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Mammography with and without radiolucent positioning sheets: Comparison of projected breast area, pain experience, radiation dose and technical image quality

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ABSTRACT

Purpose: To compare projected breast area, image quality, pain experience and radiation dose between mammography performed with and without radiolucent positioning sheets.
Methods: 184 women screened in the Dutch breast screening programme (May–June 2012) provided written informed consent to have one additional image taken with positioning sheets. 5 cases were excluded (missing data). Pain was scored using the Numeric Rating Scale. Radiation dose was estimated using the Dance model and projected breast area using computer software. Two radiologists and two radiographers assessed image quality.
Results: With positioning sheets significantly more pectoral muscle, lateral and medial breast tissue was projected (CC-views) and more and deeper depicted pectoral muscle (MLO-views). In contrast, visibility of white and darker areas was better on images without positioning sheets, radiologists were therefore better able to detect abnormalities (MLO-views). Women experienced more pain with positioning sheets (MLO-views only, mean difference NRS 0.98; SD 1.71; $p = 0{,}00$).
Conclusion: Mammograms with positioning sheets showed more breast tissue. Increased breast thickness after compression with sheets resulted in less visibility of white and darker areas and thus reduced detection of abnormalities. Also, women experienced more pain (MLO-views) due to the sheet material. A practical consideration is the fact that more subcutaneous fat tissue and skin are being pulled forward leading to folds in the nipple area. On balance, improvement to the current design is required before implementation in screening practice can be considered.

1. Introduction

Early detection of breast cancer through mammographic screening can only be achieved if high-quality mammograms enable screening radiologists to detect minimal abnormalities or subtle changes over time. Many population-based screening programmes recognise the importance of quality and hence implemented systems of quality assurance (QA), including accreditation requirements, quality assurance standards or quality control guidelines [1]. The Dutch screening programme also has a stringent QA system which is managed by the Dutch reference centre for screening (LRCB). Manufacturers continuously propose improvements to mammography equipment to increase image quality and it is our experience that they are often implemented in clinical or screening practice without being properly investigated. One of the responsibilities of the LRCB is to determine the value of new tech-

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nologies before they are implemented in the national screening programme.

Planmed, a manufacturer of mammography equipment, developed a mammographic positioning aid (MaxView™) aiming to optimise 3D breast volume on the 2D mammogram. The MaxView™ system consists of two radiolucent positioning sheets that pull the breast forward during compression [2]. It is recommended by the manufacturer for use in all standard mammographic views. The system is hypothesized to increase overall depicted breast area (up to 2 cm in some women) and improve image clarity (as the glandular tissue is better spread out). In addition, the manufacturer assumes a relatively larger benefit for women with small breasts and more comfort for women with small and dense breasts (easier to position, thus requiring less retakes). The system has been described earlier but only small numbers were included ($n = 8$)[2]. Consequently, very little is known on the exact performance of the positioning sheets and the experience of women.

Hence, the purpose of our study is to compare pain experience, projected breast area, radiation dose and technical image quality between mammography performed with and without radiolucent positioning sheets in the context of the Dutch screening programme.

2. Materials and methods

2.1. Screening setting

Details about the set-up of breast screening in The Netherlands have been described previously [3–4]. In short, the screening programme invites women between 50 and 75 for a screening mammogram every two years. Two view mammography is standard: mediolateral oblique (MLO) and craniocaudal (CC) views. The screening examinations are read by two qualified screening radiologists (double blind) who must reach consensus about recall for further diagnostic assessment. A third reader decides in cases where consensus is not reached.

2.2. Study population and design

In accordance with the Dutch Population Screening Act, a permit for this study (equal to institutional review board approval) was obtained from the Minister of Health, Welfare and Sport in January 2012. In total, 715 women who were scheduled for a screening mammogram between May and June 2012 received the study information with the invitation to screening. All participating women signed informed consent. We excluded women with a breast prosthesis, women who did not understand the Dutch language, as well as women who were mentally disabled.

All mammograms were taken on the Planmed Nuance with 18×24 and 24×30 cm fields of view. The MaxView™ system consists of two radiolucent moving sheets that are under and above the compressed breast. These sheets, controlled by two built-in traction modules, pull the breast forward during compression [2]. The standard target force for compression is between 120 and 200 N in the Dutch screening setting. In order to diminish differences in mammographic positioning, the study mammograms were made by two experienced radiographers who were trained in using the positioning sheets. All participating women received one extra view with positioning sheets allocated for one out of four views, i.e., the right CC, left CC view, right MLO or left MLO view respectively.

2.3. Image quality

Image quality was quantitatively reviewed by two experienced screening radiologists (18 and 7 years' experience) and two experienced screening radiographers (12 and 13 years' experience). Dutch screening radiologists read on average >15.000 screens per year. The number of screens read as first and second reader are equally divided. An independent blinded paired comparison was performed using the toggle (blinking) mode to evaluate whether one of the two mammograms had better image quality for each criterion or if they were equivalent. Toggle mode alternates new and prior screening mammograms superimposed digitally upon each other, rather than comparing them visually in the side-by-side or up–down fashion. The CC views were scored according to the following criteria: more breast tissue depicted on the lateral and medial side of the breast, glandular tissue projected closer towards chest wall side, glandular tissue better separated, nipple better projected in profile, more pectoral muscle, motion artefact and better contrast in white and darker areas. The MLO views were scored according to the following criteria: more and deeper pectoral muscle, glandular tissue more to chest wall side and better separated, area around the nipple better imaged, nipple in profile, inframammary angle more clearly imaged, motion artefact and better contrast in white and darker areas. In addition, screening radiologists also scored breast density and if applicable, whether relevant clinical findings were better visible on one of the two images. Additionally, an interpretation reading session was organised for radiographers and radiologists separately in which they came to a consensus about the image quality criteria. To select women with small breasts, we selected women in the lowest quartile of depicted breast area. Breast density was assigned in four categories, namely <25%, 26–50%, 51–75% and >76%. To select women with dense breasts, we selected women in the >76% category.

2.4. Pain experience

Pain experience was assessed by means of the Numerical Rating Scale (NRS): a 11-point scale from "no pain" to "severe pain" [5]. Women scored the NRS directly after each compression with and without positioning sheets. To be able to compare pain experience, applied compression force for the second view was the same as the compression force for the first view (either the view with or without positioning, randomly selected).

2.5. Breast area, breast thickness, compression force and radiation dose

To determine the amount of breast area projected on the image, the posterior nipple line and the projected breast area were calculated for images taken with and without positioning sheets. The length of the posterior nipple line was measured manually as a perpendicular line from the posterior film edge or pectoral muscle to the nipple (CC) or the pectoral muscle to the nipple (MLO) [6–7]. The projected breast area was calculated using MATLAB software (The Mathworks Inc, Novi, MI, USA). Two parameters were used from the DICOM-header: the pixel value of the background region in the processed images and the pixel size (a). The software algorithm marked all pixels above a fixed background level in the 'for presentation' mammogram as being part of the breast surface. Morphologic operations were subsequently applied to ensure that all pixels within the breast area were marked. The algorithm calculated the total number of marked pixels (n) for each image. The projected breast area was then calculated for each image ($n \times a$). Furthermore, radiographers noted the distance (mm) that the positioning sheets were moved forward from the chest wall. Compression force (Newton) and height of the compression paddle (mm), as a proxy for breast thickness after compression, were also taken from the DICOM-header for views with and without the positioning sheets. We used the breast dosimetry model developed by Dance et al. to determine glandular dose. This model is widely applied and recommended