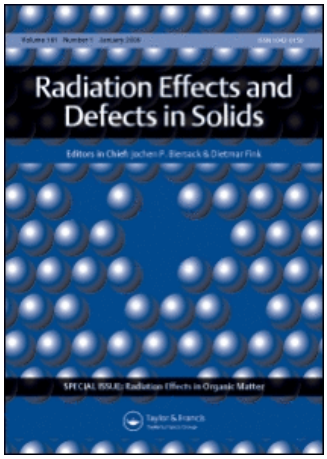

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TL dosimetry for quality control of CR mammography imaging systems

E. Gaona [ab]; J. A. Nieto [bc]; J. A. I. D. Góngora [b]; M. Arreola [d]; J. G. F. Enríquez [a]
[a] Universidad Autónoma Metropolitana-Xochimilco, México, D.F, Mexico
[b] CICATA Unidad Legaria Instituto Politécnico Nacional, México, D.F, Mexico
[c] Universidad Autónoma Metropolitana-Iztapalapa, México, D.F, Mexico
[d] Department of Radiology, Shands Hospital, Gainesville, FL, USA

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TL dosimetry for quality control of CR mammography imaging systems

E. GAONA*†§, J. A. NIETO‡§, J. A. I. D. GÓNGORA§, M. ARREOLA¶ and J. G. F. ENRÍQUEZ†

†Universidad Autónoma Metropolitana-Xochimilco, Calz. del Hueso 1100, 04960 México D.F., Mexico
‡Universidad Autónoma Metropolitana-Iztapalapa, Av. San Rafael Atlixco 186, 09340 México D.F., Mexico
§CICATA Unidad Legaria Instituto Politécnico Nacional, Av. Legaria 694, 11599 México D.F., Mexico
¶Department of Radiology, Shands Hospital at UF, PO Box 100374, Gainesville, FL 32610-0374, USA

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The aim of this work is to estimate the average glandular dose with thermoluminescent (TL) dosimetry and comparison with quality imaging in computed radiography (CR) mammography. For a measuring dose, the Food and Drug Administration (FDA) and the American College of Radiology (ACR) use a phantom, so that dose and image quality are assessed with the same test object. The mammography is a radiological image to visualize early biological manifestations of breast cancer. Digital systems have two types of image-capturing devices, full field digital mammography (FFDM) and CR mammography. In Mexico, there are several CR mammography systems in clinical use, but only one system has been approved for use by the FDA. Mammography CR uses a photostimulable phosphor detector (PSP) system. Most CR plates are made of 85% BaFBr and 15% BaFI doped with europium (Eu) commonly called barium flourohalide. We carry out an exploratory survey of six CR mammography units from three different manufacturers and six dedicated X-ray mammography units with fully automatic exposure. The results show three CR mammography units (50%) have a dose greater than 3.0 mGy without demonstrating improved image quality. The differences between doses averages from TLD system and dosimeter with ionization chamber are less than 10%. TLD system is a good option for average glandular dose measurement for X-rays with a HVL (0.35–0.38 mmAl) and kVp (24–26) used in quality control procedures with ACR Mammography Accreditation Phantom.

Keywords: Quality imaging; TLD; CR mammography

1. Introduction

The aim of this work is to estimate the average glandular dose with thermoluminescence dosimetry (TLD) and comparison with quality imaging in computed radiography (CR) mammography. The mammography is a radiological image to visualize early biological manifestations of breast cancer.

*Corresponding author. Email: gaen1310@correo.xoc.uam.mx

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In Mexico, there are two types of image-capturing devices in mammography, film screen and digital. Currently the most commonly used device is film screen, primarily because of cost. Digital systems have two types of image-capturing devices, full field digital mammography (FFDM) and CR mammography.

In Mexico, there are several CR mammography systems printed to film in clinical use, but only one system has been approved for use by the Food and Drug Administration (FDA). Mexico has no regulations for accreditation of mammography facilities.

CR Mammography uses a photo stimulable phosphor detector (PSP) system. Most CR plates are made of 85% BaFBr and 15% BaFI doped with europium (Eu) commonly called barium flourohalide [1]. The flexible CR plate is used in a cassette that is similar to screen-film cassette without a screen. CR plates are exposed in the same manner as screen-film. The latent image is stored on the CR plate in the form of trapped electrons. The CR plate is then read by the use of a stimulating red-wavelength laser that stimulates and releases the trapped electrons, resulting in a blue–green wavelength light emission. Therefore, it is important to measure and monitor the relationship between the dose and the pixel signal value in the digitized image on the digital mammography unit [2].

CR imaging systems offer an advantage over conventional film based medical imaging, in that the process of image acquisition and display are decoupled. There is a potential problem with this approach, in that good image quality can be obtained over a wide range of exposures; the operator may, therefore, be unaware that they have unnecessarily increased the radiation risk to the patient. TLD are used to examine dose in a phantom designed for mammographic procedures for six CR mammography units, using automated exposure systems. Results with both TLD and ionization chamber suggest that only one of the units simultaneously passed FDA prescriptive guidelines for image quality and dose.

The conceptual model for this phantom was first introduced by Hammerstein *et al.*, in 1979 [3]. Hammerstein *et al.* stated that the model was based on an educated estimate of the average breast in women [3]. The current American College of Radiology (ACR) phantom that is used as the 'average breast' in the United States is composed by a 4.2 cm thick acrylic block in which a wax insert is placed. The wax insert contains objects to evaluate image quality [4, 5].

2. Material and methods

The exposure [4] of the X-ray system at the entrance surface to a breast specified compressed thickness is measured with ionization chamber. From the exposure, kVp and HVL (Half Value Layer), the average glandular dose is calculated using tables [4, 6].

TLD-100 detectors were used for the estimation of the average glandular dose during quality control program of CR mammography units. For measuring dose, FDA and the (ACR) use the phantom that was initially developed for the ACR, so that dose and image quality are assessed with the same test object. This phantom was designed to represent a 4.2 cm compressed breast composed of 50% glandular and 50% adipose tissues.

In the calibration of the TL detectors, four TL dosimeters (TLD-100) and the ionization chamber were exposed simultaneously with an ACR mammography phantom (figure 1) and TL response (nC) of the dosimeters were correlated with of average glandular dose (mGy), calculated with exposure measured with ionization chamber.

The exposure (X) is measured with ionization chamber and the average glandular dose is calculated using the equation (1) and the tables [7].

$$D_g(mGy) = D_{gN}(Gm, HVL, kVp, tb) \cdot X, \tag{1}$$

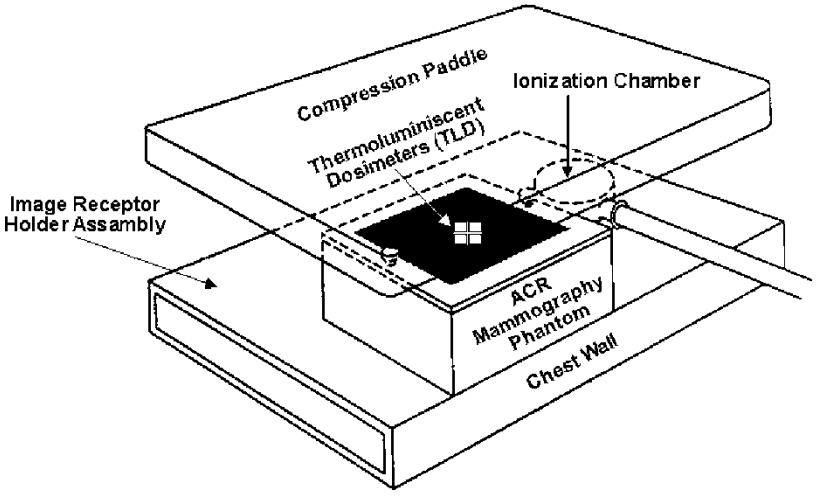

Figure 1. The exposure of the X-rays to TLD dosimeters and ionization chamber.

where D_g is an average glandular dose, D_{gN} is the dose conversion factor using ACR mammography accreditation phantom for 50% glandular/50% adipose tissue from the tables [4, 6], HVL = 0.37 mm Al, kVp = 26 and X is the exposure at the entrance surface to ionization chamber (breast) [4, 5].

The TLD reader system used was Harshaw 2000A-B, the mammography unit was GE-DMR+ with HVL = 0.37 mm Al, kVp = 26, Target/Filter combination Mo/Mo and mAs is varied for a series of exposures. This mammography unit has a quality control program and it was used exclusively for calibration procedures.

We carried out an exploratory survey of six CR mammography units from three different manufacturers and six dedicated X-ray mammography units with fully automatic exposure, HVL from 0.35 to 0.38 mm Al and a nominal large focal spot size of 0.3 mm. Four TL dosimeters (TLD-100) and the ionization chamber were exposed simultaneously, with an ACR mammography phantom to calculate the average glandular dose and image quality.

3. Results and discussion

The results of TLD calibration curve are illustrated in figure 2 with 95% confidence intervals for mean.

The curve can be defined as,

$$D_g(mGy) = -0.019717 + 0.0116545C, \tag{2}$$

where D_g is average glandular dose, C is the charge collected in nC by TLDs.

The test quality image included scoring phantom images, mean optical density and, density difference (contrast). The visibility of phantom details has been evaluated for CR mammography films with a viewbox for mammography with at least 3000 nits [4, 8]. The phantoms were imaged with fully automatic exposure in clinical conditions with range from 24 kVp and 26 kVp. The results of exploratory survey of the CR mammography units are illustrated in table 1.

The criteria for the number of objects to pass the ACR mammography accreditation are a minimum of the four largest fibers, the three largest speck groups, and the three largest masses.

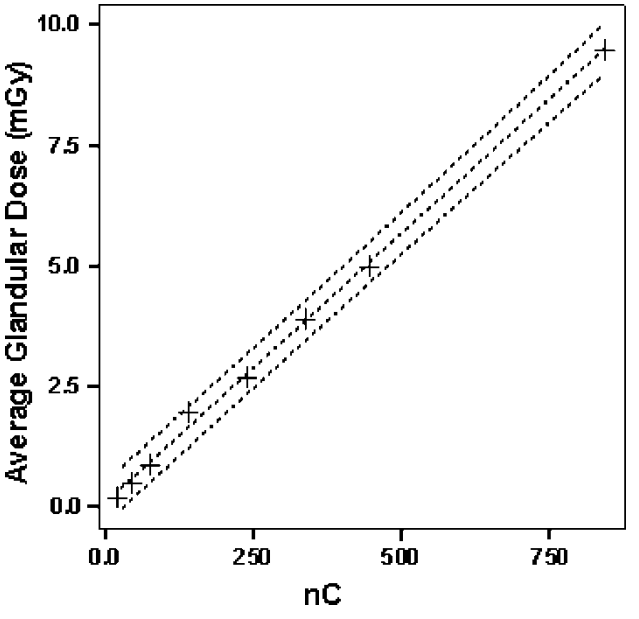

Figure 2. Calibration curve of TLD response and dose.

Table 1. Scoring phantom images.

Detector/system	Fibers visible	Specks visible	Mass visible	Mean optical density	Density difference
System scoring approved by FDA	4	3	3	At least 1.40	At least 0.40
System CR-1	3	3	3	1.86	0.51
System CR-2	4	2	4	1.20	0.40
System CR-3	4	2	3	1.30	0.26
System CR-4	4	3	4	1.61	0.45
System CR-5	5	4	4	1.74	0.61
System CR-6	4	3	4	1.45	0.52

Table 2. Comparison between the system minimum resolution and average glandular doses (D_g).

			Average glandular doses (mGy) per view	
Detector	Perpendicular to anode-cathode axis (11 lp/mm)	In the anode-cathode axis (13 lp/mm)	(D_g) TLD system*	(D_g) ionization chamber**
System CR-1	4	8	3.52	3.71
System CR-2	4	8	1.82	1.74
System CR-3	4	4	1.49	1.38
System CR-4	4	4	3.27	3.05
System CR-5	8	9	2.50	2.61
System CR-6	4	8	3.83	4.05

*From equation (2).
**From equation (1).

The optical density of the film at the center of an image of a standard FDA-accepted phantom shall be at least 1.40, when exposed under a typical clinical condition. The density difference between the background of the phantom and an added test object (4.0 mm acrylic) may be at least 0.40, when exposed under a typical clinical condition [4, 5, 8].

The system resolution and average glandular doses comparison of the CR Mammography with Screen-Film Mammography are summarized in table 2.

The average glandular dose delivered during a single cranio-caudal view of an FDA-accepted phantom, simulating a standard breast shall not exceed 3.0 mGy per exposure in clinical conditions [5, 8]. Quality image can be evaluate comparing the specifications of FDA and the results of each CR mammography unit.

4. Conclusions

In Mexico, we have insufficient experience in image quality control and their effect in the average glandular dose in digital mammography. The results show three CR mammography units (50%) having a dose greater than 3.0 mGy without demonstrating improved image quality. Results with both TLD and ionization chamber suggest that only one of the units simultaneously passed the FDA prescriptive guidelines for image quality and dose. The differences between the doses averages from TLD system and dosimeter, with ionization chamber being less than 10%. TLD system is a good option for average glandular dose measurement for X-rays with a HVL (0.35–0.38 mm Al) and kVp (24–26) used in quality control procedures, with ACR Mammography Accreditation Phantom.

References

[1] J.T. Bushberg, in *The Essential Physics of Medical Imaging*, 2nd edn (Philadelphia, Lippincott Williams & Wilkins, Philadelphia, 2002), pp. 155–156.
[2] E.D. Pisano, M.J. Yaffe and C.M. Kuzmiak, *Digital Mammography* (Lippincott Williams & Wilkins, Philadelphia, PA, 2004), pp. 22–24.
[3] G. Hammerstein, D. Miller and D. White, Radiology **130** 485–491 (1979).
[4] R.E. Hendrick, L.W. Bassett, M.A. Botsco *et al.*, ACR *Mammography Quality Control Manual* (Reston, American College of Radiology, VA, 1999), pp. 117–121, 149–163.
[5] Food and Drug Administration (FDA), in *Mammography Quality Standards Acts Regulations* (FDA, Rockville, MD, 2002), pp. 40–51.
[6] D.R. Dance, C.L. Skinner, K.C. Young *et al.*, Phys. Med. Biol. **45** 3225–3240 (2000).
[7] American Cancer Society (ACS), *Cancer Facts & Figures 2003* (American Cancer Society, Atlanta, GA, 2003).
[8] E. Gaona, in *Los Rayos X en Mamografía*, Distribuidora y Editora Mexicana, S.A. de C.V. (México, D. F., 2002) pp. 121–141.