



## Initial result of a prospective study: Comparison between a low dose 3D stereo mammography and FFDM

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### Abstract:

**Purpose:** The purpose of this was to identify in prospective study a potential clinical benefit of 3D stereo mammography (3DM) compared to that of FFDM. **Methods and Materials:** In 3DM exam, an additional low-dose image is taken from 4 degree right after taking standard FFDM images in left/right CC and MLO. A total of 1284 patients underwent 3DM exams for diagnostic purpose since February, 2011 through November, 2011. Four experienced radiologists participated to this prospective study. Every day, one radiologist reads only FFDM on a standard mammography workstation and assigns BIRADS scores. Another independently reads stereo-pairs of FFDM and a low dose 4 degree images on a 3DM workstation and assigns BIRADS scores. All of BIRADS 4 and 5 and some of BIRADS 3 patients are recommended biopsy. When biopsy results are collected, FFDM and 3DM BIRADS scores are prospectively compared based on biopsy results.

**Results:** So far, 41 biopsy results were collected. Out of these 41 cases, 18 cancer cases and 23 cancer-free cases were found. Out of 23 cancer-free cases, 9 cases were classified to BIRADS 2 by 3DM but BIRADS 3 or 4 by FFDM. Of the remaining 14 cancer-free cases, there were no meaningful difference between 3DM and FFDM reading results. From this result, specificity was 54.5% for 3DSDM and 13.6% for FFDM. The p-value of the null hypothesis of equal specificities was 0.008.

**Conclusion:** Use of 3DM for breast imaging may have great potential in a substantial decrease in recall rate.

### Purpose:

Over the last decade, there has been a progressive shift in breast imaging. Two-dimensional full-field digital mammography (FFDM) took over film-screen mammography (FSM) in this digital era. Superior performance as indicated by the ACRIN DMIST results [1], image acquisition workflow, improved technologist productivity, reading features, sharing, storage and retrieval were the main factors for technology adoption. However, like FSM, diagnostic outcomes were limited by overlapping tissues, especially in dense breasts, due to the two-dimensional nature of the projection images.

3D stereo digital mammography (3DSDM) is expected to help radiologists overcome this limitation, leading to potential reduction of false readings and thereby further improving diagnoses of breast cancer. Getty, et al. conducted a large prospective study [2] and reported that 3DSDM could provide higher sensitivity and specificity compared to FFDM and that 3DSDM reading time could be shorter than FFDM. However, Getty, et al. used double dose for 3DSDM acquisition compared to FFDM and it was not clear if some improvements came from 3D effect or dose increase.

The purpose of this study is to prospectively identify a potential clinical benefit of a low-dose 3DSDM compared to FFDM as an initial result of an ongoing prospective study.

### Methods and Materials:

Patients had undergone 3DSDM exams since February 3, 2011. All patients had some kind of clinical reasons such as pain or suspect palpation and all exams were for diagnostic purposes. There was no screening examination.

The FFDM system with a 3DSDM option used in this study (Amulet, FUJIFILM Corporation) has received MDD and CE marking in European market. All examinations were performed under informed consent by the participant.

In 3DSDM exam, an additional low-dose image is taken from 4 degree immediately after taking 0 degree images in left/right CC and MLO which are standard FFDM exams (Figure 1). A standard mammography image (0 degree image) and its corresponding 4 degree images are treated as a stereo-pair in the 3DSDM. The acquired stereo-pair images are sent to a 3D mammography workstation with a stereo 3D monitor (RadiForce GS521-ST, EIZO Nanao Corporation). The stereo 3D monitor consists of two 5 mega pixel grayscale monitors for mammography with a half mirror as shown in Figure 2.

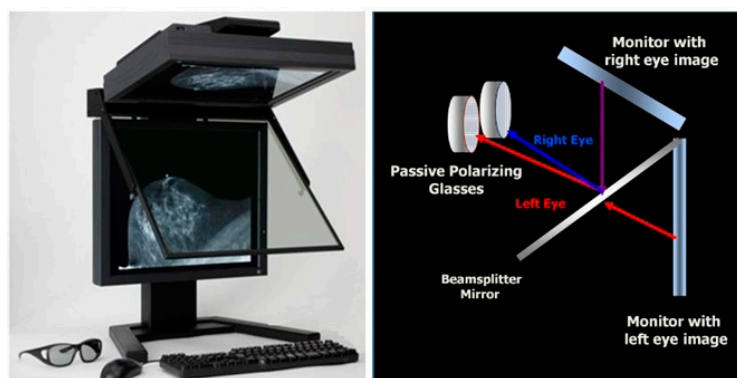


Fig. 2 3D monitor and its mechanism.

Without any reconstruction processes, one of the paired images is displayed on one of the 5 mega pixel grayscale monitors and the other image is on the other monitor. As shown in Fig. 2 (right), the light coming from the top monitor reflected on the half mirror and the light from the bottom monitor comes through the half mirror. The polarization of the light coming through the half mirror rotates 90 degree. By wearing a pair of polarized glasses, viewer's visual system fuses the stereo-paired images into a single instant, in-depth, 3D image of a breast.

The spatial resolution of both 0 and 4 degree images acquired for this study is 50µm/pixel. The target/filter combination used is W/Rh. The average glandular dose used for this study is 1.04 mGy for 0 degree images and 0.35 mGy for 4 degree as shown in Figure 3. These AGD was measured with a 45 mm PMMA phantom.

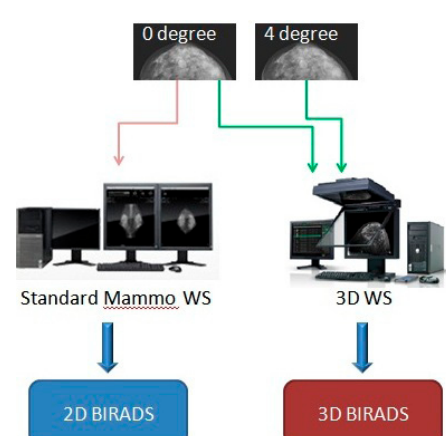


Fig. 4 Comparison of FFDM and 3DM readings

As shown in Figure 4, each day one radiologist read only 0 degree images as FFDM on 2D workstation with two 5 mega pixel grayscale monitors. He reads FFDM with prior films/digital images if available. In addition, he access patients for palpation if necessary. Then, he comes up with BI-RADS categories. In the same day, another independently read stereo-pair images (0 and 4 degree images) of the same cases on a 3D workstation with prior films or prior digital images if available. So far, roughly 80% priors are accessible by films and only remaining 20% are in digital images. Findings from palpation exams done by FFDM readers are shared with 3DSDM readers by writing if available. Then, 3DSDM reader comes up with his own BI-RADS categories.

The 3D workstation has a function to display 2D mammograms on the 3D monitor and can switch between 2D and 3D display modes. But, the 2D display mode is not used in reading 3DSDM in this study to compare purely FFDM and 3DSDM.

Four experienced radiologists with experience ranging from 15 to 25 years of reading mammograms participate to the study. To minimize inter-reader variability, these four radiologists take turns at FFDM and 3DSDM reading. A reader never reads both FFDM and 3DSDM of the same cases.

All of BI-RADS categories 4 and 5 in at least one of FFDM and 3DSDM reading and some of BI-RADS category 3 patients were recommended biopsy. Based on the recommendation, patients are referred to other hospitals/clinics to get biopsy. Biopsy results are collected as many as possible by following up these hospitals/clinics or patients. Based on biopsy results, BI-RADS categories between FFDM and 3DSDM reading were compared in terms of sensitivity and specificity.

Bennett's  $\chi^2$  test [4] was employed to compare sensitivity and specificity between 2D FFDM and 3DSDM.

### Results:

From February 3, 2011 through November 17, 2011, a total of 1284 patients underwent 3DSDM exams. Patients' age ranging was from 19 to 89 years old. Out of these 1284 cases, 6 cases were excluded mainly because of motion artifacts during 3DSDM acquisitions and 1278 cases were used for the analysis.

First, we analyzed BI-RADS category distribution of FFDM and 3DSDM to find out whether or not there are different reading trends between two. Both distributions are shown in Figure 5. As shown in this figure, there is no major difference between two distributions although there are about 3% difference between FFDM and 3DSDM in BI-RADS categories 2 and 3.

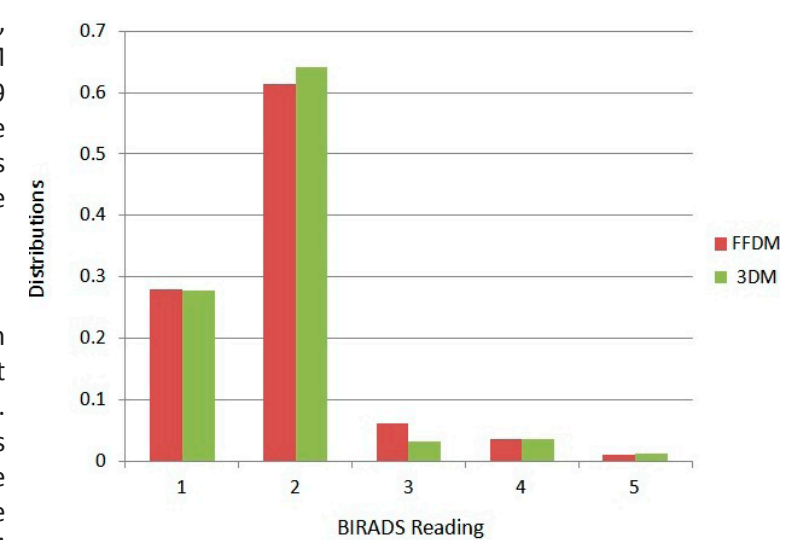


Figure 5 BIRADS distributions of reading on FFDM and 3DM.

BI-RADS categories of FFDM and 3DSDM and the number of cases in each category are shown in Table 1. Of the 1278 cases, 70 cases were rated BI-RADS category 4 or 5 by at least one of FFDM and 3DSDM, 78 cases BI-RADS category 3 by at least one of them (3 or less by the other) and 1130 cases BI-RADS category 1 or 2 by both FFDM and 3DSDM.

By November 17, 2011, forty one biopsy results were collected. As shown in Table 1, out of these 41 cases, 18 cancer and 23 cancer-free cases were identified. Out of 18 cancer cases, one was categorized as BI-RADS category 4 only by 3DSDM but BI-RADS category 2 by FFDM although all other 23 cancer cases were detected by both. On the other hand, 9 out of 23 cancer-free cases were classified as BI-RADS category 2 by 3DSDM whereas they were classified as BI-RADS category 3 or 4 only by FFDM. Of the remaining 14 cancer-free cases, 11 cases were detected as false positives by both FFDM and 3DSDM and the remaining 3 cases were classified to BI-RADS category 1 or 2 by both FFDM and 3DSDM.

Table 1 BI-RADS categories of FFDM and 3DM, and their number of cases.

BI-RADS Categories	Total Cases	Biopsy Findings	
		positive	negative
<b>A total number of cases (Feb. 3, 2011 - Nov. 17, 2011)</b>	<b>1284</b>	<b>18</b>	<b>23</b>
<b>Excluded Cases</b>	<b>6</b>	<b>0</b>	<b>0</b>
<b>BIRADS 4 or 5 (by FFDM or 3DM)</b>	<b>70</b>	<b>18</b>	<b>14</b>
BIRADS 4 or 5 only by FFDM	8	0	3
BIRADS 4 or 5 only by 3DM	12	1	0
BIRADS 4 or 5 both by FFDM and 3DM	50	17	11
<b>BIRADS 3 (at least by FFDM or 3DM) or less</b>	<b>78</b>	<b>0</b>	<b>6</b>
BIRADS 3 only by FFDM	41	0	6
BIRADS 3 only by 3DM	7	0	0
BIRADS 3 both by FFDM and 3DM	30	0	0
<b>BIRADS 1 or 2 (by FFDM and 3DM)</b>	<b>1130</b>	<b>0</b>	<b>3</b>

Table 2 Breast density distributions.

ACR BI-RADS classification for breast density	Total
<b>A total number of cases (Feb. 3, 2011 - Nov. 17, 2011)</b>	<b>1284</b>
<b>Excluded Cases</b>	<b>6</b>
Type 1	154
Type 2	615
Type 3	469
Type 4	32
Not Recorded	8

Distribution of the ACR BI-RADS classification for breast density was shown in Table 2. The breast density types were made by FFDM only.

Table 3 Cancer-free cases.

	FP	TN
3DM	10	12
FFDM	19	3

Table 4 Cancer cases.

	TP	FN
3DM	19	0
FFDM	18	1

Table 5 Sensitivity and specificity.

	Sensitivity	Specificity
3DM	100%	54.5%
FFDM	95%	13.6%

By taking only biopsy proven cases including cancer and cancer-free cases, sensitivity and specificity of FFDM and 3DSDM were calculated and are shown in Table 3. As shown in this table, sensitivity was 100% for 3DSDM and 95% for FFDM. Obviously there is no difference in sensitivity between FFDM and 3DSDM. On the other hand, specificity was 54.5% for 3DSDM and 13.6% for FFDM. The null hypothesis of equal specificities was tested by using Bennett's  $\chi^2$  test and it turned out p-value = 0.008. By this result, it is able to say that there is a statistically significant difference between specificities between 3DSDM and FFDM. The null hypothesis of equal sensitivities was tested, too. It turned out p-value=0.317 and there is no statistical difference in sensitivities.

### Conclusion:

Use of 3D Stereo Digital Mammography may have great potential in a substantial reduction of the recall rate.

### References:

- [1] Pisano E, Hendrick RE et. al. "Diagnostic Accuracy of Digital versus Film Mammography", Radiology; 246:376-383 (2008).
- [2] Getty, DJ, D'Orsi, CJ and Pickett, RM. "Stereoscopic digital mammography: Improved accuracy of lesion detection in breast cancer screening," Proceedings of the International Workshop on Digital Mammography, 74-79 (2008).
- [3] Bennett, BM, "On comparisons of sensitivity, specificity, and predictive Value of a number of diagnostic procedures", Biometrics, 28, 793-800 (1972).