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OPTIMIZATION OF EXPOSURE PARAMETERS IN AUTOMATIC OPTIMIZATION OF EXPOSURE PARAMETERS (AOP) MODE OF FULL FIELD DIGITAL MAMMOGRAPHY (FFDM) SYSTEM: BREAST PHANTOM STUDY

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Abstract

This experimental study investigated the significant different in image quality and dose between different automatic exposure of exposure parameter (AOP) mode in full field digital mammography (FFDM) system. CIRS012A and PMMA breast phantom (4cm, 5cm and 6 cm thickness) were used as subject using Senographe Essential FFDM system. TLD chip was used as dose measurement tool. Exposures were taken in cranio-caudal projection. 2 radiographers with more than 10 years of working experience in performing mammography scored the image independently. Kappa finds a good agreement between raters (kappa value=0.9, $p<0.01$). One-way ANOVA shows a significant different in dose between CNT and DOSE mode ($p=0.013$). However, there is no significant different in image quality between CNT, DOSE and STD ($p>0.05$). DOSE mode is the preferred selection in optimizing between dose and image quality.

Keywords: AOP mode, CNT, DOSE, STD, FFDM, image quality, dose, breast phantom.

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Introduction

This paper aims to investigate the significance different in image quality and average glandular dose (AGD) between different mode of Automatic Optimization Parameters (AOP) selection. Full Field Digital Mammography (FFDM) system has incorporated the automatic beam quality selection mode which is known as AOP (Bsrisse et al., 2007). In AOP mode, the kilovoltage peak (kVp), mAs, target material and filter are automatically selected based on the thickness and composition of the breast (Ozdemir, 2007). The AOP mode has three selections which are the standard (STD), dose (DOSE) and contrast (CNT).

However, Ko et al. (2013) found that radiographers are not familiar on the selection of DOSE and CNT mode in AOP selection. The common selected mode is STD. By understanding more on the characteristics of each mode selected, optimization could be highly appreciated.

Literature Review

Breast cancer is a major concern for women in most parts of the world. In 2006, breast cancer was reported to be the most common cancer among female in Peninsular Malaysia (Omar et al., 2006). It is also reported as the most frequent cause of cancer death among female in economically developing and developed countries (Ferlay et al., 2008). In diagnosing the disease, mammography is the most effective

tool for early detection before it becomes clinically palpable (Sree at al., 2011). Consequently, regular mammography screening may significantly reduce the mortality of breast cancer (Krishnaiah et al., 2012).

The conventional image capturing system in mammography was successfully obtained by using film-screen mechanism. Unlike other conventional imaging procedures which use double emulsion film, mammography uses single emulsion film with single radiographic intensifying screen to record the image.

The full field digital mammography (FFDM) system which is totally cassette-less system has been rapidly replacing the screen-film mammography. The advantage of digital mammography system is the ability to do the post-processing and manipulation of the images due to its wider dynamic range if compared to film screen system (Faridah, 2008). This will consequently increase the diagnostic value of the images, reduce repeat exposure and reduce extra radiation dose delivered to patient.

Most FFDM system has incorporated the automatic beam quality selection mode which is known as automatic optimization of exposure parameters (AOP). In AOP mode, the kilovoltage peak (kVp), milliamperage-seconds (mAs), target material and filter are automatically selected based on the thickness and composition of the breast (Ozdemir, 2007). The AOP mode has three selections which are the standard (STD), dose (DOSE) and contrast (CNT). These three selections of AOP mode are designed to give a balance between high image quality and low dose during mammographic procedure (Ozdemir, 2007). The STD mode gives balance between dose reduction and good contrast while the DOSE mode emphasizes on the dose reduction with optimum image quality (Ko et al., 2013). The CNT mode is preferable when higher image quality with higher contrast is the point of focus (Ko et al., 2013).

However, the selection of DOSE and CNT modes were not familiar among radiographers (Ko et al., 2013). The common selected mode is STD. Suitable selection of exposure parameters is a main concern in mammography as it may reduce radiation dose to the glandular breast tissue, as glandular breast dose is closely related to carcinogenesis (Kanaga et al., 2010). Thus, by understanding more on the characteristic of each mode selected, optimization between image quality and radiation dose could be highly appreciated.

Methods

This study was conducted based on experimental design and involved the qualitative evaluation of image quality. FFDM Senographe Essential system, which was manufactured by General Electric Healthcare (GE) was used. The AOP mode has three selections which are the standard (STD), dose (DOSE) and contrast (CNT).

Thermo luminescence dosimeter (TLD-100H) was used in this study to capture the dose received. 3 sets of mammography phantom model CIRS012A (Computerized Imaging Reference System Inc.) which have the shape of a real breast and different thickness of compressed breast (4cm, 5 cm and 6 cm) were used to assess image quality. For assessment of average glandular dose (AGD), *polymethylmethacrylate (PMMA)* breast phantom with different thickness of compressed breast (4cm, 5 cm and 6 cm) were used.

Each phantom was positioned on the surface of FFDM image receptor in cranio-caudal (CC) position and compression was applied until the compression plate touched the surface of breast phantom. The first exposure made was using the STD mode. For dose measurement, *PMMA* was used. TLD chip was positioned at the surface of FFDM image receptor in cranio-caudal (CC) position and compression was

applied until the compression plate touched the surface of breast phantom. These steps were repeated using the CNT mode and DOSE mode. TLD chips were read using TLD reader.

Image quality was evaluated through qualitative assessment by using weighted scoring protocol adapted from American College of Radiology (ACR) Mammography Quality Control Manual (Papp, 2018). Evaluation was done based on the visibility of speck, fibers and masses on the image of CIRS012A phantom. The grading score used with respect to the visibility of fibers, speck and masses were 1, 0.5 and 0.

Total image score was obtained by summing up the visualization score of mass, fiber and speck. Two independent radiographers with minimum experience of 10 years in mammographic procedure have scored the images independently with blinded exposure parameters. Edge enhancement application and magnification tool was not allowed.

Statistical analysis: Data was analyzed by using statistical software for social science (SPSS) version 21.0. Statistical test used was One-way ANOVA.

Ethical approval: Ethical approval was obtained from the ethical committee of Faculty of Health Sciences, Universiti Teknologi MARA (UiTM).

Results

Figure 1 shows the pattern of mean AGD versus AOP mode for all breast thickness. CNT shows the highest value of AGD for all breast thickness, followed by STD. The lowest value of AGD is given by the DOSE. To find the significant difference in AGD between three selections of AOP mode, one-way ANOVA test was performed. All assumptions for using this test are met. According to the test conducted, there is a significant different in AGD value between CNT and DOSE mode ($p=0.013$). Mean AGD in CNT selection is significantly higher than mean AGD in DOSE selection.

Figure 2 shows the pattern of relationship between image quality score and AOP mode for all breast thickness. CNT selection gives the highest score in all thickness of breast. CNT also gives the highest score for the visualization of mass, speck and fiber for all breast thickness, except in 4cm thickness whereby highest score for the visualization of fiber is given by the DOSE mode. The DOSE mode gives the lowest score for the total image score, visualization of mass and visualization of speck. While the STD mode gives moderate score between CNT and DOSE, except for visualization score of fiber, the STD shows the lowest score.

Kappa test shows a good agreement between the two raters (kappa value = 0.90, p value of <0.01). One-way ANOVA was used to test the significance difference in image quality score between different modes of AOP. All assumptions of using one-way ANOVA are met in this test. The result shows that there is no significant different in image quality between different selections of AOP mode.

Figures, Diagrams and Pictures

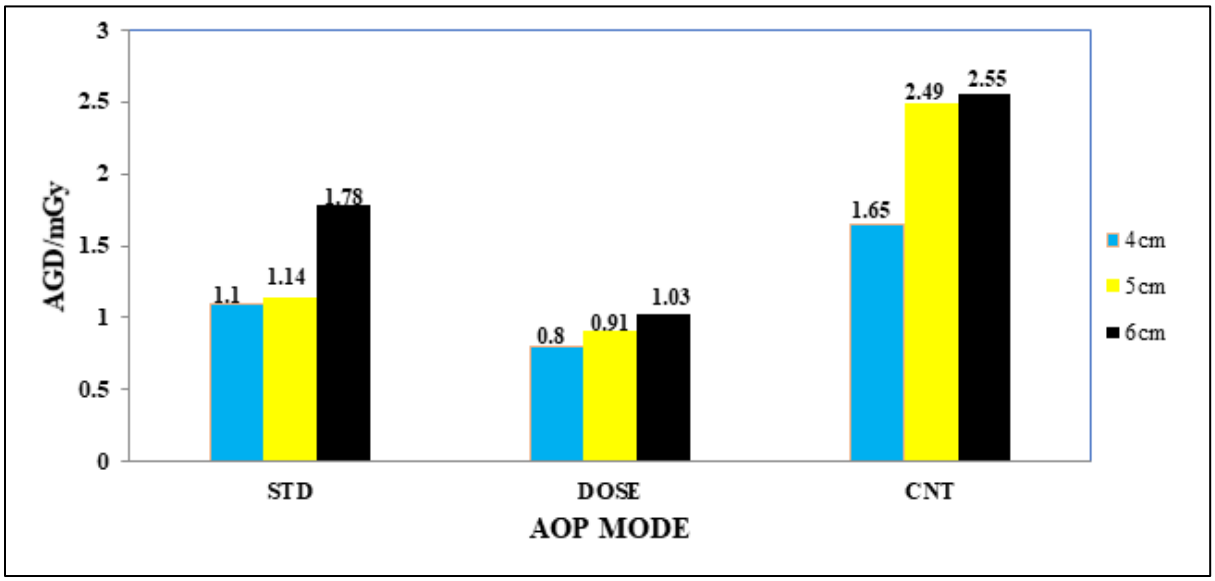

Fig 1: The pattern of mean AGD versus AOP mode for all beast thickness.

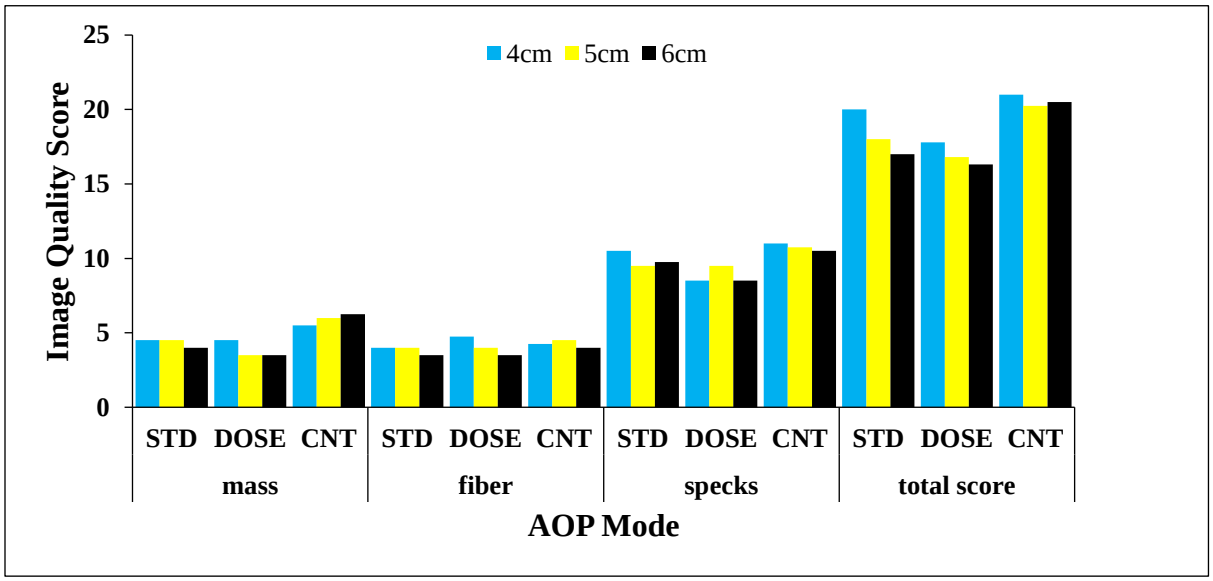

Figure 1: Pattern of image quality score versus AOP mode.

Discussion

Dose received by patient in CNT mode is significantly higher than the dose received in DOSE mode. This is due to the nature of the mode itself. CNT mode uses high mAs selection to get the best quality of images

while the DOSE mode uses optimum mAs selection to get optimum dose with acceptable image (Ko et al., 2013). During data collection process, the FFDM system selected the same kVp value for the same breast thickness for each mode but different value of mAs (Chen et al., 2012). Among the three selections, mAs selected for CNT was the highest, followed by STD and DOSE. Thus, different in AGD value between CNT and DOSE is due to the amount of mAs (Chen et al, 2012). Although STD mode gives higher value of AGD compared to DOSE mode, but there is no significant different between these two modes in term of dose. Thus, to compromise for optimization purpose, DOSE mode may be selected rather than STD mode due to its lower value of dose reading.

For image quality assessment, CNT mode gives the highest total score compared to STD and DOSE mode, but there is no significant different between those three selections. This is slightly different with the result of previous study conducted, which found that there is a significant different in image quality score between CNT and DOSE mode (Ko et al., 2013). This could be due to the background of evaluator. The previous study used radiologists as evaluator while for this study, experienced radiographers were used.

Although this study found no significant different in image quality between CNT, DOSE and STD mode, but it is found that in evaluating abnormality in fibrous tissue of a 4cm compressed breast, DOSE mode is more preferred to be used. Previous study has highlighted the importance of choosing CNT mode to be used for characterization of microcalcifications and masses in diagnostic mammography procedure and should not compromise to the dose reduction (Ko et al., 2013). To optimize and balance the requirement between dose and image quality, this study found that the selection of either STD and DOSE mode could be used. Between the two modes, the selection of DOSE mode is the most preferred as it provides acceptable image quality similar to STD, with the lowest radiation dose.

Conclusion

In conclusion, DOSE is the optimum selection in AOP mode which gives balance between dose and image quality for all breast thickness. The result of this research will give a clear direction to radiographer on the dose reduction initiative in mammography procedure. Dose reduction will give an impact on reducing the risk of radiation induced cancer. To improve the accuracy of this research, the method of image quality assessment can be improved by using both qualitative and quantitative measurement.

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