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A SURVEY ON PHYSICAL FACTORS AND COMPRESSED BREAST THICKNESS IN VOLUNTARY MAMMOGRAPHY SCREENING USING FFDM SYSTEM IN MALAYSIA: PRELIMINARY RESULTS

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ABSTRACT

This paper aims at presenting preliminary results of a survey on physical factors, namely tube potential (kV), tube current exposure time product (mAs) and compressed breast thickness (CBT) during voluntary mammography screening using Full-Field Digital Mammography (FFDM) System in Malaysia. Retrospective data were collected from 1128 FFDM images of 282 women from three major ethnic groups (Malay, Chinese and Indian) who underwent voluntary screening mammography at Breast Centre, International Islamic University Malaysia from January to March 2008. Results from the present study were then compared with results from the previous study on Screen-Film Mammography System (SFM) according to the ethnic group for both Cranio-caudal (CC) and Mediol-Lateral (MLO) views. We found that the mean kV for CC view for the three ethnic groups are Malay (28), Chinese (28) and Indian (28), and for MLO view are Malay (29), Chinese (28) and Indian (29). These values are higher than the kV for SFM which were Malay (26), Chinese (27) and Indian (26) for CC and Malay (26), Chinese (27) and Indian (26) for CC and MLO views respectively. The mean mAs for CC and MLO views for FFDM were lower compared to SFM systems. These values were Malay (104), Chinese (108) and Indian (91) for CC views and Malay (106), Chinese (105), and Indian (94) for MLO views for the FFDM system. The values for SFM system are for CC and MLO views were Malay (120), Chinese (106) and Indian (126), and Malay (166), Chinese (132), Indian (183) respectively. The median CBT for CC and MLO views increased by 27% and 7% respectively on the FFDM compared to the SFM system. In conclusion, the FFDM operates with higher kV, lower mAs, and higher CBT when compared with SFM system. Median CBT on CC and MLO view with FFDM system are 27% and 7% higher respectively compared to the SFM. We are currently collecting data on mean glandular dose with FFDM systems to assess how the change in local mammography practice influences this value. This will allow comparison with related data from other parts of the world.

Keywords*:* Compressed Breast Thickness, Full-field Digital Mammography, physical factors.

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INTRODUCTION

The use of screen film mammography (SFM) is rapidly being replaced by full field digital mammography (FFDM) systems in the early detection of breast cancer. Studies on large numbers of women have shown that the detection rate for breast cancer is nearly equal for both modalities (Lewin *et al*., 2001 and Skaane & Skjennald, 2004).

It is important that potentially beneficial mammographic examinations of asymptomatic women in a breast cancer screening programme are justified (Michielsen *et al.*, 2008), as they involve exposure to X-radiation. Selection of the best combination of physical factors in mammography allows optimal visualization of anatomy and signs of pathology without unnecessary or excessive radiation to the breast. A selection of these factors generally has an effect on specific image quality characteristics and radiation dose to the breast. High voltage (kV) influences the energy of the X-ray photon (photon penetration). The photon energy spectrum of the X-ray beam is one of the most critical factors in optimizing a mammographic procedure with respect to image contrast, sensitivity and breast dose. While tube current exposure time product (mAs) controls the photon's intensity, the photon energy spectrum depends on the combination of three factors, namely anode material, selected filter and kV. These factors are either set manually or by automatic exposure control (AEC) if available, after evaluating compressed breast thickness (CBT) and breast density. The AEC typically makes a brief exposure to measure penetration through the breast and then calculates appropriate physical factors for breast imaging (Sprawls, 1993).

In previous surveys, we collected data on physical factors (Jamal *et al.*, 2003) and CBT (Jamal *et al.*, 2004) during diagnostic mammography in Malaysia from SFM systems using molybdenum/molybdenum (Mo/Mo) target/filter combination. This paper aims at presenting preliminary results of a survey on physical factors, namely kV, mAs and CBT during voluntary mammography screening using an FFDM system with the same target/filter combination. The results are compared with the results obtained from the previous study with SFM.

MATERIAL AND METHODS

FFDM System

The FFDM system used in this survey is Hologic Lorad Selenia System, with Half Value Layer of 0.33 and 0.35 mm Al at 26 and 28 kV for Mo/Mo target/filter combination respectively. It operates using a molybdenum (Mo) anode and filter and is calibrated annually according to the American College of Radiology Standard. It also operates in a semi AEC mode with Mo/Mo target/filter combination. All mammograms were taken using 18 x 24 cm^2 image receptors.

Survey Sample

To collect the data, a survey form was sent out to the participating centre. The form consists of a questionnaire to be completed by designated and qualified radiologists and mammographers at the participating breast imaging centre. The requested information included patient and procedure related data (age, date of examination, type of views, and CBT), and physical factors (kV and mAs). The anode/filter combination was Mo/Mo for all mammograms included in this study). Data was collected from 1128 FFDM images of 282 women (age range 29-76 years). The women were from the three major ethnic groups in Malaysia, namely Malay, Chinese and Indian, who underwent voluntary screening mammography at Breast Centre, International Islamic University Malaysia (IIUM Breast Centre) from January to March 2008. Women from other ethnic groups were excluded from this survey. These data were retrieved from the DICOM header of mammograms performed at the Centre. The standard four views, namely left and right Cranio-caudal (CC) and left and right Medio-Lateral (MLO) views were available for each subject. These survey questionnaire forms were returned for data tabulation and analysis upon completion by the designated staff at the Centre.

Data Analysis

Data on physical factors from the returned survey forms were analyzed using descriptive statistics, including mean, median and quartile values for both physical factors and CBT. Analysis was done for each view for the each of the three ethnic groups. Results were then compared with results from a previous study on SFM according to ethnic groups and for both CC and MLO views. Graphic presentation as a Box-Whisker plot was used to display the distribution of CBT for CC and MLO views for each ethnic group.

RESULTS

Table 1 shows distribution of kV and mAs for different ethnic group using FFDM system as compared with results obtained using SFM from the previous study (Jamal *et al.*, 2003). We found that the mean kV values for CC views for the three ethnic groups are Malay (28), Chinese (28), and Indian (28), and for MLO views are Malay (29), Chinese (28), and Indian (29) for FFDM. These values are higher than the kV values for SFM which were Malay (26), Chinese (27) and Indian (26) for CC, and Malay (26), Chinese (27), and Indian (26) for MLO views. The mean mAs for CC and MLO views are Malay (104) Chinese (108) and Indian (91) and Malay (106), Chinese (105) and Indian (94) for FFDM system respectively. These values are lower than those reported for SFM system, which were Malay (120), Chinese (106) and Indian (126), and Malay (166), Chinese (132) and Indian (183) for CC and MLO views respectively.

Table 2 shows distribution of CBT for the three ethnic groups using FFDM system as compared with results obtained using SFM from the previous study (Jamal *et al.*, 2003). The medians of CBT for CC and MLO views with FFDM were higher by 27% and 7% respectively, compared to SFM systems.

Fig. 1 shows Box-whisker plots of CBT for the different views and ethnic groups. Fig. 1a shows plot for the CC views, while Fig. 1b shows a plot for MLO views. For each ethnic group, median CBT are comparable for both CC and MLO views.

Table 1: Physical factors for Cranio-caudal (CC) and Medio-lateral Oblique (MLO) views for three Malaysian ethnic groups

Ethnic group	Age (years)		Clinical factor				
			View	Tube potential (kV)		Tube current exposure time product (mAs)	
	SFM*	FFDM		SFM*	FFDM	SFM*	FFDM
Malay	50±8 (35-87)	48±7 (29-73)	LCC	26±1 (25-30)	28±2 (24-32)	118±59 (4-334)	102±30 (50-191)
			RCC	26±1 (25-30)	28±2 (24-32)	122±75 (16-562)	106±37 (43-230)
			Mean CC	26±1 (25-30)	28±2 (24-32)	120±67 (4-562)	104±34 (43-230)
			LMLO	26±1 (25-30)	29±2 (24-33)	162±86 (15-676)	102±23 (46-172)
			RMLO	26±1 (25-30)	29±2 (24-33)	170±105 (15-819)	109±32 (55-245)
			Mean MLO	26±1 (25-30)	29±2 (24-33)	166±96 (15-819)	106±28 (46-245)
Chinese	52±8 (31-81)	54±7 (40-76)	LCC	27±1 (25-28)	28±2 (24-32)	106±53 (23-257)	108±37 (11-348)
			RCC	27±1 (25-31)	28±2 (24-32)	105±54 (19-315)	108±32 (31-258)
			Mean CC	27±1 (25-31)	28±2 (24-32)	106±54 19-315)	108±35 (11-258)

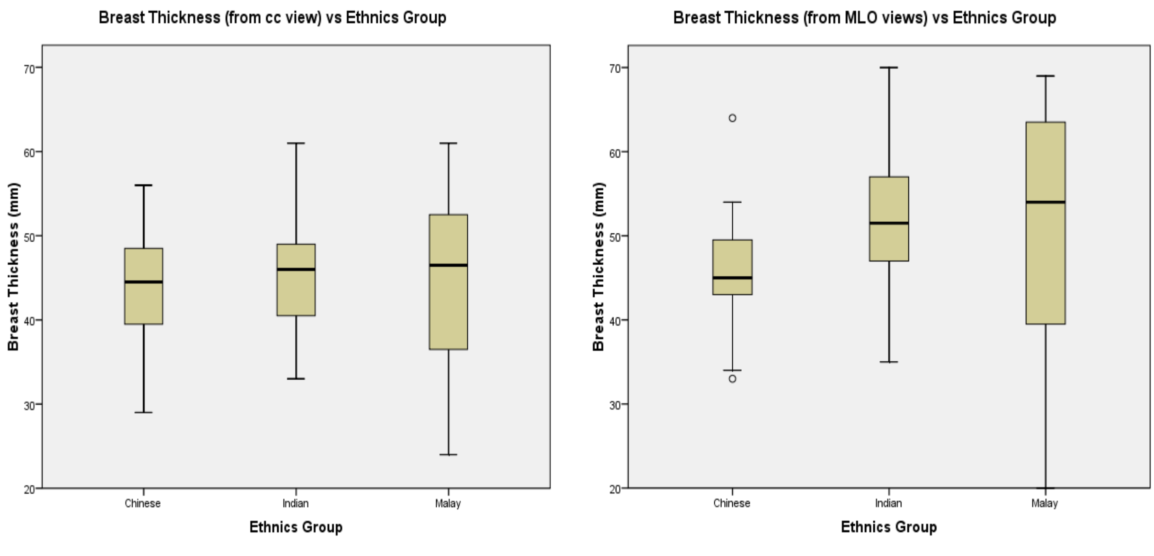
			LMLO RMLO Mean MLO	27±1 (25-29) 27±1 (25-31) 27±1 (25-31)	28±2 (24-32) 28±2 (24-32) 28±2 (24-32)	131±69 (21-306) 133±74 (15-362) 133±72 (15-362)	104±30 (37-284) 106±26 (38-181) 105±28 (37-284)
Indian	50±8 (37-71)	52±9 (40-67)	LCC RCC Mean CC	26±1 (25-29) 26±1 (25-29) 26±1 (25-29)	28±2 (25-31) 28±1 (2-30) 28±2 (25-31)	126±64 (19-372) 125±58 (25-295) 126±62 (19-372)	89±15 (68-120) 92±15 (67-121) 91±15 (67-121)
			LMLO RMLO Mean MLO	26±1 (25-31) 26±1 (25-31) 26±1 (25-31)	29±2 (26-31) 29±2 (26-32) 29±2 (26-32)	180±110 (30-800) 185±119 (21-800) 183±115 (21-800)	87±30 (10-125) 101±20 (78-138) 94±25 (10-138)
All	51±8 (31-87)	52±8 (29-76)	CC MLO	26±1 (25-31) 26.5±1 (25-31)	28±2 (24-32) 28±2 (24-32)	117±61 (14-372) 160±97.5 (15-819)	108±35 (11-348) 105±28 (37-284)

*fromJamal *et al*.,2003;
SFM, Screen-Film MammographyFFDM, Full-Field Digital Mammography; MLO,Mediolateral Oblique; RCC, Right Craniocaudal; LCC, Left Cradiocaudal; RMLO, Right Mediolateral Oblique; LMLO, Left Mediolateral Oblique.

Table 2: Compressed breast thickness (CBT) values for three Malaysian ethnic groups in mammography

Ethnic group	Compressed Breast Thickness (mm)				
	View	SFM*		FFDM	
		Median	Mean	Median	Mean
Malay	LCC	39(29,46)	38	47(43,52)	46±10
	RCC	39(30,46)	38	47(41,54)	47±10
	LMLO	48(38,55)	46	52(45,58)	51±12
	RMLO	46(37,56)	46	50(44,58)	50±13
Chinese	LCC	35(24,43)	33	47(39,53)	46±12
	RCC	35(25,42)	33	46(39,53)	46±11
	LMLO	42(30,49)	39	48(40,54)	47±11
	RMLO	39(26,49)	38	47(41,54)	47±11
Indian	LCC	38(32,46)	39	45(41,49)	45±7
	RCC	39(32,48)	40	47(42,49)	45±6
	LMLO	46(39,58)	48	53(46,56)	52±8
	RMLO	47(39,56)	48	51(48,57)	52±9
All	CC	37(29,45)	37	47(40,55)	46±11
	MLO	45(36,54)	44	48(42,56)	48±11

* from Jamal *et al*.,2004
SFM, Screen-Film Mammography; FFDM, Full-Field Digital Mammography; MLO,Mediolateral Oblique; RCC, Right Craniocaudal; LCC, Left Cradiocaudal; RMLO, Right Mediolateral Oblique; LMLO, Left Mediolateral Oblique.



(a) (b)

Fig 1. Box-whisker plot of Compressed Breast Thickness (CBT) for (a) Cranio-caudal view; and (b) Medio-lateral view for three different ethnic groups. The 25th and 75th percentile marks the box and whisker extend to the range outliers which is not central, represents the study populations, which is not normally distributed. The open circles (o) are outliers that represent cases that have values of more than 1.5 box-lengths from the 75 percentile.

DISCUSSION

The survey results presented in Table 1 show that the FFDM system selected a harder beam than the SFM system. This may be due to the fundamental detector differences between FFDM and SFM systems. Screen-film cassettes require a softer X-ray beam to obtain excellent X-ray absorption efficiency in the cassette phosphor. The spread of kV and mAs is nearly consistent for both SFM and FDM using Mo/Mo. Each setting however, will result in a different dose to the breast. The kV affects the radiographic density. As energy (kV) of the stream of electrons in the X-ray tube increases, the more likely the X-ray photons created from these electrons will penetrate the breast and react with the imaging plate. This will result in a decrease in radiographic density, compared with low energy beams that may be absorbed in the breast on the way to the image receptor. The higher the KV, the more scatter is produced resulting in lower image resolution (Sprawl 1993). This is the reason why kV is not primarily used to control the exposure.

The mAs is the primary controlling factor of radiographic density. Increasing mAs causes more photons of the particular energy to be produced. We found that mAs values with the FFDM are lower than that of SFM systems for both CC and MLO views. This could be due to the fact that less photon is needed with FFDM systems due to image receptor design which uses amorphous selenium for direct image capture. The more dense breasts would require more photons to reach the image receptor to produce optimal images.

We also found that median CBT on CC and MLO view with FFDM system are 27% and 7% higher respectively compared to the SFM system (Jamal *et al.*, 2003). This may be explained by the fact that FFDM system used harder beams at higher kV as compared with that used by the SFM system. CBT influences the length of X-ray passage through the breast, and therefore the mean glandular dose.

A limitation of this survey is that compression force was not included as one of the physical parameters in this survey. It is expected that this parameter together with breast glandularity and density will influence CBT and dose to the breast (Kruger & Schueler, 2001).

CONCLUSION

In conclusion, we found that the FFDM system operates with higher kV, lower mAs with higher CBT when compared with an SFM system. Median CBT on CC and MLO view with FFDM system are 27% and 7% higher respectively compared to the SFM. We are currently collecting data on mean glandular dose with FFDM systems to assess how the change in local mammography practice influences this value. This will allow comparison with experience in other parts of the world.

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