Optimising mammographic compression protocols for Asian women

By Prof. Kwan Hoong Ng & Dr Susie Lau

In this article, we summarise our recent study in which we investigated the variability of mammographic compression parameters amongst Asian women, and also the effects of reducing compression force on image quality and mean glandular dose (MGD) in Asian women.

We found that force-standardized protocols led to widely varying compression parameters, but that it is feasible to reduce mammographic compression force with minimal effects on image quality and MGD in Asian women.

BREAST COMPRESSION DURING MAMMOGRAPHY

Breast compression is used in mammography both for optimizing image quality and reducing radiation dose [1-3]. When compressed, the breast deforms, giving rise to a breast contact area between the breast and compression paddle. The extent of breast deformation depends on the elasticity of breast tissue and size. [1]. One obvious disadvantage of breast compression is of course the pain and discomfort experienced by many women, particularly those who have undergone conservative treatment for breast cancer [1, 4-7].

During mammography, radiographers normally compress the breast according to established compression protocols [8-10], and also according to their own experience and judgment based on the tautness of the breast, its size and the pain tolerance of the women. Currently available mammographic compression protocols are force-standardized, subjective, and do not take breast size and elasticity into account [1, 4, 6, 11]. This lack of consistent and objective guidelines in mammographic compression has led to large variations in both the force and pressure applied by radiographers during mammography [1, 4, 12, 13].

It was observed in recent studies that force-standardized compression protocols result in women with smaller breasts being subjected to higher compression pressures and possibly experiencing more pain during mammography compared to women with larger breasts [4, 11, 14, 15]. Moreover, studies also revealed that although there was a tendency to apply greater compression forces to women with greater breast volumes, large variations still existed even between women with similar breast volumes [4, 16]. In addition, over-compression of the breast has also been reported in several studies, in which the compressed breast thickness (CBT) was not reduced even when additional compression force was applied. This causes unnecessary increase in pain and discomfort to the women without any benefits in image quality and radiation dose [11, 13, 14, 17].

Variations in compression force result largely from differences in the experience of the radiographers. One aim of the compression technique used should be to minimize variability as this could affect the consistency of the imaging procedure [1, 4, 12, 16]. Likewise, the level, and variability, of the pain and discomfort experienced by women during mammography should also be minimized as this could affect future participation in screening mammography [1, 4, 12, 18, 19]. Recent studies have suggested using pressure (applied force divided by the breast contact area) instead of force to standardize mammographic compression [1, 4, 11]. Pressure-based standardization inherently takes breast elasticity and size into account, and provides an objective and consistent mammographic compression for each individual breast [1, 4, 11]. These studies also proposed standardizing compression pressure at 10 kPa (about 75 mmHg), on the basis that this pressure corresponds to the normal diastolic pressure in the breast, and so results in constant venous blood outflow from the breast, regardless of breast size and the view in which the mammography is carried out [craniocaudal (CC) or mediolateral-obl ique (MLO)] [1, 4, 6, 11, 15].

However the currently available compression protocols [8-10] have largely been optimized for Caucasian women and thus Asian women (who generally have smaller breasts)

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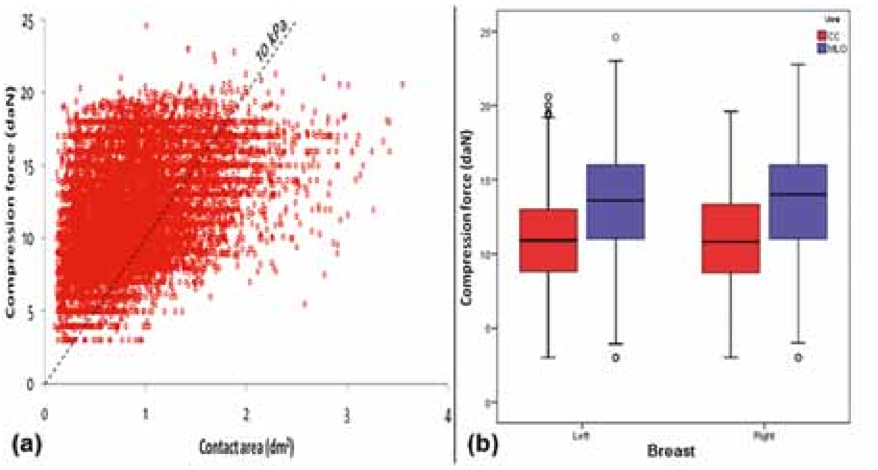

Figure 1. (a) Scatter plot showing compression force against contact area. (b) Box plot showing compression force for the left CC, left MLO, right CC and right MLO views [20].

are examined using protocols that might not be optimal for them. Previous studies of compression have mainly been carried out in Caucasian women — little is known about mammographic compression in Asian women.

For this reason, we recently investigated the mammographic compression practices used with the Asian women attending our center by analyzing the variability of compression parameters and other relevant imaging parameters. We also evaluated the possible impact of reducing compression force on image quality and mean glandular dose (MGD) in a phantom-based study [20].

MAMMOGRAPHIC COMPRESSION PARAMETERS IN ASIAN WOMEN

In the first part of our study, we collected 15818 "For Processing" raw digital mammograms (CC and MLO views) from 3772 Asian women aged 35-80 years (mean: 57±9 years) who underwent screening or diagnostic mammography at our center. The mammograms were processed using an automated volumetric breast density (VBD) measurement system (Volpara Version 1.5.1) to extract compression parameters during mammography, including the compression force applied and the compressed breast thickness (CBT) from the DICOM header of the images. The breast contact area between the breast and the compression paddle was computed by the Volpara software, based on the total breast area segmented from the background in the images. Compression pressure was estimated by dividing the applied compression force by the breast contact area. Other parameters including breast volume, volumetric breast density (VBD) and MGD were also computed from the images by the Volpara software. We then investigated the relationships between these parameters (i.e. compression force, compression pressure, CBT, breast volume, VBD and MGD) with the breast contact area.

As expected, compression pressure and breast volume were observed to correlate strongly and statistically significantly with breast contact area as these two parameters were derived from breast contact area [Figures 1 and 2]. Compression force, CBT and VBD showed moderately significant correlation with breast contact area, whereas MGD showed weak, but still significant, correlation with breast contact area [Figure 3]. We also found that the force-standardized protocol as currently practiced in our center with our Asian women and patients resulted in large variations in both compression force and in compression pressure applied. The compression force applied in MLO views was found to be significantly higher than that in CC view, whereas the compression pressure applied in CC view was significantly higher than that of MLO.

The overall median compression force for our study population was approximately 12.0 daN. Based on our data and the proposed pressure-standardized protocol, the optimal median compression force should be approximately 8.1 daN. In a previous film-screen mammography study, it was reported that many women experienced breast pain with compression forces of 12.0 daN; reducing the compression force to 9.0 daN was found to be more acceptable and tolerable to the women in the study [21].

Consequently, we carried out a study using phantoms to investigate the potential impact on image quality and MGD of reducing the compression force from 12.0 daN to 9.0 daN in digital mammography in Asian women. Analysis of data from 105 Asian women aged 24-78 years (mean: 52±11 years) who underwent screening or diagnostic mammography at our center revealed that the CBT increased by 3.3±1.4 mm when the compression force was reduced from 12.0 daN to 9.0 daN.

PHANTOM STUDY FOR ASSESSING IMAGE QUALITY AND MEAN GLANDULAR DOSE

In this part of our study, we used the RMI156 Mammographic Accreditation Phantom to simulate a typical 4.2 cm of compressed human breast (composed of

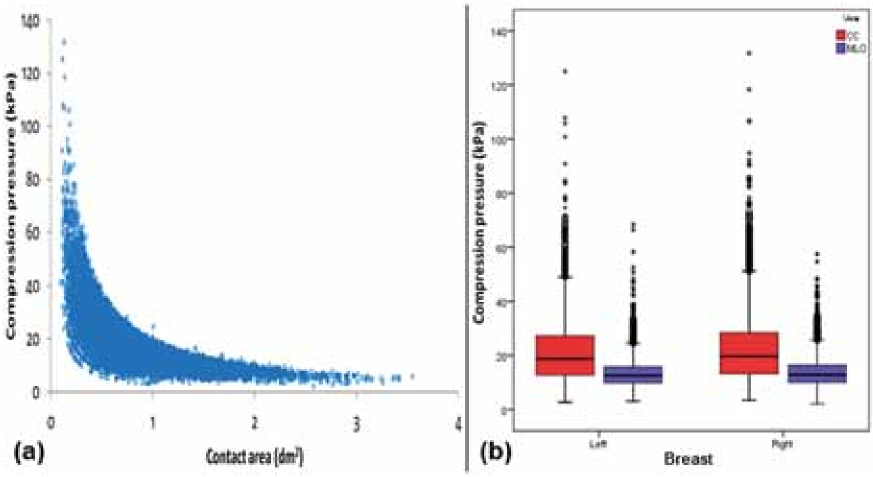

FIGURE 2. (a) Scatter plot showing compression pressure against contact area. (b) Box plot showing compression pressure for the left CC, left MLO, right CC and right MLO views [20].

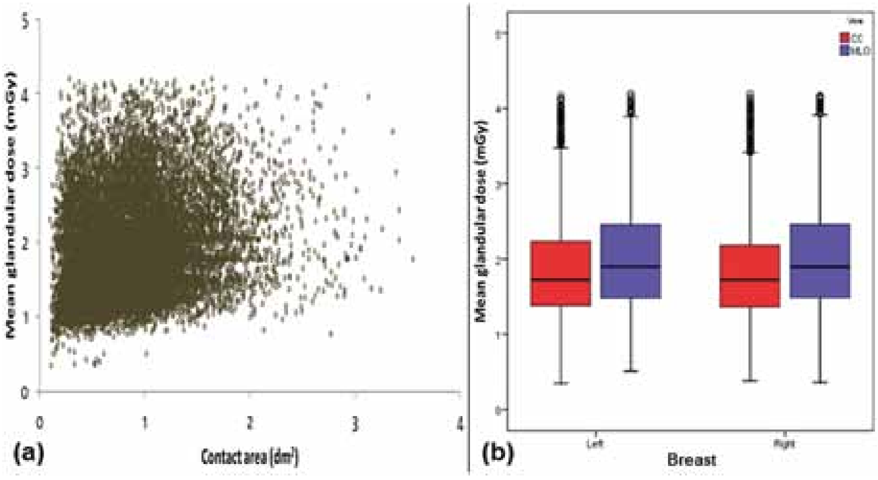

FIGURE 3. (a) Scatter plot showing mean glandular dose against contact area. (b) Box plot showing mean glandular dose for the left CC, left MLO, right CC and right MLO views [20]. .

50% adipose tissue and 50% glandular tissue). To simulate different thicknesses of breast tissue, 10.2 cm X 10.8 cm slabs of polymethyl methacrylate (PMMA) were used. Images of the RMI156 phantom were first acquired using the two most frequent anode/filter combinations and tube voltages (kVp), namely tungsten/rhodium combination (W/Rh) at 28 kVp, and tungsten/silver combination (W/Ag) at 30 kVp. The phantom was then imaged with increasing numbers of PMMA slabs of different thicknesses (1-6 mm, with 1 mm increments) added between the phantom and compression paddle to simulate the increase in CBT.

Four professionally trained observers were then asked to score the phantom image quality from no PMMA slabs added up to a total of 6 mm PMMA slabs added. The images, displayed on a diagnostic monitor, were scored according to test features, such as fibers, masses and calcifications in the images.

Statistical analysis revealed that there were no significant differences in the fiber, mass, calcification and total scores when the phantom was imaged without any added slabs and with 5 mm of PMMA slabs added, using both W/Rh at 28 kVp and W/Ag at 30 kVp, so indicating that the image quality was similar under these conditions. From these findings, we expect that the increase of 3.3±1.4 mm in CBT which would result from lowering the compression force would have limited impact on image quality. Estimates of MGD in the phantom study showed that an increase in CBT caused by the decrease in compression force from 12.0 daN to 9.0 daN would also have limited effects on MGD.

CONCLUSION

Currently available force-standardized protocols do not take breast elasticity and size into account, and led to widely varying compression parameters, particularly compression force and compression pressure. This has already been shown in Caucasian women but has now been confirmed also in Asian women. These force-standardized protocols have largely been optimized for Caucasian women, thus Asian women who generally have smaller breasts are subjected to protocols that might not be suitable for them.

We also showed that it is feasible to reduce compression force in Asian women with limited impact on image quality and MGD in digital mammography.

In view of the limitations of force-standardized protocols, pressure-based standardization as promoted by some researchers [1, 4, 6, 11, 15], would appear to be superior for mammographic compression protocols.

In the light of all this, we trust that manufacturers will take steps to improve the compression mechanism and measurement, with the overall aim of providing women with a more comfortable experience during mammography, while of course maintaining image quality.

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