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Research paper

Usefulness of tungsten shield in mammography

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Abstract

Background/Objectives: In order to minimize unnecessary artifacts and medical radiation dose for acquiring final diagnostic medical image with high diagnostic value in X-ray mammography, a tungsten shield was produced to evaluate the usefulness of clinical application.

Methods/Statistical analysis: The radiation dose at the time of mammography was measured in the same posture as breast cancer examination in a clinical hospital for health screening. In the R - CC, L - CC. R - MLO, L- MLO posture mammography, the distribution of radiation dose for each part by placing a glass dose device at the breast position with the breast equivalent phantom. In order to reduce measurement error, mammography was repeated five times.

Findings: When the eco-friendly shield was used, the average dose was 40 ± 0.34μGy, which showed a radiation dose reduction efficiency of 64.6% and a reduction factor of 2.8. Using eco-friendly shield tungsten shield, reproducibility of fibrin was 4.5, reproducibility of specks was 4.0, and reproducibility of the mass was 4.0 ± 0.2, resulting in 12.5, exceeding the approved acceptance criteria of 10.

Improvements/Applications: This result is expected to be used as an important basic data for predicting patient's radiation dose, determining test method and decreasing medical radiation dose in future breast cancer examination.

Keywords: *Mammography; Shield; Tungsten; Usefulness; Glass Dosimeter.*

1. Introduction

Early diagnosis and accurate diagnosis of breast cancer is very important to increase the probability of breast cancer treatment. Mammography, breast ultrasonography, tissue examination with excisional biopsy, and magnetic resonance imaging (MRI) have been used for the diagnosis of breast cancer [1], [2].

In the case of tissue examination with excisional biopsy resecting only a part of the lesion, a follow-up examination of the remaining lesions is required, scarring and insertion of repeated syringe needles have been suggested as inconveniences of examination, breast ultrasound is known to be difficult to distinguish between malignant and benign tumors, and it is known that it is difficult to detect when the size of breast cancer is small [3], [4].

MRI-based breast cancer examination is known to be more accurate than mammography or ultrasound to assess the size of breast cancer, but its utilization is relatively low due to the cost of examination [5]. Digital mammography is the most excellent and widely used method for diagnosis of micro calcification lesions and cancer, other than diagnosing lesions by touch [6].Because the breast region is known to be more sensitive to radiation than other regions of the human body, digital mammography using X-rays has been on the rise for the purpose of early detection of breast cancer [7].

Mammography is characterized by small X-ray absorptions of lesion and surrounding tissues such as mammary gland tissue and adipose tissue, and the need to reveal fine calcifications. In order to improve the detection rate of breast lesions, a small focus is used and the use of a small focus results in an increase of the exposure time to increase the radiation dose [4], [7] It has been reported that the amount of radiation the patient receives during breast examination may cause more radiation exposure than the benefit of early detection [8].

The glass dosimeter is capable of repeated measurement and readout of the radiation radiation dose because the silver ion particle fluorescence center produced by irradiation is not destroyed by repeated measurement. In addition, the measurable dose range is 10μGy to 500Gy, and it has wide measurement range, low fading effects and excellent direction and energy dependence [9-13].

Tungsten is an off-white solid metal with an atomic number of 74, which has the meaning of 'heavy stone'. It is heavy and hard, has the highest melting point of 3,422ºC among metal elements, and has the lowest vapor pressure, making it widely used as an incandescent filament and various electrical and electronic materials. Recently, tungsten shield has been attracting attention as an eco-friendly X-ray shielding defense due to the hazard to human body of lead material [14-16].

Studies involving the reduction of breast radiation dose include, evaluation of radiation dose by exposure method and program treatment [7], study on absorption dose and lead shielding in breast tissue using simulation [17], [18], study on image evaluation using Monte Carlo simulation [19], and evaluation of the permeation dose considering the compression pad material of the mammography equipment [20]. However, these studies have been based on dose assessment by apparatus or accessories, and there is no study of radiation dose using eco-friendly shield and glass dosimeter.

This study was performed to produce an eco-friendly tungsten shield in mammography with high radiation tissue weighting factor and to measure radiation dose using glass dosimeter to provide basic data to minimize radiation dose and acquire optimal images.

2. Subjects and methods

2.1. Materials and equipment

The radiation generator was a Phillips LORAD selonia system [Figure1]. To measure the radiation dose of the subject, a full body phantom (Model PBU-31, Kyoto Kagaku, Japan) consisting of human body equivalent material and a glass dosimeter Dose Ace (Model GD-352M and FGD-1000, Asahi Techno Glass Co-operation, Shizuoka , Japan) were used [Figure2].

Fig. 1: Radiographic Equipment and Full Body Phantom.

Fig. 2: Glass Dosimeter.

2.2. Measurement of radiation dose with or without eco-friendly shield during mammography

The radiation dose at the time of mammography was measured in the same posture as breast cancer examination in a clinical hospital for health screening. In the R - CC, L - CC. R - MLO, L- MLO posture mammography, the distribution of radiation dose for each part by placing a glass dose device at the breast position with the breast equivalent phantom. In order to reduce measurement error, mammography was repeated five times [Figure3].

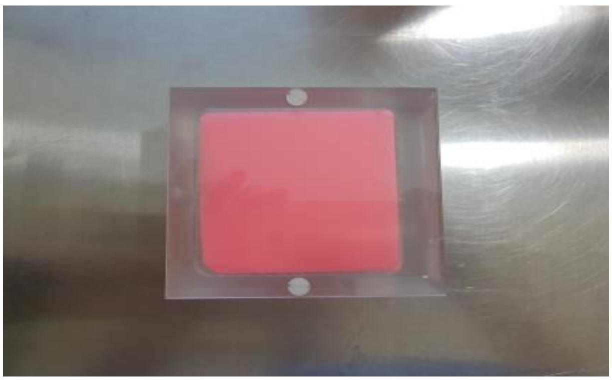

Fig. 3: Breast Equivalent Material Phantom.

2.3. Glass dosimeter dose measurement

The calibration of the glass dosimeter was performed using a glass element irradiated with 6mGy using a ^{137}Cs standard source at the Japan Radiation Standards Institute. In consideration of the characteristics of the element, the annealing process was performed at 400 ° C for 1 hour before the irradiation, and the background was measured as 10-20μGy after cooling, and after panoramic scan, the pre-heating was performed at 70 ° C for 1 hour, then cooled, and the dose value irradiated to the element was measured by a reader where dose accumulated value was repeated 10 times and mean value and standard deviation were calculated. The radiation dose value was derived by subtracting the background value from the calculated value [9 13].

2.4. Image evaluation method

Qualitative analysis of breast tissue equivalent phantom was performed to evaluate the image quality of images with or without eco-friendly shield. Qualitative analysis consisted of evaluating the number of fibers, specks, and masses reproduced in the image by one radiology specialist and five radiologists with more than 10years experience. The standard of number of fibers was 6, and the number of specks and masses was 5.

2.5. Statistical processing and analysis

Data were analyzed using the SPSSWIN (Ver 13.0) statistical program, and t-test and ANOVA were performed to verify the significance of the mean values of the radiation dose measurements in the control and experimental groups. The significance level of all statistics was $p < 0.05$.

3. Results and discussion

3.1. Dose reduction effect of eco-friendly shield in mammography examination

Medical exposure refers to the exposure of a patient or an individual to radiation for medical treatment at a medical facility, which is distinct from the occupational exposure of a medical worker [21].Radiation dose measurements during breast imaging were measured in postures for a clinical hospital setting for breast cancer examination for health screening purposes. In the R - CC, L – CC, R - MLO, L- MLO posture mammography, the distribution of radiation dose for each part by placing a glass dose device at the breast position with the breast equivalent phantom.

For R – CC posture, 29kVp 72.2mAs, Mo filter was used, for L - CC posture, 29kVp 76.9mAs, Mo filter was used, for R - MLO posture, 28kVp 83.5mAs, Mo filter was used, and for L- MLO posture, 28kVp 77.8mAs, Mo filter was used. In order to reduce measurement error, mammography was repeated 5 times.

In glass dosimeters used in radiation dose measurement, electrons and holes PO4 are generated when silver ion activated phosphate of glass element is irradiated with ionizing radiation, the generated electrons are captured by Ag+ in the glass element to become Ago, and the holes are trapped in PO4+, or migrate to Ag+ over time to form Ag++. These Ago and Ag++ form a more stable state RPL (Radio Photo Luminescence) center. When irradiated with ultraviolet rays at the center of RPL, energy is absorbed to create excited state, and then it returns to the stable state and emits orange fluorescence. At this time, the number of RPL centers emitting fluorescence is constant and can be read out repeatedly since it does not disappear in the surrounding environment and reading process. This feature is the biggest difference when compared to a thermo luminescence dosimeter (TLD) that can only read once. Also, the amount of fluorescence emitted from the glass dosimeter is proportional to the amount of irradiated radiation, and the dose accumulated through simple heat treatment at 400 ° C for one hour is reset and can be reused [22].

For the results of the radiation dose measurement according to the use of eco-friendly shield in mammography, the mean dose was 113 ± 1.06μGy when no shield was used and the mean dose was 40 ± 0.34μGy when using an eco-friendly shield[Table 1].Here, using the eco-friendly shield, the radiation dose reduction efficiency was 64.6% and the reduction factor was 2.8. These results are expected to be important data for the use of eco-friendly shield in mammography.

Table 1: Comparison of Radiation Dose with and Without Eco-Friendly Shield

Scan no.	No Shield [μGy±SD]	eco-friendly shield [μGy±SD]
1	113 ±1.16	39±0.36
2	113 ±1.06	41±0.35
3	112 ±1.05	40±0.33
4	115 ±1.06	40±0.31
5	112 ±1.08	40±0.34
Average	113 ±1.06	40±0.34
% Reduction		64.6%
Reduction Factor		2.8

3.2. Image quality evaluation results according to use of eco-friendly shield in mammography examination

Mammography examination is a representative site for acquiring images using low-voltage and high dose exposure conditions in simple radiography using X-ray, and since the organs exposed by X-ray during the examination include the breast, heart, gonads, thyroid, and lens of the eye with relatively high radiation sensitivity, it is necessary to pay more attention than other areas [23].

Table 2: Evaluation Results of Image Quality According to Use of Eco-Friendly Tungsten Shield during Breast Examination

Division	No Shield	eco-friendly shield
fiber	5.0±0.2	4.5±0.0
speck	4.5±0.0	4.0±0.0
mass	4.5±0.2	4.0±0.2
total	14.0±0.2	12.5±0.1

A qualitative analysis was performed with the obtained mammograms to analyze the application of the eco-friendly tungsten shield to reduce the radiation dose. Qualitative analysis of breast tissue equivalent phantom was performed to evaluate the image quality of images with or without eco-friendly shield. Qualitative analysis consisted of evaluating the number of fibers, specks, and masses reproduced in the image by one radiology specialist and five radiologists with more than 10years experience. The standard of number of fibers was [6], and the number of specks and masses was 5.
As a result of evaluation, when the shielding was not used, the reproducibility of fiber was 5.0 ± 0.2, the reproducibility of speck was 4.5, and the reproducibility of mass was 4.5, and by reproducing a total of 14 cases, it passed the official acceptance criteria of 10. When eco-friendly tungsten shield was used, the reproducibility of fiber was 4.5, the reproducibility of speck was 4.0, and the reproducibility of mass was 4.0 ± 0.2, totaling 12.5, exceeding the approved acceptance criteria of 10 [Table 2].
However, the reproducibility of fiber, the reproducibility of specks, and the reproducibility of mass are different from those in the case of no shielding, which is thought to be due to the scattering due to the tungsten shield. Diagnostic radiography using X-rays should gain legitimacy because the benefit gained by the examinee is more advantageous than the risk due to the exposure, and the radiation defense optimization of the patient should be achieved[9, 23]. To achieve optimization in diagnostic radiography, much attention and will of practice is required for radiation dose reduction and radiation protection of radiation workers. For this reason, in order to minimize the radiation dose of the breast cancer examination, it is considered that the workers need to wear an eco-friendly shield.

4. Conclusion

To minimize the radiation dose during X-ray mammography and obtain an optimal image for diagnosis, the radiation dose distribution was measured using a glass dosimeter and an environmentally friendly tungsten shield, and the acquired image quality was evaluated.
When the eco-friendly shield was not used, the average dose was 113 ± 1.06μGy, and when using an eco-friendly shield, the average dose was measured as 40 ± 0.34μGy, which showed a radiation dose reduction efficiency of 64.6% and a reduction factor of 2.8. When eco-friendly tungsten shield was used, the reproducibility of fiber was 4.5, the reproducibility of speck was 4.0, and the reproducibility of mass was 4.0 ± 0.2, totaling 12.5, exceeding the approved acceptance criteria of 10.
This result is expected to be used as an important basic data to decrease the radiation dose of medical care by presenting the data for predicting the radiation dose of patients and determining the method of examination in future breast cancer examination.

5. Acknowledgment

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