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Comparison Between Film-Screen and Digital Mammography for Woman Breast Cancer Screening: Mean Glandular Dose

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Abstract: Introduction: Most studies in mammography have only been carried out in a comparison of image quality and lesion detection in film-screen mammography (FSM) and full field digital mammography (FFDM) systems. The aim of this paper was to evaluate mean glandular dose (MGD) of patient and affecting factors by FSM and FFDM to estimate which one gives a brief radiation protection to patient. Material and Methods: The FSM units with fast and slow screen film detectors used for comparison to FFDM in this study. In addition to technical factors, a set of data consisting of age, weight, height and compressed breast thickness (CBT) were also recorded for each patient.Results: Entrance skin exposure (ESE) for CBT of 4cm, 27 kVp in FSM by fast and slow screen film detector, was 4.5 mR/mAs and 11 mR/mAs, respectively. But ESE variation by FFDM (Gitto) by Mo filter was 14 mR/mAs. In conventional units, mean CBT of 6.02 cm with fast and slow screen film detector were 1.55 and 1.96 mGy. In digital unit by mean CBT of 5.41 cm, MGD was 2.26 mGy, respectively. Significant correlations were observed between MGD and breast thickness, breast density, applied kVp and mAs.inConclusion: In spite of advantages presented by digital technology, this technology leads to a significantly greater MGD to patient when comparing to conventional mammography especially with fast film-screen mammography and patients with high breast thickness.

Key words: Film-Screen · Digital · Mammography · MGD

INTRODUCTION

Mammography is one of the most recommended methods for early detection of breast abnormalities [1]. Mammography screening in women leads to reduction of mortality [2]. The past decade has seen the rapid development of mammography in many techniques. Despite its long clinical success, mammography has a number of problems in use if radiation protection of patient is not carefully regarded [3]. However, there have been rare control studies which compare differences in mammography equipments in patient radiation dose. Also, there is controversy in the amount of patient dose received from conventional and digital mammography.

Direct exposure films were the first common receptors for mammography examinations. Film-screen receptors compared with direct exposure films reduces patient dose and not only provides higher contrast at medium film densities but also image receptor speed. Digital units which have been almost in use from 2000 have all the characteristics of a film-screen unit but the last element of the imaging chain, the detectors, is different. Digital mammography use laser-stimulated photo-stimulatable phosphors and by removing the films and screens from the imaging chain, these units could provide a higher dynamic range and allow to digital archiving and easy image transport including teleradiology.

Most studies in mammography have only been carried out in a comparison of image quality and lesion detection in conventional film-screen mammography (FSM) and full field digital mammography (FFDM) systems [4]. However, numerous studies have attempted to compare patient mean glandular dose (MGD) in FSM and FFDM unites.

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Development of mammography is an important issue in breast cancer diagnosis but problem of optimization of image quality and patient dose is becoming more and more of a priority in X-ray imaging, as reflected by European legislation [5]. What makes these studies important is that, the optimization of the mammographic procedure is crucial as the female breast is a comparatively radiosensitive organ [6]. During the history of mammography several dose indices were suggested. Among those indices the mean glandular dose (MGD) to the breast has become the most popular quantity for estimating the risk from mammography, because the breast cancer almost always initiates from glandular tissue of the breast. On the other hand, the invivo measurement of MGD which means the average radiation absorbed dose to glandular tissue of the breast is not practically feasible. Thus, the method of MGD estimation includes the measurement of the entrance skin exposure (ESE) and multiplying by the exposure to dose conversion factors derived from Monte-Carlo simulations. Wu *et al*. [7] and Wu *et al*.[8] developed a Monte-Carlo model which was validated by experimental methods. They calculated X-ray spectra for different anode-filter combinations and determined the normalized glandular dose to the breast for all studied anode-filter combinations as conversion factors. These conversion factors were dependent on beam quality, (which depends on anode/filter/kVp), compressed breast thickness and breast parenchymal pattern. In published researches we did not find data for FFDM (Gitto) in comparison with other FSM units. So, perhaps this is first comparison data of this device. The aim of this paper was to evaluate MGD and factors affecting it during mammography examinations by FSM and FFDM units to estimate which one gives a brief radiation protection to patient.

MATERIALS AND METHODS

In this research, 1497 mammograms performed by film-screen mammography (FSM) and full field digital mammography (FFDM) systems requested by physician from 390 patients referred to the radiology center. Mammograms obtained in both craniocaudal (CC) and medio-lateral oblique (MLO) views were included.

The FSM unit of GE Senographe 600T (general Electric, USA) with fast screen film detector, Philips (mammo-Diagnost U, Netherland) with slow screen film detector and FFDM unit (Giotto Image, Bologna- Italy) have been used in this study. FSM is equipped with Molybdenum (Mo) anode, filters of Mo and Al are available and images were obtained in semi-automatic mod. FFDM unit was equipped with a 0.3 mm molybdenum target and also two Molybdenum and Rhodium filters were available. All the images were obtained in automatic mod in which appropriate filter, kVp, mAs were set by the unit. In the current study Quality Control (QC) program was performed on FS and FFD mammography units.

The exposure factors including kVp, mAs and filter type were recorded for all mammograms. In addition to technical factors, a set of data consisting of age, weight, height and compressed breast thickness were also recorded for each patient. Compressed breast thickness (CBT) was measured using ruler from the top of compressor paddle to the image receptor by the technologist radiologist. Classification of breast parenchymal pattern of the patient was performed according to Wolfe [9], by three expert radiologists with at least 10 years of experience. According to this classification breast parenchymal patterns divided to 4 Types including: Type 1 (almost entirely fat, <25% fibroglandular), Type 2 (scattered fibroglandular densities, 25-50% fibroglandular), Type 3 (heterogeneously dense, 51-75% fibroglandular), Type 4 (extremely dense, >75% fibroglandular). ESE measurement was performed using a semi-circular phantom of polymethylmethacrylate phantom consisting eight slabs with 0ne cm thickness placed in parallel to the compression paddle (CC view of mammography)

The relation between ESE and applied kVp for different breast thicknesses compared by type of anod-filter and mammography units in phantom. To calculate the mean glandular dose for each view, tube output in terms of entrance skin exposure per mAs (mR/mAs) was measured using a semi-conductor detector (T60005, PTW-Freiburg dosimetery and quality control kit, Germany). ESE measurement was performed by semi-circular using a Polymethylmethacrylate (PMMA) phantom consisting eight slabs with one cm thickness placed in parallel to the compression paddle (CC view of mammography). Methods for ESE measurement by phantom were described [10]. In most recent studies MGD is measured with two different conversion factors. In this study conversion factor of Wu et al and NCRP report No. 149 were used. To calculate the MGD for each view, in two unites a MATLAB m-file was programmed to extract the appropriate exposure to dose convertor (D_{gN}) from tables based on used kVp, filter, HVL of the beam, compressed breast thickness and breast parenchymal pattern of the patient.

Then MGD (D_g) was calculated using the following equation:

$$D_g = D_{gN} . X_{ESE}$$

Where D_{gN} is the normalized average glandular dose (average glandular dose per unit entrance skin exposure) and X_{ESE} is the entrance skin exposure associated with the mammography examination and is calculated through ESE per mAs for appropriate kVp and breast thickness multiplied to the applied mAs for the breast examination.

RESULT

Quality control results for kVp accuracy and reproducibility for FSM (GE and Philips) and FFDM (Mo and Rh filter) by ranging from 25-35 kVps, output (mR) linearity with mAs were performed during this project. The variation of ±5% from selected kVp has been recommended as acceptable in both units.

A comparison of entrance skin exposure (ESE) and kVp, mAs with compressed breast thickness (CBT) of 2-8 cm studied. ESE for CBT of 4cm and 7cm at (27, 32) kVp in FSM (GE), were (4.5, 8.5 mR/mAs) and (8, 12 mR/mAs), respectively. But in Philips (FSM) in same CBTs and kVps, ESE were (11, 19 mR/mAs) and (14, 22 mR/mAs) (respectively. ESE variation by FFDM (Gitto) by Mo filter, CBT of 4 and 7cm, at (27 and 32) kVps were (14, 22 mR/mAs) and (15, 24 mR/mAs), respectively. But by Rh filter, ESE were 11, 19 mR/mAs at same kVps in 7cm CBT.

FSM Unit: The mean age of patient was 44.1 years ranging from 20-77 years old. About 3.4% of studied population was 20-30 years and 28.6%, 45% and 15% were seen for subsequent decades, respectively. Finally, 8% were over 60. The mean height and weight values of 162±4.9 cm and 71.7±12.8 kg were observed for studied population. The mean BMI was 26.6±2.7, ranging from 21.7 to 47.8.

Most women (52.3%) in the current study had type 2 breasts. The most frequent pattern after type 2 was type1 which belonged to breasts with high percent of adipose tissue. MGD of Patients who have Type 1 breast (fatty) and Type 4 (very dense) were 1.64mGy and 0.75mGy, respectively.

CBT of ranging from 3.06 to 8.16 cm were seen with a mean of 6.02±1.13cmm. CC and MLO position`s CBT were 5.7 and 6.34 cm, respectively. MGDs ranging from 0.31 to 3.52 mGy were resulted with a mean of 1.55±0.67 are shown in Table 2. A pearson correlation test was applied for evaluation of correlation between MGD and breast thickness and a correlation coefficient (R^2) of 0.653 was resulted. The same method was performed for KVp and mAs correlation with MGD and correlation coefficients (R^2) of 0.667 and 0.860 were resulted, respectively.

To evaluate the correlation between MGD and breast density and composition, a spearman correlation test was performed and statistically significant correlation at 0.01 level was seen.

Table 1: Descriptive analysis of exposure factors and MGD (mGy) for CC and MLO mammograms in FFDM.

FFDM		*CBT*	*kVp*	*mAs*	*MGD*
CC	Mean	4.9±1.0	28.5±1.5	73.7±16.6	2.0±0.7
	Minimum	2	25	37	0.6
	Maximum	8	32	170	5.5
MLO	Mean	5.8±1.2	29.5±1.4	87.6±22.7	2.4±.8
	Minimum	2	25	42	0.7
	Maximum	9	32	195	5.8

Table 2: Descriptive analysis of exposure factors and MGD (mGy) for CC and MLO mammograms in FSM

FSM		*CBT*	*kVp*	*mAs*	*MGD*
CC	Mean	5.7±1.1	28.8±1.2	131.1±58.8	1.46±0.6
	Minimum	3.06	26	52	0.3
	Maximum	7.76	32	250	3.5
MLO	Mean	6.3±1.0	28.9±1.1	158.8±57	1.64±.6
	Minimum	3.26	27	35.6	0.31
	Maximum	8.16	32	269	3.2

FFDM Unit: The mean age of studied population was 45.7 years ranging from 26-76 years old. About 2.7% of studied population was 20-30 years and 26.5%, 44% and 20.8% were seen for subsequent decades, respectively. Finally, 6% was over 60. The mean height and weight values of 156±6 cm and 72.7±1.2 kg were observed for studied population. The mean BMI was 29.4±5.3, ranging from 17.7 to 47.8.

Most women (54.4%) in the current study had type 2 breasts. Type1 breast was the most frequent pattern after type2 with almost adipose tissue. The effect of breast parenchymal pattern on MGD has been shown in Table 1.

A significant correlation was also seen between MGD and breast parenchymal pattern (p<0.01). Additionally, significant correlations were also seen between breast parenchymal pattern and age, weight and BMI. Otherwise, a negative correlation coefficient showed that the breast glandular content decreases with increasing age, weight and BMI.

Mean compressed breast thickness for CC and MLO images were shown to be 4.9±1 and 5.8±1.2 cm, respectively, with 5 cm as the most frequently seen for both views. For MLO views, CBT ranged from 2-9 cm and for CC views, CBT ranging from 2-8 cm were observed.

A significant correlation between MGD and CBT was seen with a correlation coefficient of 0.692. To analyze the difference between MGD of thin breast (less than 5 cm) and thick breasts (more than 5 cm) a significant difference was seen (P<0.01). MGD of Patients who have Type1 breast (fatty) and Type 4 (very dense) were 2.48mGy and 1.67mGy, respectively.

The analysis of technical factors used in examination showed that mAs ranged from 42 to 195 for MLO versus 37 to 170 for CC positions. But the most frequently used kVp was 30 for both views. The correlation coefficient of 0.829 was seen between MGD and applied kVp that it was statistically significant at 0.01 levels ($p < 0.01$). The measured MGD ranged from 0.67 to 5.59 mGy especially due to mAs variation. A correlation coefficient of 0.890 was also seen for MGD and mAs, the correlation was significant at 0.01 level ($p < 0.01$). Also, filter effect of Mo and Rh showed the mean MGD 2.06 and 2.96 mGy, respectively. The mean MGDs of 2 and 2.4 mGy were estimated for CC and MLO views, respectively. The descriptive analysis between exposure factors and MGD has been shown in Table 1.

Relation between mean ages, CBT and BMI in each groups of breast Types of women undergoing to mammography is showed in Figure 1.

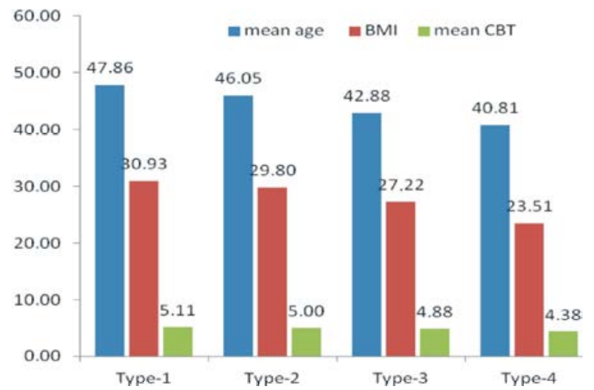

Fig 1: Relation between breast Types and mean ages, CBT and BMI in each groups.

DISCUSSION

The present study was designed to determine of FSM and FFDM units' deference on the patient dose and factors affecting it during mammography. We found MGD can be affected with these factors: patient body characteristics (age, CBT, BMI, type of breast), mammography type and radiation output and dose convertor factor. Preliminary studies showed no differences in sensitivity in detecting cancers between conventional mammography and soft copy digital mammography in women after 50 years old [11].

Patient age is one of the important factors which affect on the breast parenchyma. The mean age observed in the current study population (45.7 y) has shown lower than Asian [12] and other countries [13, 14]. In this paper unfortunately we found that more than 29% of referred women to mammography are under 40 (20-40) years old. Because of sensitivity of breast composition in younger woman to radiation dose, selection and using mammography unite with lower dose, is recommended.

In both mammographies' unites by CC and MLO positions a direct relation was observed between MGD and breast thickness. The patients with thicker breasts received higher dose. CBT of CC position by FSM and FFDM were 5.2 and 4.9 cm, respectively. But MGDs were calculated 1.46 mGy for FSM lower than 2 mGy for FFDM in comparison. Also, the dose of max and min recorded CBT for both mammography units were lower for FSM (table 2). In MLO position CBT was more than CC position for FSM (6.34 cm) and for FFDM (5.8 cm) but MGDs were 1.64 mGy and 2.4 mGy, respectively. Therefore, these results have shown that even in patients with lower CBT higher MGD received in FFDM unit. Also, in thicker breast, 8 and 9 cm MGDs were 5.5

and 5.8 mGy, respectively. However, different organizations have recommended different MGD limiting values and in different countries almost all agree with the ACR recommendation which has determined 3 mGy as the dose limit for a mammography examination [15]. But measured MGD by FFDM for thicker breast was higher than standard dose recommended by ACR. In respect to no statistically significant difference in cancer detection rate in FS and FFD systems [16], in patient with big size and thicker breast using FSM is recommended for radiation protection purpose. In comparison of Mo and Rh filters, Rh filter had been used mostly for imaging breasts thicker than 6 cm, and it was seen that using Rh filter instead of the Mo reduce MGD about 26% in FFDM.

In comparison of relation of MGD and breast paranchymal patterns, Type1 (fatty) and Type 4 (very dense) were including high and low dose receiving pattern of patients. It seems that increasing of density of breast parenchyma dose not induce to MGD increases. The mean BMI was 29.4, which is apparently more than standard BMI.

Three main categories in the published papers titled comparison between FSM and FFDM in breast doses were found: 1) in calculated MGD did not find significant difference between FSM and FFDM unites [17]. 2) MGD of FFDM was higher than measured by FSM unit [14]. 3) The MGD was significantly lower for FFDM in comparison to FSM but not all of the FFDM unites provided lower doses than FSM units [18]. But they did not determine kind of image receptor (slow or fast) of FSM systems. AS the Moran and colleagues showed that mean estimated entrance surface air-kerma (ESAK) value delivered by FFDM system was higher than value obtained for fast screen film combination. Dose values for small and intermediate breasts are similar for FFDM unit and for FSM with slow image receptors but much higher if compared with FSM with fast image receptors [14].

Also, present study showed that effectiveness of type of FSM on the amount of ESE with 27 and 32 kVp for different breast thicknesses showed that there is about twice variation between FSM by GE and Philips units. In FFDM with two types of filters (Mo, Rh) showed 1.2 time variation with same mammography conditions.

It should be reminded that digital unit has ability to image processing post mammography therefore, when technologist dose not sure about technical factors or developing condition of film for avoiding of mammogram repeat of and patient double dose of radiation, using FFDM preferred.

In conclusion, the MGD obtained in the present study was higher to FFDM in comparison to SFM with fast image receptor in small to large breast sizes. Therefore, for optimization of patient dose who candidate for mammography, determining of patient age which refer to sensitivity of breast, size or thickness of breast and image receptor of FSM unite should be carefully consider in selection of mammography unites (FFDM or FSM).

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REFERENCES

1. Jacobson, D.R., 1998. Mammography radiation dose and image quality. Radiation Protection Dosimetry, 80: 295-297.
2. Shields, M. and K. Wilkins, 2009. An update on mammography use in Canada, Health reports, statistics canada.
3. Kwan, H., R.J. Aus, L.A. Dewerd and J.R. Vetter, 1997. Entrance Skin Exposure and Mean Glandular Dose: Effect of Scatter and Field Gradient at Mammography. Radiology, 205: 395-398.
4. Undrill, P.E., A.D. O'KANE and F.J. GILBERT, 2000. A Comparison of Digital and Screen-Film mammography using Quality Control Phantoms. Clinical Radiology, 55: 782-790.
5. European Commission, 1997. Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionizing radiation in relation to medical exposure, and repealing directive. 84/466/Euratom. Official Journal of the European Communities L., 180: 22-27.
6. Eklund, S., A. Thilander, W. Leitz and S. Mattson, 1993. The impact of anatomic variations on absorbed radiation doses in mammography. Radiation Protection Dosimetry, 49: 167-170.
7. Wu, X., G. Barns and D.M. Tucker, 1991. Spectral Dependence of Glandular Tissue Dose in Screen-Film Mammography. Radiology, 179: 143-148.
8. Wu, X., E.L. Gingold, G. Barns and D.M. Tucker, 1994. Normalized Average Glandular Dose in Molybdenum Target- Rhodium Filter and Rhodium Target-Rhodium Filter Mammography. Radiology, 193: 83-89.

9. Wolfe, J., S. Albert and S. Belle, 1982. Salane M. Breast Parenchymal Patterns: Analysis of 332 incident Breast Carcinomas. American Journal of Radiology, 138: 113-8.
10. Skaane, P., S. Hofvind and A. Skjennald, 2007. Randomized trial of screen-film versus full-field digital mammography with soft-copy reading in population-based screening program: follow-up and final results of Oslo II study. Radiology, 244: 708-17.
11. Lewin, J.M., R.E. Hendrick, C.J. D'Orsi, P.K. Isaacs, L.J. Moss, A. Karellas, G.A. Sisney, C.C. Kuni and G.R. Cutter, 2001. Comparison of full-field digital mammography with screen-film mammography for cancer detection: results of 4945 paired examinations. Radiology, 218: 873-880.
12. Jamal, N., K.K. Ng and D. Mc Lean, 2003. A study of mean glandular dose during diagnostic mammography in Malaysia and some factors affecting it. Britith Journal of Radiology, 76: 238-45.
13. Chevalier, M., P. Moran, M. Pombar, R. Lobato and E. Vano, 1998. Breast dose measurements on a large group of patients: results from a 4 year period. Radiation Protection Dosimetry, 80: 187-90.
14. Moran, P., M. Chevalier, J.I. Ten, F. Soto and E.A. Vano, 2005. survey of patient dose and clinical factors in a full-field digital mammography system. Radiation Protection Dosimetry, 114: 375-9.
15. Oh, K.K., J. Hur, E.K. Kim and S.S. Choo, 2003. Dosimetric eveluation of the mean glandulardose for mammography in Korean women: A preliminary report. Yonsei Medical Journal, 44: 863-868.
16. Skaane, P., A. Skjennald and K. Young, 2005. follow-up and final results of Oslo I study comparing Screen-film mammography and full-field digital mammography with soft-copy reading. Acta Radiologica, 46: 679-689.
17. Fischmann, A., K.C. Siegmann, A. Wersebe, C.D. Claussen and M. Muller-Schimpfle, 2005. Comparing of full-field digital mammography and film-screen-mammography: image quality and lesion detection. Britith Journal of Radiology, 78: 312-5.
18. Hauge, H.R., K. Pedersen, A. Sanderud, S. Hofvid and H.M. Olerud., 2012. Patient doses from Screen-film mammography and full-field digital mammography in a population-based screening program. Radiation Protection Dosimetry, 148: 65-73.