobular carcinoma and 3 were rare histological types (apocrine breast carcinoma, glycogen-rich clear cell carcinoma and mucinous carcinoma in one each, Table 1,2). The largest diameter of these invasive lesions ranged from 2-28 mm, with a mean of 13.5 mm. According to the TNM classification, T-stages were Tis in 7 (18%), T1 in 26 (67%), and T2 in 6 (15%). Twenty-one out of 32 (66%) invasive carcinomas had the EICs.

Surgical approach

Preoperative marking was performed by a surgeon. Using a US, green dye was injected vertically into the mammary gland and fat tissue around the tumor with 10-20 mm surgical margins, and then BCS was performed. To ensure the orientation of the specimens, the surgeon marked them with a short suture and a long suture on their superior end and the areolar end, respectively (Fig. 1).

Imaging protocol

All specimens underwent DM and DBT by using the same digital system; MAMMOMAT Inspiration (Siemens, Forchheim, Germany), which implements: (i) a W-target X- ray source, combined with Rh-filter; and (ii) an a- Se digital detector with a squared pixel pitch of 85 µm [5]. First, the specimens were placed on the mammography plate, oriented as the anterior-posterior (AP) position and underwent DM (Fig. 2) and DBT (Fig. 3). Next, they were put between two sponges to be oriented as latero-lateral (LL) position and underwent DM (Fig. 2) and DBT (Fig. 3). For DBT, the movable X-ray source spanned an overall angular range of ±25° and 25 projections were acquired at the requested positions. The tube voltages for DM and DBT ranged between 25 and 34 kVp depending
on the specimen size. Using an automatic exposure control, the tube currents for DM and DBT were 13-322 mAs and 13-137 mA, respectively. The oriented specimens were imaged with minimum compression to avoid specimen distortions. Images of DBT were reconstructed by the shift-and-add method and the filtered back projection (FBP) method with a slice thickness of 1.0 mm (Fig.3)[6].

**Image analysis**

All SR images obtained by DM and DBT were sent to a dedicated workstation, Mammo Read Viewer (TOYO Corporation, Tokyo, Japan) and were interpreted by a radiologist with 17 years of experience in breast imaging. The reader was blinded to lesion dimensions and pre- and post-surgical histopathological diagnosis. DM and DBT images of the same patients were presented in independent reading sessions separated in order to avoid recall bias. SR images were compared with the background of fibro-glandular tissue to detect the lesions. For each specimen, the reader recorded on both DM and DBT images for AP and LL views the detectability of the centrally located lesions, invasive lesions and extended areas beyond the margin of centrally-located lesions, respectively. Evaluation of the detectability of SR was performed by comparing lesions with histopathological diagnoses (Fig. 4-7).

**Statistical analysis**

The Fisher exact test was used to compare categorical variables. All tests were two-tailed. The significance level was defined as p<0.05.
Table 1: Final histopathological diagnosis in 39 lesions

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<table>
<thead>
<tr>
<th>Final histopathological diagnosis</th>
<th>No.</th>
</tr>
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<tbody>
<tr>
<td>Invasive carcinomas with EICs</td>
<td>21</td>
</tr>
<tr>
<td>Invasive carcinomas without EICs</td>
<td>11</td>
</tr>
<tr>
<td>DCIS</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 2: Histopathological subtypes in 32 invasive carcinomas

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<table>
<thead>
<tr>
<th>Histopathological subtypes</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive ductal carcinomas</td>
<td>28</td>
</tr>
<tr>
<td>Invasive lobular carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Apocrine breast carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Glycogen-rich clear cell carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Mucinous carcinoma</td>
<td>1</td>
</tr>
</tbody>
</table>
**Fig. 1:** The figure shows the orientation of specimens. To correctly orient the specimens, their margins were marked by the surgeon with a short suture for the superior end (blue allow) and a long suture for the areolar end (yellow allow).

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**Fig. 2:** The figures show the methods of specimen radiography by digital mammography (DM). In the anterior-posterior plane, the specimen was positioned on the mammography plate, and then, the rotated specimen put between two sponges binded with a rubber band was positioned. After setting, DM were performed.

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**Fig. 3:** The figures show the methods of specimen radiography by digital breast tomosynthesis (DBT). In the anterior-posterior plane, the specimen was positioned on the mammography plate, and then, the rotated specimen put between two sponges binded with a rubber band was positioned. After setting, DBT were performed. Then, DBT images were reconstructed like white lines.

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**Fig. 4:** The figure showed the estimation of the detectability of the centrally located lesions for the data analysis

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**Fig. 5:** The figure showed the estimation of the detectability of the invasive lesions for the data analysis

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**Fig. 6:** The figure showed the estimation of the detectability of the DCISs for the data analysis

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**Fig. 7:** The figure showed the estimation of the detectability of the EICs for the data analysis

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Results

AP view

Thirty-seven of 39 (95%) lesions were detected as the centrally located lesions by the DM and DBT method (Fig. 8). Thirty-one of 32 (97%) invasive cancers were detected by the DM and DBT method. Fourteen of 21 (67%) EICs were detected by both methods. While 1 of 7 (14%) and 2 of 7 (29%) DCISs were detected by DM and DBT, respectively, there was no statistical significance (Table 3).

LL view

Twenty-seven of 39 (67%) lesions were detected as the centrally located lesions by the DBT method (Fig. 8); the rates were higher \( p = 0.0003 \) than by DM (11 of 39: 28%). Twenty-three of 32 (72%) invasive lesions were detected by DBT; the rates were higher \( p < 0.0001 \) than by DM (5 of 32:16%). Three (14%) and eight (38%) of 21 EICs were detected by DM and DBT, respectively. Only 1 of 7(14%) DCISs was detected by both methods (Table 3).
Fig. 8: Specimen radiography of a 47-year-old woman treated for a DCIS confirmed at histopathological analysis. In AP view, the reader detected the centered lesion (blue circle) as a polygonal mass with clustered calcifications by DM (A) and DBT (B). Compared with found lesions (yellow lines) at histopathological map (C), the remaining lesions were missed with both DM and DBT. In LL view, the reader missed by DM (D) and detected the centered lesions (blue circle) by DBT (E) compared with found lesions (yellow circle) at histopathological slide (F).

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Table 3: The number of malignant lesions correctly detected with DM and DBT

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Conclusion

SR using DBT could detect breast cancers as accurately as using DM in an AP view. Meanwhile, detection rates of SR of centrally located breast cancer lesions and invasive cancers using DBT mode were significantly higher than using DM mode in an LL view. DBT indicates its potential to more precisely diagnose especially vertical invasion owing to prevented tissue overlap in evaluating breast surgical specimens. Nevertheless, DBT were inexact due to the limited angle; DBT could point out more lesions than DM in an LL view. The main limitation of our study is the small sample size.
References


