J Korean Soc Breast Screening 2015 ; 12 : 12-16

Original Article

Comparison of Image Quality of 2 dimensional Digital Mammography and Synthesized 2 dimensional Projection Image from 3-dimensional Digital Breast Tomosynthesis

Jieun Koh, MD, Eun-Kyung Kim, MD, PhD, Min Jung Kim, MD, PhD,
Jung Hyun Yoon, MD, Hee Jung Moon, MD, PhD

*Department of Radiology and Research Institute of Radiological Science, Severance Hospital,
Yonsei University College of Medicine, Seoul, Korea*

Purpose: To compare the image quality and diagnostic performance of reconstructed 2-dimensional (2D) images from 3 dimensional (3D) digital breast tomosynthesis (DBT) with full-field digital mammography (FFDM) in the same patients.

Materials and Methods: A total of 142 patients (mean age 52.9 years, range 36–78 years), who underwent both DBT and FFDM, was included. Synthesized 2D projection images (C View) were reconstructed. Overall image quality, contrast, noise, and visibility of masses and microcalcificaitons were classified using a 5-score scale (1; not acceptable, 2; poor, 3; moderate, 4; good, and 5; excellent) and were compared between FFDM and C View. Cancer probability was scored only in 25 patients with pathologic confirmation. The area under the receiver operating curves (AUCs) of C View and FFDM were calculated.

Results: The scales of image quality, contrast, noise, and mass visibility of FFDM and C View were not statistically different (P=0.211, 0.211, 0.200, and 0.340). Microcalcifications were better visualized on C View than on FFDM (P=0.001). The AUC of C View was 0.981, not significantly different from 0.956 of FFDM (P=0.387).

Conclusion: C View demonstrated comparable image quality, contrast, noise, and mass visibility with FFDM. Microcalcifications were better visualized on C View than on FFDM.

Index words: Tomosynthesis; Synthesized image; Mammography

Introduction

Breast cancer mortality can be reduced by screening using mammography (1). However, despite the many benefits of mammography, several limitations exist including low sensitivity and high false-positive rates (2–4). The common reason for missed breast cancers is overlap with normal breast tissue in 2-dimensional (2D) mammography projections (5, 6). Asian women demonstrate dense breasts especially more than other populations. Cancers are more obscured in these dense breasts and mammography is less effective in detection of cancer lesions (7). Moreover, not only does overlapping breast tissue lower the sensitivity, it also increases the false-positive value of mammography (8). To overcome the limitations produced by the anatomical noise of mammography, digital breast tomosynthesis (DBT) is

Corresponding to: Hee Jung Moon, M.D., Ph.D., Department of Radiology, Research Institute of Radiological Science, Yonsei University College of Medicine, 50 Yonsei-ro, Seodaemun-gu, Seoul 120-752, Korea
Tel: 82-2-2228-7400 Fax: 82-2-393-3035 E-mail: artemis4u@yuhs.ac

nowadays used in clinical practice. Several studies have shown that DBT can reduce recall rates in screening mammography (8-10) and improve clinical performance (11), while maintaining comparable image quality with mammography (8). DBT is used in addition to full-field digital mammography (FFDM) because microcalcifications may not be detected on tomosynthesis alone (12). However, the double exposure of radiation and increase in interpretation time are the main limitations of FFDM being added to DBT (13, 14). During the acquisition of 3-dimensional (3D) tomosynthesis data, 2D images can be generated without additional exposure. DBT plus synthesized 2D projection images were reported to be adequate for screening such as FFDM plus DBT (14). The purpose of this study was to compare the image quality and diagnostic performance of synthesized 2D projection images from 3D tomosynthesis with FFDM in the same patients.

Materials and Methods

The Institutional Review Board approved this retrospective study and waived the requirement for informed consent.

Study population

We included 141 patients who underwent both DBT and FFDM from April 2014 to July 2014. The mean age of the study population was 52.9 years (range 36-78 years). Pathologic confirmation was available in 25 patients, and 11 patients were confirmed by core biopsy, 2 by vacuum-assisted biopsy, and 12 by surgery. Five patients were diagnosed as benign and 20 as malignant. Benign lesions were confirmed to be fibroadenoma (n=1), fibrocystic change (n=1), pseudoangiomatoid stromal hyperplasia (n=1), a benign phyllodes tumor (n=1), and a radial scar (n=1). Malignant lesions were confirmed to be invasive ductal carcinoma (n=16) and ductal carcinoma in situ (n=4).

Image acquisition

Both FFDM and DBT images were acquired using a dedicated tomosynthesis system (Selenia Dimensions; Hologic) operating in combo mode. Both the craniocaudal (CC) view and medio-lateral-oblique (MLO) view were acquired for each breast. Synthesized 2D projection images were reconstructed from 3D data using C View™ software (Hologic).

Image interpretation

One breast imaging radiologist retrospectively analyzed both FFDM and C View. The picture archiving and communication system (PACS) was used for image evaluation. Overall image quality, contrast, and noise were evaluated with a 5-score scale (1; not acceptable, 2; poor, 3; moderate, 4; good, and 5; excellent). The visibility of mass or microcalcifications was also evaluated with a 5-score scale (1; not acceptable, 2; poor, 3; moderate, 4; good, and 5; excellent). Cancer probability was scored with percentage according to suspicious features appearing on C View or FFDM.

Data and statistical analysis

Image quality, contrast, noise, visibility of mass or microcalcifications were compared between FFDM and C View using the Wilcoxon signed-rank test. The existence of masses or microcalcifications was referenced by ultrasound or the magnification view. We evaluated the area under the receiver operating curves (AUCs) for cancer probability in pathologically confirmed cases using pathologic results as the reference standard. A P value <0.05 was considered as significant. All statistical analyses were performed using SPSS Version 20 (SPSS Inc., Chicago, IL, USA).

Results

The scale scores of image quality for FFDM and C View were not statistically different (P=0.211). Image contrast and noise were not significantly different between FFDM and C View (P=0.211 and P=0.200), (Table 1). Mass was visualized in 27 cases. Four masses were visualized on C View but not on FFDM. Two masses were detected only on FFDM. There was no statistical difference of mass visibility between FFDM and C View (P=0.340). Microcalcifications were found in 14 cases. Microcalcifications were better visualized on C View than on FFDM (P=0.001), (Fig. 1).

There were 20 patients who were pathologically confirmed with malignancy. Four patients had microcalcifications only, which appeared on both FFDM and C View. Twelve patients showed mass density only and in one patient, a mass was detected only on C View. Four patients had both microcalcifications and mass density and one patient had microcalcifications only on C View. Among five pathologically proven benign cases, three showed mass density on FFDM and C View, one showed microcalcifications on FFDM and C View, and one showed both mass density and microcalcifications on FFDM and C View. The AUCs for cancer probability in the 25 pathologically confirmed cases were 0.956 for FFDM and 0.981 for C View, respectively (P=0.387).

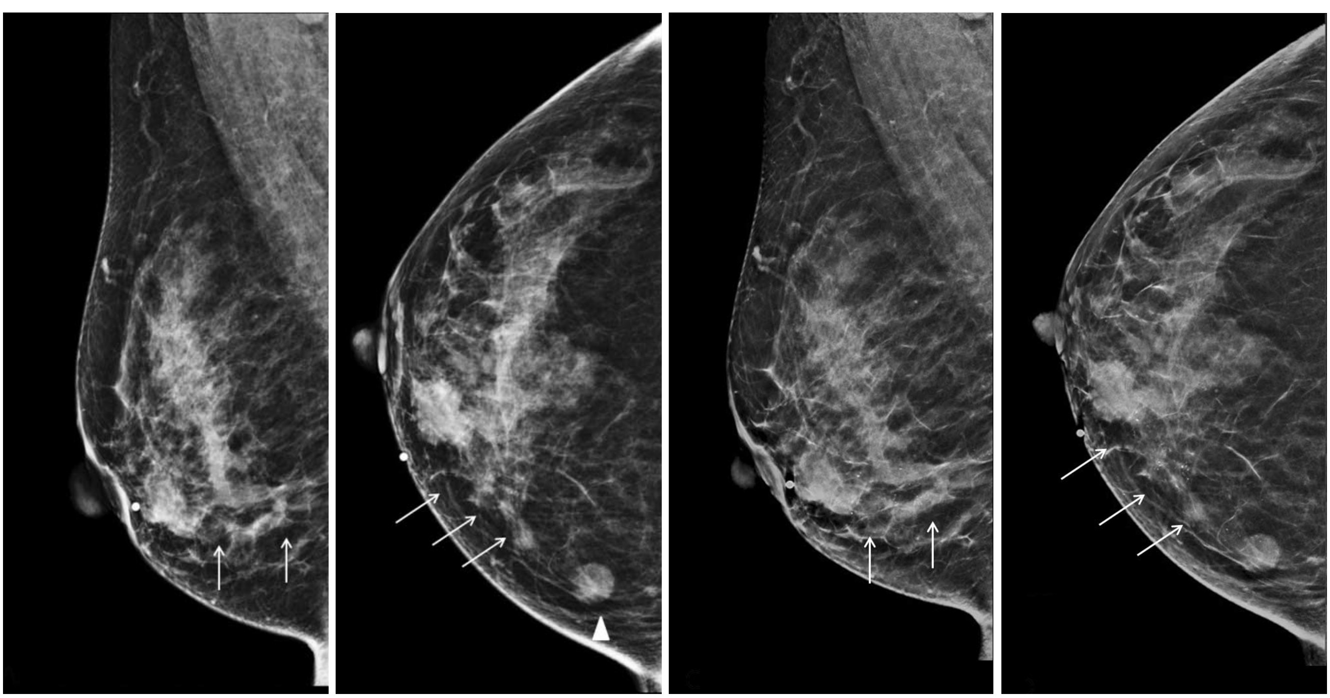
Table 1. The Comparison of Overall Image Quality, Contrast, Noise, Mass Visibility, and Microcalcification Visibility between 2D Mammography and C View

	2D mammography	C View	P value
Overall image quality	4	4	0.211
Contrast	4	4	0.211
Noise	4	4	0.200
Mass	4	4	0.340
Microcalcification	3	5	0.001

Discussion

We compared image quality, contrast, noise, and visibility of masses or microcalcifications on FFDM and C View in the same patients while excluding tomosynthesis images. The image quality, contrast, noise, and visibility of masses and microcalcifications observed on C View were comparable to or higher than those of FFDM. The AUCs of FFDM and C View had high values and were comparable.

In this study, microcalcifications were better visualized on C View than on FFDM. In previous studies, visibility of microcalcifications was compared between DBT and FFDM. DBT demonstrated equal or greater clarity of calcification detection compared with FFDM (15). Another study had conflicting results with FFDM being more sensitive in the detection of microcalcifications than DBT (12). In a recent multicenter study of microcalcification clusters, DBT and FFDM represented discordant characterization in approximately 10% of the study population (16). DBT assigned lower BI-



a b c d

Fig. 1. A 40-year-old female with right breast cancer.
Mediolateral oblique (**a**) and craniocaudal (**b**) view of FFDM show an irregular mass in the lower medial quadrant of the right breast with a skin marker indicating the mass. Linear distribution of fine pleomorphic microcalcifications (arrows) are noted at the medio-posterior aspect of the main mass and another round mass (arrow head) is observed medial to the microcalcifications on craniocaudal view.
Mediolateral oblique (**c**) and craniocaudal (**d**) view of C View show comparable mass detection while microcalcifications (arrows) are more clearly observed than on FFDM.

RADS classification and a small proportion of malignancy was missed, while unnecessary biopsy of benign lesions was avoided (16). Although microcalcifications may be detected with greater sensitivity on DBT, caution is needed when characterizing these microcalcifications. Calcifications are high contrast features that can cause reconstruction artifacts and can appear on every reconstruction plane (17). These artifacts may cause detection errors because more calcifications may appear on C View. This phenomenon should be further evaluated in the future.

The visibility of masses on C View was also comparable with FFDM. These results corresponded with previous studies (14, 18). In the present study, some masses were visible on only one of the C View or FFDM images. The reason for this is not clear but a 3D-reconstructed volume of DBT has limited resolution in depth direction and masses in the out-of-focus plane can be blurred which may explain why they are not detected (19). The fibroglandular tissue may obscure a mass even in C View as it does in FFDM.

The AUC of C View and FFDM had high values, 0.981 and 0.956, respectively. The diagnostic performances of C View and FFDM were not significantly different. DBT is now more commonly in use and expected to overcome the limitations of FFDM caused by structural noise from overlapping normal parenchyma (5). DBT can especially reduce the recall rate in women with dense breasts (18). However, using FFDM with DBT for screening causes an increase in radiation dose (14). C View is applicable in clinical use because it improves the image quality of 2D image reconstruction while avoiding additional radiation from routine FFDM. A previous study which compared the cancer detection rate between FFDM plus DBT and C View plus DBT in different groups also showed comparable results (14).

This study has several limitations. First, this study was of retrospective design. The number of patients was relatively small and the number of pathologically confirmed cases was even smaller. The cases without pathologic confirmation were not included for AUC analysis because at least 12 months of follow-up was thought to be needed to confirm false-negatives. Further validation with a large number of patients is needed. Second, only one radiologist reviewed the images and this might a cause of bias.

In conclusion, C View showed comparable image quality, contrast, noise, and visibility of mass with FFDM. Microcalcifications were better visualized on C View than on FFDM.

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J Korean Soc Breast Screening 2015 ; 12 : 12-16

디지털 유방촬영술과 디지털 유방단층영상합성법의 2차원 재구성 영상의 화질 비교연구

고지은 · 김은경 · 김민정 · 윤정현 · 문희정

연세대학교 의과대학 세브란스병원 영상의학과

목적: 같은 환자에게 촬영된 디지털 유방단층영상합성법의 2차원 재구성 영상과 디지털 유방촬영술의 영상 화질을 비교한다.

대상 및 방법: 디지털 유방단층영상합성법과 디지털 유방촬영술을 동시에 촬영한 142명 (평균 연령 52.9세, 범위 36-78세)이 연구의 대상이 되었다. 디지털 유방단층영상합성법을 통해 2차원 투사영상 (C View)이 재구성 되었다. 디지털 유방촬영술과 C View 각각의 전체적인 영상 화질, 대조도, 잡음, 종괴의 선명도, 미세석회화의 선명도를 5단계로 평가, 비교하였다 (1; 매우 나쁨, 2; 나쁨, 3; 보통, 4; 좋음, 5; 매우 좋음). 악성 예측도는 조직학적 확진이 된 25명에게서 평가가 되었다. C View와 디지털 유방촬영술의 진단 수행도는 area under the receiver operating curves (AUCs)를 구하여 평가하였다.

결과: 디지털 유방촬영술과 C View의 전체적인 영상 화질, 대조도, 잡음, 종괴의 선명도는 통계학적으로 차이가 없었다 (P=0.211, 0.211, 0.200, 0.340). C View에서 디지털 유방촬영술보다 미세석회화가 더 명확히 보였다 (P=0.001). C View와 디지털 유방촬영술의 악성을 예측하는데 AUC 값은 C View에서 0.981이고 디지털 유방촬영술은 0.956으로 통계학적인 차이가 없었다 (P=0.387).

결론: C View는 디지털 유방촬영술과 동등한 영상 화질, 대조도, 잡음, 종괴의 선명도를 보여주었다. 미세석회화는 디지털 유방촬영술보다는 C View에서 좀 더 명확히 보였다.

Index words: Tomosynthesis; Synthesized image; Mammography