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Original article

Comparison of full-field digital mammography and digital breast tomosynthesis in ultrasonography-detected breast cancers

Kyung Jin Nam [a], Boo-Kyung Han [b, *], Eun Sook Ko [b], Ji Soo Choi [b], Eun Young Ko [b], Dong Wook Jeong [c], Ki Seok Choo [a]

[a] Department of Radiology, Pusan National University Yangsan Hospital, Pusan National University School of Medicine, 20 Geumo-Ro, Mulgeum-eup, Yangsan-si, Kyeongsangnam-do 626-770, Republic of Korea
[b] Department of Radiology, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-Ro, Gangnam-gu, Seoul 135-710, Republic of Korea
[c] Department of Family Medicine, Pusan National University Yangsan Hospital, Pusan National University School of Medicine, 20 Geumo-Ro, Mulgeum-eup, Yangsan-si, Kyeongsangnam-do 626-770, Republic of Korea

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ABSTRACT

Objective: To determine what percentage of cancers, detected by screening ultrasonography (US), were detectable by full-field digital mammography (FFDM) and digital breast tomosynthesis (DBT).
Materials and methods: Eighty-four consecutive women in whom mammography was negatively interpreted and supplementary screening US initially detected breast cancers at outside hospitals underwent both FFDM and DBT. We excluded cases with overt suspicious findings on repeat mammography and ineligible cases. In the remaining 41 cases, three radiologists who were blinded to tumor location, even though they were aware that they had breast cancers independently reviewed both FFDM and DBT. The reference standard was the reference FFDM made by two unblinded reviewers who were aware of the tumor location and shape on DBT, US, and magnetic resonance imaging (MRI). The visibility score based on the correct marking was compared between FFDM and DBT.
Results: Among the 41 cases, the cancers were visible in 25 (61.0%) on FFDM and in 34 (82.9%) on DBT ($P = 0.047$) by the unblinded review. In the blinded analysis, the cancers were significantly more "constantly visible" in the three radiologists on DBT than on FFDM [53.7% (22/41) vs. 26.8% (11/41), respectively, $P = 0.013$]. The dominant lesion type was "focal asymmetry" on DBT (39.0%) and "asymmetry" on FFDM (31.7%).
Conclusions: Our analysis suggests that 54% of cancers that were detected by US and were not evident on 2D mammography were detectable by screening using DBT. Additional 29% of cancers were visualized on DBT, when the area of concern was known.

Introduction

Conventional mammography has a known benefit for detecting cancer and is currently the standard of care for breast cancer screening [1,2]. However, mammography has been faulted for its high false-positive rate and low sensitivity, particularly in women with dense tissue [3]. Although a clinical study showed that the advent of full-field digital mammography (FFDM) has increased sensitivity from 55% with screen film to 70% with digital mammography, it continues to be limited for detecting noncalcified breast cancers in women with dense breasts [2,4]. Digital breast tomosynthesis (DBT) removes overlapping of breast tissue, which can mask breast abnormalities, potentially raise sensitivity for breast cancers, and decrease the false-positive rate [5,6]. Tomosynthesis increases the conspicuity of many lesions while reducing the superimposition of structures by reducing structure noise [7]. In the series by Andersson et al., cancer visibility was superior on DBT to that on FFDM, suggesting that tomosynthesis may have higher sensitivity for breast cancer detection [8].

Abbreviations: DBT, digital breast tomosynthesis; FFDM, full-field digital mammography; US, ultrasonography; MRI, magnetic resonance imaging.

* Corresponding author. Tel.: +82 2 3410 2518; fax: +82 2 3410 2559.
E-mail addresses: kj-violet@hanmail.net (K.J. Nam), bkhan@skku.edu (B.-K. Han), es.ko@samsung.com (E.S. Ko), jisoo.choi@samsung.com (J.S. Choi), claudel@skku.edu (E.Y. Ko), dwjeong75@hanmail.net (D.W. Jeong), kschoo0618@naver.com (K.S. Choo).

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Screening ultrasonography (US) has been increasingly used to detect early breast cancer worldwide. According to a multicenter trial of combined screening with mammography and US (ACRIN 6666), combined screening detected an additional 4.2 cancers per 1000 women at elevated risk for breast cancer [4]. That study and a subsequent similar study revealed that cancers seen only on US were mostly node-negative invasive cancers, with a median size of 10 mm [4,9]. The high-prevalence of US-only detected cancers and tolerance of US scanning in women makes US screening implementation possible. Because US-only detected cancers are usually small, it is hard to identify them on mammography, even retrospectively. Due to the inherent limitation of mammography to show sonographically obvious cancers, it has become more difficult to use mammography as a sole method to screen breast cancers. To our knowledge, the utility of DBT in a population of screening US-detected cancers has not been described previously in the scientific literature.

Therefore, the purpose of this study was to determine what percentage of cancers, detected by screening US, were detectable by FFDM and DBT.

Materials and methods

Case descriptions

The institutional review board approved this retrospective study and waived informed consent. A total of 865 women were imaged by both conventional FFDM and DBT of both breasts at our institution from January 2013 to June 2013. Because our institution has a breast cancer center where the majority of the patients were referred from outside hospitals, 455 women had breast cancers. Among them, we identified 84 women in whom mammography was negatively interpreted and supplementary screening US initially detected breast cancers at outside hospitals. The interval between the first mammography at outside and repeat mammography at our hospital was less than 6 weeks. Seventy-one cases were eligible after excluding 13 cases for the following reasons: incomplete image set ($n = 5$), status vacuum assisted biopsy ($n = 5$), status excision biopsy ($n = 2$), and Paget's disease ($n = 1$). To conduct our comparative review session only with the mammographically occult or subtle cancers, one site-radiologist with 17 years breast imaging experience, who did not participate in this comparative study, classified these 71 cases into US-detected, mammographically missed cancers, and US-detected, mammographically occult or subtle cancers. Mammographically missed cancers were those showing retrospectively overt malignant findings on FFDM repeated in our site, which were concordant with those of US-detected cancers. Excluding these 30 cases, the study population included 41 women (mean age, 52.0 years; range, 37–70 years) with US-detected, mammographically occult or subtle cancers.

Imaging methods

Patients underwent FFDM with a commercially available system (Selenia; Hologic, Bedford, MA, USA). DBT images were obtained using a tomosynthesis system (Dimensions, Hologic) utilizing a tungsten tube with 15° tube motion, 0.7 mm aluminum filtration, 11 projection images, a 10-s acquisition time, and a manual technique designed to match radiation dose to that delivered by the digital mammography system. Tomosynthesis was performed in combination with conventional FFDM in all patients who first visited our breast clinic, regardless of breast density and at no cost to the patient. Patients were informed before the examination of the use of tomosynthesis and could opt for conventional FFDM alone. DBT images were obtained for each breast with both craniocaudal (CC) and mediolateral oblique (MLO) projections.

Review sessions

All FFDM images were stored in a centralized picture archiving and communication system. Digital examinations were interpreted on 5-megapixel monitors at full resolution with one breast on each monitor. DBT images were stored in a tomosynthesis-dedicated workstation.

Review sessions were composed of an unblinded review by two informed radiologists and an independent blinded review by three study radiologists who had 2–10 years experience with breast imaging.

In the unblinded review, two informed radiologists (H.B-K., N.K.J.) evaluated the presence of visible findings and determined the location and the lesion type of cancers on FFDM and DBT, based on the DBT, US, and magnetic resonance imaging (MRI) findings, which showed histologically confirmed-malignant lesions. They marked cancer sites with arrows on FFDM images by consensus, regardless of the degree of visibility. Even when the tumor was not visible on FFDM or DBT, arrow marks were made by a ballpark estimation based on the findings of the other modalities. The arrow-marked FFDM images were used as reference images. MRI was done and used for all cases to show the location of the tumors three-dimensionally and to document concordance between US and mammography-identified lesions. Dominant lesion type was divided into negative, asymmetry, focal asymmetry (including architectural distortion), calcifications only, mass, and mass with calcifications. Breast density was scored at four levels using FFDM according to the Breast Imaging Reporting and Data System: 1, fatty; 2, scattered fibroglandular tissue; 3, heterogeneously dense; 4, extremely dense.

In the blinded review, other three radiologists (K.E.S., C.J.S. and K.E.Y.) were blinded to tumor location and shape on US and they were not aware of how many cases contained imaging abnormalities, even though they were aware that the cases had breast cancers that were detected originally in outside hospital US. Other clinical information, including age, examination date, and other imaging findings were also masked. They evaluated the FFDM and DBT images independently with at least a 4 week interval between the reviews to minimize case recall. The cases were presented in a randomized order. The radiologists were able to adjust the viewing window and level and to magnify each image during reading. The study radiologists analyzed the FFDM and DBT images and stored representative slices, if any. They marked the presumed tumor site with an arrow on PACS monitors. If multiple lesions were seen, they chose the lesion showing the most actionable findings. They individually described dominant lesion type. Dominant lesion type was also classified into the above six types. Lesion type in the blinded review was described only for concordance with reference image.

Outcome analysis

One of the informed radiologists (N.K.J.) compared the blinded radiologists' results with the reference images to evaluate FFDM and DBT performance. She assigned a visibility score from 0 to 2 to the cases, based on the location and lesion type they described; score 2 if the reader correctly marked a malignancy in both views (CC and MLO), score 1 if the reader marked a malignancy only in one view (CC or MLO), and score 0 if the reader did not mark a malignancy in any view or marked a wrong site for the interpretation of FFDM and DBT. Two cases that showed malignant lesions in only one view on the reference image were classified as score 2 even though the reader marked a lesion in only one view. If the sum