BREAST DOSES FOR TOMOGRAPHY EXAMINATIONS: A PILOT STUDY

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Abstract

A number of clinical studies have been developed to analyze the sensitivity and specificity of breast tomosynthesis (3D) against 2D digital mammography. The results of these studies suggest that tomographic acquisitions may have a higher sensitivity for breast cancer detection. The aim of this work is to analyze the mean glandular doses delivered with a particular tomography system (Selenia Dimensions) recently installed and to evaluate the impact on breast doses. The mammography examinations with the tomographic system consist of two views per breast and 3D and 2D acquisitions for each view. Data related to both acquisitions for 100 women were recorded from the images at the work station. We also recorded the data corresponding to the previous examinations made for each patient with the previous mammography system (Selenia). MGDs were estimated from the measured tube output, the mAs corresponding to each exposure, the conversion factors tabulated by Dance and the tomography factor also tabulated by Dance for this particular system. MGD for 3D plus 2D per view is around twice the values for 2D exposures with the Selenia Dimensions, and 1.4 times the values for 2D with the old Selenia system.

1. INTRODUCTION

A number of clinical studies have been developed to analyze the sensitivity and specificity of breast tomosynthesis (3D) against planar mammography. The results of these studies indicate that the cancer visibility on 3D examinations is superior to digital mammography, which suggests that tomographic acquisitions may have a higher sensitivity for breast cancer detection. As a consequence, it has the potential to decrease the recall rate when used adjunctively with digital mammography [1-3]. While the combination of the Selenia's 2-D and 3-D images approximately doubled the radiation dose the patient received, it improved the accuracy with which radiologists detected cancers, decreasing the number of women recalled for a diagnostic work-up. There is uncertainty for radiation risk estimates; however, the increase in cancer risk from having both a 2-D and 3-D exam is expected to be less than 1.5 percent compared to the natural cancer incidence, and less than 1 percent compared to the risk from conventional 2-D mammography.

The benefits encountered during the clinical studies for the tomography systems have to be outweighed against the risks associated with the highest doses of this type of examinations. The aim of this study is to analyze the mean glandular doses delivered with a particular tomography system (Selenia Dimensions) recently installed and to evaluate the impact on breast doses.

2. MATERIALS AND METHODS

Breast examinations were performed with the system Selenia Dimensions (Hologic Inc, Bedford, USA) installed in a facility belonging to a big hospital in the Madrid area. The facility provides services to the breast screening program of the Madrid area and also makes diagnostic examinations. The system is able to perform both digital breast tomosynthesis (3D) and full-field digital mammography (2D). The X ray tube is equipped with W target filtered with 0.7 mm thick Al filter for 3D acquisitions, and 50 μm-thick rhodium or silver filters for 2D acquisitions. The source to image distance is 70 cm with 2.5 cm air gap between the detector and the breast support table. The a-Se detector is 24 × 28 cm and rotates around an axis located on the detector surface and perpendicular to the chest wall [3].

2D images are obtained at clinical conditions using the auto-filter mode setting for the automatic exposure control (AEC). In this modality the exposure factors are selected in base on the thickness of the compressed breast and from breast attenuation data derived in a pre-exposure (5 mAs for breast thickness <5 cm and 10 mAs for breast thickness ≥5 cm) made before each exposure. 3D acquisitions consist of 15 projections over a 15º angular range (from -7.5º to +7.5º). The target/filter combination is W/Al and the kVp depends on the breast thickness following a low-dose protocol. The tube loading for each projection is the same. As recommended [4], the mammography examination will consist of a 2D image set or a 2D plus 3D image set (named COMBO). In our case, the set COMBO is performed in all mammography examinations regardless of whether it is for screening or diagnosis. Thus, the examination consists in two views per breast: craniocaudal (CC) and mediolateral-oblique (MLO). For each view, 2D and 3D acquisitions are performed.

Demographic and exposure data were collected for one hundred patients at the work station of the facility. In order to evaluate the impact of the new imaging modality on breast doses, we also collected data of the last examination performed for each patient before the tomographic system was installed. In this case, breast images were acquired with a Selenia system (Hologic Inc, Bedford, USA).

Mean glandular dose (MGD) for 2D and 3D examinations were estimated using, respectively,

$$\boldsymbol{MGD_{2D} = K_{2D} gcs} \quad (1)$$

$$\boldsymbol{MGD_{3D} = K_{3D} gcsT} \quad (2)$$

where
g, c and s are conversion factors tabulated by Dance [5, 6, 7];
T is the tomo factor which is also tabulated according with the geometry and features of the Selenia Dimensions tomographic system [7];
K_{2D} is the incident air kerma at the top surface of the breast without backscatter; and
K_{3D} is the total air kerma delivered during the tomographic acquisition.

K_{2D} was calculated from the tube output (previously measured for each kV and target/filter combination) and the tube loading (mAs) of each exposure. In the case of 3D, the tube output is measured at the 0º position and K_{3D} is determined from the tube output multiplied by the total mAs for the examination. The resulting values were corrected for the appropriate focus-breast distance. The conversion factors depend on the (target/filter combination), X ray beam quality (half-value layer), compressed breast thickness and breast glandularity. T-factor depends only on the breast thickness. The MGD associated with the pre-exposure were added to MGD values related to the main exposure. Since it was not possible to determine the individual breast glandularity, we followed the approach described in the European Guidelines. Women were divided into two groups as a function of the age: 40-49 years and 50-64 years [8]. For each group, the glandularity depends on breast thickness.

Tube output and half value layer were measured with an ionization chamber from Radcal (Model 20x6-6M, Radcal Corp., Monrovia, Ca) with a radiation monitor controller Radcal (Model 2026C) and Al sheets of 99.99 purity.

3. RESULTS

A total of 100 woman were included in the study. The average age was 54y (±11y), ranging from 33y up to 83y. The average thickness was 55 mm (±14 mm), ranging from 19 mm up to 90 mm. Approximately 70% of the examinations were registered as for screening.

AEC settings for 2D images acquisition were W/Rh (86%) for breast thicknesses lower than 75 mm with a kVp selection ranging from 25 kV up to 32 kVp, 30 and 31 kVp being the most frequently selected (50% of the cases). The W/Ag combination (14%) was selected for breast thicknesses higher than 75 mm. The kilovoltage for this case ranging from 30 kVp up to 34 kVp. The imaging techniques, comprising tube voltage chosen for 3D acquisitions are summarized at Fig. 1. The kV

setting most frequently selected is 29 kV (67%) for breast thicknesses between 35 and 55 mm. The average mean glandular dose (MGD) per image for 3D acquisitions was 1.3 mGy (±0.5) ranging from 0.5 mGy up to 3.5 mGy. The corresponding value for 2D acquisitions was 1.0 mGy (±0.4) ranging from 0.4 mGy up to 2.9 mGy. MGD per image for both 2D and 3D acquistions are lower than the acceptable and achievable levels defined in the European Guidelines [8] [Fig. 2 (left)] and also lower than the corresponding values estimated using PMMA blocks[Fig. 2 (right)] during the quality control procedures.

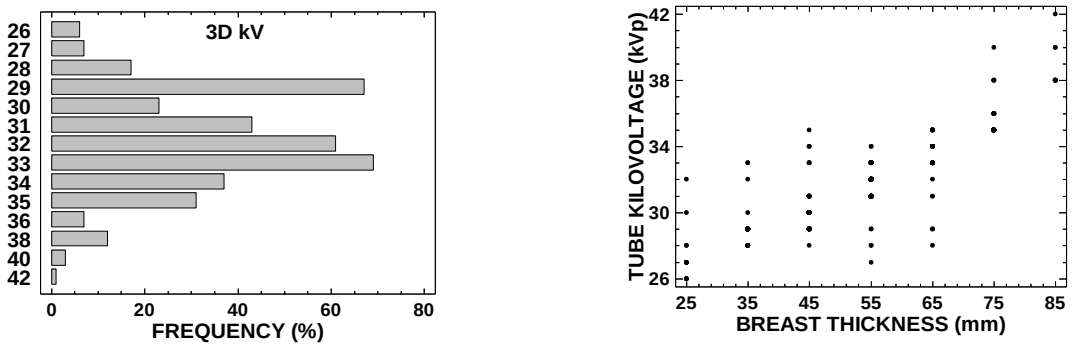

FIG. 1. Imaging techniques for tomographic acquisitions. The target/filter combination used was always W/Al.

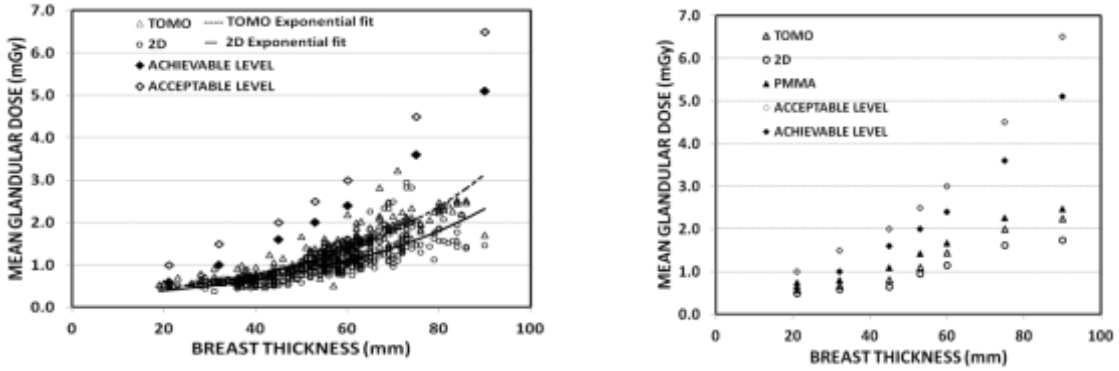

FIG. 2. Mean glandular dose per image for 2D and 3D acquisitions (left). Mean glandular doses averaged for breast thicknesses intervals to compare with values determined using PMMA blocks (right).

The total MGD delivered per view (MGD COMBO) was calculated by summing the corresponding MGD/image associated with 2D and 3D acquistions for each view. The average value is 2.3 mGy (±0.9) ranging from 1 mGy up to 5 mGy.

MGD values delivered with the COMBO modality (2D+3D per view) are spread in a wider interval in comparison with the corresponding ones for 2D examination (Fig. 3). On average, MGD for the COMBO modality is a factor of 2.2 higher than the 2D acquisition for the Selenia Dimensions system. This factor has been also calculated by considering the MGD delivered to each patient by using the mammographic system previously installed at the facility (Selenia system). In this case, the factor is 1.4 on average.

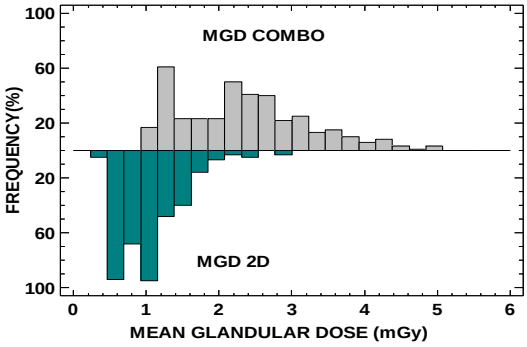

FIG. 3. MGD histogram for the COMBO modality (2D+3D) and the 2D modality.

TABLE I. RATIOS OF MGD COMBO AND MGD FOR 2D ACQUISITIONS WITH SELENIA DIMENSIONS AND SELENIA FOR COMPRESSED BREAST THICKNESS INTERVALS.

Breast thickness (mm)	MGD-COMBO/2D-MDG Selenia Dimensions	MDG-COMBO/ 2D-MDG Selenia
20-30	2.12	1.12
31-40	2.18	1.12
41-50	2.25	1.04
51-60	2.24	1.53
61-70	2.27	1.82
71-80	2.23	1.58
81-90	2.31	

4. CONCLUSIONS

Breast doses per image delivered with the tomographic system in both modalities (2D and 3D) are lower than the acceptable level defined in the European Guidelines for compressed breast thickness between 21 and 90 mm. According to FDA recommendations, 3D acquisitions have always to be performed in conjuction with 2D acquisitions (COMBO modality). In this case, MGD are a factor of 2.2 higher than the corresponding values for only 2D acquistions. The differences between both modalities decreases if the previous mammographic system installed (1.4) is considered. This result makes more valuable the benefits derived from the imaging techniques associated with 2D Selenia Dimensions.

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