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Numerical Model of Compressed Breast for the Japanese Women
: For the Dose Estimation of Mammography

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1. Introduction

The absorbed dose in mammography has been studied since 1980's. Some researchers have reported measurements of the absorbed dose in equivalent phantoms of breast tissue using the ion chamber, and some others the computational estimation of the dose by using the Monte Carlo simulation technique. In their investigations, the phantoms based upon the compressed-breast size data of European and American women are used. In general, the breast size of the women in East Asia is smaller than that of the European or American women. The compressed breast thickness is typically 4.4 to 6.4cm for the Europeans and Americans, whereas 3.8cm for the Japanese. Therefore, applying the above models to the Japanese women without any modification will lead to an overestimation of the absorbed dose. A standard numerical model that represents a mean more similar to Japanese mammalian physiology (not only the thickness but also the projected shape) should be developed to provide a comprehensive numerical tool to more carefully evaluate the proper dose.

In this study, we developed a numerical model of compressed breast for the Japanese women, featuring a part of an oval column based upon the average data of thickness of the compressed breast, and area, height and width of the mammographic images.

2. Materials and Methods

2.1 Equipment and Samples

To construct the model of compressed breast, we sampled and averaged the thickness of the compressed breast, and area, height and width of projected images of the compressed breast (**Fig.1**). The images were obtained by using a clinical mammographic unit (Senographe DMR; GE Medical Systems, Milwaukee, Wis.) for 281 women during two weeks in July 1997 at Shin-Sapporo Breast Clinic (Sapporo, Japan). Five hundreds and sixty images of mammography were taken for the cranio-caudal position. The area of the projected breast images was measured by using the image scanner (GT-9500, Epson, Japan). The thickness was recorded automatically by a digital indicator of the compressing unit attached to this. All images were taken by two radiographers, and it was supposed that the variation originates from the compressing and positioning procedures is minor.

2.2 Numerical Model

Assuming that the compressed breast shapes a part of an oval column, we measured the lengths of long-(a) and short-axis(b) of the projected image while the thickness is being sampled and averaged. The projected area is formulated by

$$S = k\,a\,b + e. \qquad (1)$$

Here, S is the area, a and b are the lengths of long- and short-axis, respectively, of the projected image of a semi-oval shape. k is a coefficient characterizing the shape of the semi-oval (i.e., if k gets closer to 0.5, the semi-oval looks like a triangle, and if k to unity, it comes to a rectangle), and e is the error.

We derived the coefficient k and the error e by a linear regression from the data of a, b and S, and then determined the elliptic function so as to make its partial area satisfy the relation of Eq.(1).

3. Results and Discussion

3.1 Thickness of the compressed breast

The average age is 43.2±10.1 years old (the average age ± the standard deviation, S.D.). The average thickness is 3.15±1.13 cm (left: 3.13±1.13 cm, right: 3. 17±1.13 cm). The result of thickness, area, long axis and short axis are given in **Table**. The difference of these values between right and left is not significant (thickness: $p=0.508$, area: $p=0.996$, Long axis: $p=0.917$, Short axis: $p=0.904$).

3.2 Numerical Model

The coefficient of correlation between S and ab was found to be 0.982, which was surprisingly close to unity. Thus, according to Eq.(1), we obtained $k=0.72$ and $e=0.02$. The standard error of k was 0.01 and that of e was 1.015. Because e is negligibly small compared to the other term, the equation can be simplified as,

$$S = 0.72\,a\,b \quad (cm^2). \qquad (2)$$

From this relationship, we can obtain an elliptical function that gives a segment framing the projected image as shown in **Fig.2**.

Goodsitt et al also tried to formulate the base figure of compressed breast and they proposed a third or forth order multinomial expression with a *cluster analysis*. However, the procedure to determine the multinomial expression is rather complicated. Our model using the elliptical function, though it was applied to only the Japanese mammogram so far, can be constructed just by measuring the lengths of the long- and short-axis of the projected images. One problem in the present modling is that we have to treat the base figure and the thickness independently because the correlation between them was not recognized.

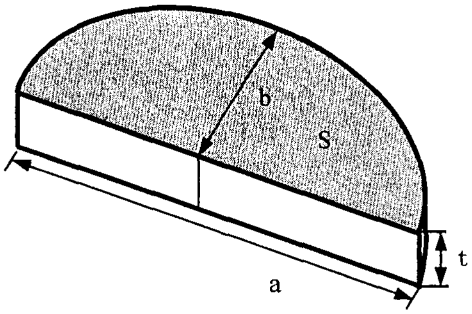

Fig. 1 Model

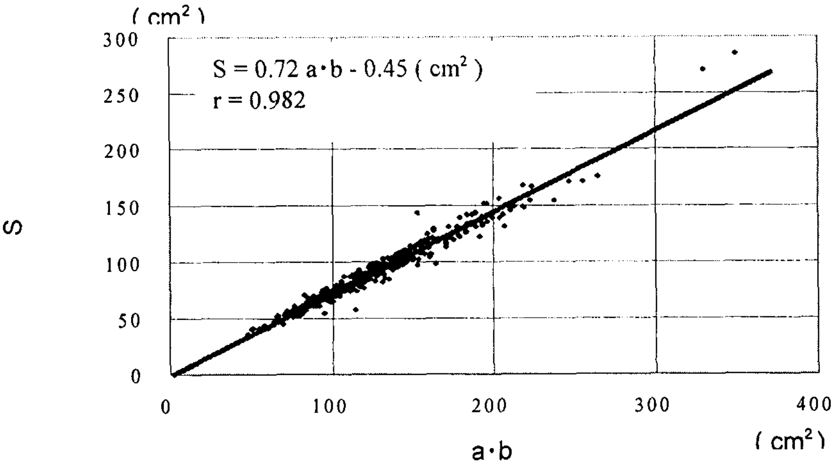

Fig. 2 The relationship between a•b and S

Table The mesurment value of thickness, area, axis

	Thickness(cm) t	Area(cm^2) S	Long axis(cm) a	Short axis(cm) b
Left	3.11±1.16	90.99±32.60	17.21±2.19	7.22±1.68
Right	3.17±1.13	90.98±32.60	17.18±2.09	7.19±1.74
Total	3.15±1.13	90.99±32.60	17.20±2.14	7.20±1.71

Mean±S.D.