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A method to investigate image blurring due to mammography machine compression paddle movement

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ABSTRACT

Background: Compression paddles can move during mammography exposures. Speculation suggests that this movement can cause image blurring. No research has been published to demonstrate whether such movement could cause image blurring.
Aim: Develop a method to determine whether paddle movement can cause image blurring
Method: A Hologic Selenia Dimensions mammography machine calibrated to give compression force in Newtons (N) with 24 × 30 cm fixed and flexible paddles was used. Eleven metal ball-bearings with 1.50 mm diameter were inserted onto the surface of a deformable breast phantom. The ball-bearings were placed at various points, from nipple to chest wall. The phantom was compressed using the foot pedal then hand wound to 80 N and also 150 N respectively to represent low and high compression forces used in clinical mammography. Under these conditions, images were created by exposing the phantom/ball-bearings. Image blurring was determined by measuring the change in ball-bearing diameter (distortion) using computer software.
Results: Ball-bearing diameters increased, illustrating the effect of compression paddle motion on the images. The change in ball-bearing diameter is the highest around the nipple region for both fixed (1.688 ± 0.013 mm at 80 N, 1.694 ± 0.005 mm at 150 N) and flexible (1.714 ± 0.003 mm at 80 N, 1.661 ± 0.005 mm at 150 N) paddles.
Conclusion: The increase in ball-bearing diameter suggests that image blurring due to paddle movement can be identified on images of ball-bearings adhered to the surface of a deformable breast phantom. Increase in diameter could be used as an indicator of movement severity.

Introduction

Mammographic images seem to have become more susceptible to blurring since the introduction of full field digital mammography (FFDM). The superior contrast resolution of FFDM, compared to film/screen systems, could make blurring more visible.[1,2] Previous work suggests that image blurring may be induced by poor positioning technique, patient movement, patient respiration and suboptimal compression.[3,4] A number of breast imaging centres have identified blurred images and have taken steps to minimise these factors. However, blurring still persists, and few reports have been published about this phenomena.[5,6] Research by Kelly et al.[7] suggests that image blurring may be induced by compression paddle movement during the image acquisition process. In a multicenter phantom study, Hauge et al.[8] noticed that compression paddles continue to move slightly after compression force had ceased being applied. Measurements made during a different phantom-based multicentre study by Ma et al.[9] also suggests that movement at the paddle can occur in the ‘compressed state’. Ma went onto explain that this movement followed an exponential decay. According to Geerligs et al.[10] the movement at the paddle is probably caused by the thixotropic behaviour of the breast, which is the structural changes of the adipose tissue due to mechanical loading.

This study outlines a method to determine whether image blurring due to paddle motion can be detected on FFDM mammography images.

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Method

Equipment setup

A Hologic Selenia Dimensions 2-D FFDM unit (*Hologic Incorporated, Bedford, MA, USA*) calibrated to give a compression force in Newtons (N) was used in this study. FFDM system resolution was 15.33 pixels per mm. Routine equipment quality assurance (QA) had been performed on the machine and the results complied with manufacturer specifications.[11] It would be un-ethical to expose the patients repeatedly in order to investigate the effect of paddle motion on image quality. Consequently, a deformable breast phantom was used to simulate clinical imaging conditions. The phantom, originally described by Hauge,[8] comprised of a prosthetic breast insert (*Trulife, Sheffield, United Kingdom*), this was attached in a semi-mobile fashion to a rigid backboard, thereby representing the chest wall and the minor motion associated with the breast sitting on the pectoral muscle. A thin latex coating was applied to the surface of the prosthesis, allowing it to be fixed to the backboard in a fashion similar to Skin. Hauge demonstrated similar compression characteristics to human female breast tissue for this construction.

Eleven metal ball-bearings, with 1.50 mm spherical diameter, were adhered onto the phantom surface using adhesive tape. The ball-bearings were positioned at various points, from nipple to chest wall, Figs. 1 and 2. The phantom was compressed to approximately 80 N and then 150 N to represent low and high compression forces used in clinical mammography. The experimental setup is shown, Fig. 3. Four sets of images (40 in total) were acquired by using fixed and flexible 24 × 30 cm paddles at 80 N and 150 N compression. The images were acquired after compression was applied in order to study how ball-bearing diameters vary at various points in time after compression force application had ceased. The time interval between the acquired images is 26 s (ie T_1

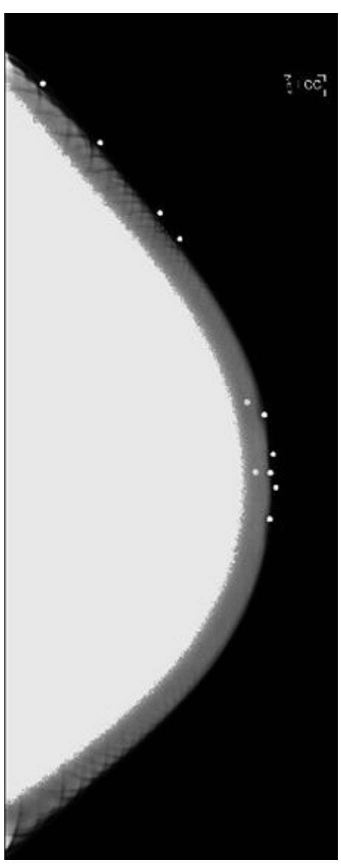

Figure 1. Mammogram showing the adhesion location of the eleven metal ball-bearings on the phantom surface.

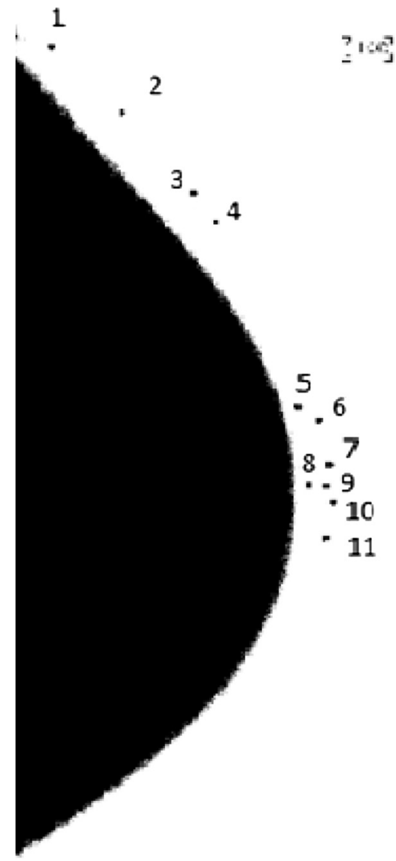

Figure 2. Schematic diagram showing the relative location of the eleven metal ball-bearings using numbering system.

Figure 3. The experiment setup showing the breast phantom mounted semi-mobile onto a rigid supporting board.