Original Article

Effects of Reduced Compression in Digital Breast Tomosynthesis on Pain, Anxiety, and Image Quality

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Abstract

Background: **Most women are reluctant to undergo breast cancer screenings due to the pain and anxiety they experience. Sectional three-dimensional (3-D) breasttomosynthesis was introduced to improve cancer detection, but breast compression is still used for the acquisition of images. This study was conducted to investigate the effects of reduced compression force on pain, anxiety and image quality in digital breast tomosynthesis (DBT).**

Methods: **A total of 130 women underwent screening mammography using convenience sampling with standard and reduced compression force at the breast clinic. A validated questionnaire of 20 items on the state anxiety level and a 4-point verbal rating scale on the pain level were conducted after the mammography. Craniocaudal (CC) and mediolateral oblique (MLO) projections were performed with standard compression, but only the CC view was performed with reduced compression. Two independent radiologists evaluated the images using image criteria scores (ICS) and the Breast Imaging-Reporting and Data System (BI-RADS).**

Results: **Standard compression exhibited significantly increased scores for pain and anxiety levels compared with reduced compression ($P < 0.001$). Both radiologists scored the standard and reduced compression images as equal, with scores of 87.5% and 92.5% for ICS and BI-RADS scoring, respectively.**

Conclusions: **Reduced compression force in DBT reduces anxiety and pain levels without compromising image quality.**

Keywords: *compression, anxiety, pain, breast, reduction*

Introduction

Screening mammography is the gold standard for the early detection of breast cancer (1,2). The use of breast compression is vital to immobilise the breast, separate overlapping breast tissue and reduce scattered radiation, thus facilitating image interpretation (1,3). However, women who undergo screening complain of pain as well as discomfort in their breasts and avoid consecutive mammography screenings in future years (4,5).

The discomfort may also be the result of an inexperienced radiographer with poor communication and competency skills (1,6). According to earlier studies, painful sensation (76%), fear of being diagnosed with breast cancer (45%), cost of the procedure (72%), and disapproval from the patient's husband (65%) are barriers to mammography screening (7,8). Therefore, due to women's reluctance to undergo screening, breast cancer is detected in late stages, causing delay in further management (8,9).

Measures must be taken to reduce anxiety and pain to encourage more women to undergo mammography (10). Patients who experience high anxiety levels also experience increased levels of discomfort and pain (11), which are directly related to the compression level. Therefore, the aim of this study was to evaluate the effect of reduced compression force in digital breast tomosynthesis (DBT) on pain, anxiety and image quality.

Methods

This is a prospective study on 130 Malaysian women aged 40 to 69 years. Ethical approval was obtained from the ethical committee before commencement of the study (NN-027-2013). Informed consent was obtained from the women prior to the acquisition of mammography with the HOLOGIC Digital Breast Tomosynthesis Selenia Dimension (DBT) at the Breast Screening Clinic, National Cancer Society of Malaysia. Participants were excluded if they were previously diagnosed with breast cancer, had breast augmentation, were breast-feeding or were pregnant. This study was conducted from February to September 2013. Table 1 shows the demographic data of the participants.

The State Form of 'State-Trait Anxiety Inventory' Form Y-1 (STAI Form Y-1) (19) validated questionnaire, comprising 20 items (Cronbach's Alpha 0.77), was used to measure the state anxiety level after standard and reduced compression mammography. The questionnaire was rated according to the degree of anxiety: 1 was 'not at all', 2 was 'somewhat', 3 was 'moderately so', and 4 was 'very much so'. The 20 items were summed to measure the state anxiety level scored by the participants. The score was categorised into low (20 to 23), average (24 to 46), and high (47 to 80) levels of anxiety.

The 4-point verbal rating scale (VRS-4) was used to measure the pain level and referred to the 'Pain Intensity Rating Scale' (12). The categories of pain levels were 0 (no pain), 1 (some pain), 2 (considerable pain), and 3 (pain that could not be more severe). Pain levels for the first (standard) and second (50, 60 or 70% reduced compression from standard) compression force were obtained after the acquisition of mammography. A higher VRS-4 score indicated more pain or high pain intensity. Finally, the outcome anxiety of the participants was determined using a Likert scale ranging from 0 to 10 to determine the participant's anxiety level while awaiting interpretation of the mammogram.

Standard DBT mammography was performed with craniocaudal (CC) and mediolateral oblique (MLO) views, with an additional view (CC) of the selected breast using reduced compression. All parameters were similar except for the applied compression force, and the participants were not informed of the compression force. The standard compression force ranged between 60 and 170 Newton (N), whereas 30 to 90 N was the range used for the reduced compression force on one CC view of either breast (13). Standard compression is the optimum compression force identified by the radiographer, which is indicated by no changes in the breast thickness with an increase in compression. Women can better tolerate a compression force of approximately 90 N in mammography (14).

This study included 60% and 70% reductions rather than only 50%. Because a study of 50% reduction of compression has already been conducted by Fornvik et al. (2010), the authors decided to reduce the compression by 60 and 70% because a greater reduction may reduce the pain and anxiety levels and encourage more women to undergo screening mammography. Nevertheless, a further reduction of 80% to 90% was planned but not performed due to time constraints. Percentages of reduction were based on the breast cup size for each woman. The breast sizes were categorised as small (31 to 34 cup size), moderate (35 to 38 cup size) and large (39 to 52 cup size).

The demographic data, the outcome anxiety level and the participants' related information were measured. Only one radiographer performed the mammography screening on the patients throughout the study. The participants were provided a complete explanation by the radiographer before the procedure began.

Two hundred sixty images were blinded with the use of a five mega-pixel flat panel monitor (Secureview) and evaluated independently by two radiologists with at least five years of experience using the European Guidelines image criteria score (ICS) and the BI-RADS score (15). Each radiologist was given a set of images, including a standard image and a reduced compression image of the CC view, to rate for the ICS and BI-RADS scores. The evaluation process had no time limit. Random images were selected for re-evaluation by the same radiologists to obtain the strength of the evaluation.

The data were analysed using the SPSS version 21.0. A p-value less than 0.05 was considered statistically significant. Descriptive analyses were presented in numbers and percentages. Kendall's-tau-B correlation coefficients were used to measure the strength of relatedness between parameters, and Cohen's kappa was used to measure the strength of agreement between interpreters based on the BI-RADS score. One-way analysis of variance (ANOVA) was then used to evaluate the anxiety levels based on the amount of compression force applied. A two-sided paired sample t test was conducted to measure the levels of pain and anxiety before and after exposure.

Results

Descriptive

Descriptive analysis was used to describe the demographic data in relation to the anxiety, pain level, and breast compression force in 130 women. The mean (SD) age of participants in this study was 48.6 (6.07) years. Table 1 presents the demographic characteristics of the women. Of the participants, 55% had no previous experience with mammography, and 82.5% had no family history of breast cancer. A significant difference in pain level was noted between patients with and without previous mammography experience. This result indicates that those who had previous experience with mammography expressed higher pain levels. Of the women in the study, 49% had moderate-sized breasts, 41% had small breasts, and 10% had large breasts. No existing correlation was noted between breast size and pain level. Most (92.9%) of the participants were not on hormone replacement therapy (HRT).

Participant characteristics correlated with anxiety and pain levels

Table 2 presents the demographic factors and correlation matrix for the study variables. A weak, positive correlation was noted between the scores for anxiety and education (r = 0.149, n = 130, P < 0.001) as well as outcome anxiety (r =

Table 1: Demographic characteristics of the subject (n = 130)

	Number (n)	Percentage (%)	Mean (SD)
Age			
40–49	83	64	48.6 (6.07)
50–59	40	31	
60–69	7	5	
Size of breast			
31–34 (small)	52	40.5	
35–38 (medium)	64	49.2	
39–42 (large)	14	9.5	
HRT intake			
Yes	8	6.3	
No	122	92.9	
Symptoms of breast:			
Lump			
Yes	11	8.7	
No	119	90.5	
Pain			
Yes	14	11.1	
No	116	88.1	
Family history of breast cancer			
Yes	21	16.7	
No	109	82.5	
Done mammography before			
Yes	58	46.0	
No	72	53.2	
Education levels			
Yes	8	6.2	
No	76	58.5	
University	46	35.4	

0.229, n = 130, P < 0.001). Women with higher education levels tended to have higher anxiety levels compared with those with lower education levels. A weak, positive correlation also existed between pain and previous mammography experience (r = 0.188, n = 30, P < 0.001)*. A weak, negative correlation was noted between age and outcome anxiety (both = -0.172). Older women were less anxious (P < 0.001). Subsequent participant characteristics did not exhibit any correlation with pain and anxiety levels.

A paired sample t test was conducted to evaluate the pain level scores for standard and reduced compression during mammography screening (Table 3). A significant decrease was noted in pain level scores from standard compression (mean = 2.13, SD (standard deviation) = 0.69) to reduced compression (mean=0.69, SD = 0.74, t (129) = 26.34, P < 0.001 (two-tailed)). The mean decrease in the pain score was 1.44 with a 95% confidence interval ranging from 1.33 to 1.55. A significant decrease was noted in anxiety levels with standard compression (mean = 57.15, SD = 8.18) compared with reduced compression (mean = 47.23, SD = 6.85, t (129) = 15.44, P < 0.001 (two-tailed)). The mean decrease in the anxiety score was 9.92 with a 95% confidence interval ranging from 8.65 to 11.20.

Compression and image quality

The mean (SD) standard compression applied was 93.0 N (5.13), whereas the reduced compression was 38.5 N (2.44), which is in the range of 50% to 70% of standard compression. A one-way between groups ANOVA exhibited a significant difference between anxiety levels and compression at 50%, 60% and 70% (F (2, 127) = 7.4, P < 0.001). The effect size, which was calculated using eta squared, was 0.10. Post-hoc comparisons using Tukey's honest significant difference (HSD) test indicated that the mean score for Group 1 (participants who had a 50% compression reduction [mean = 49.64, SD = 5.77]) reflected a significantly reduced anxiety level compared with that of Group 3, (participants who had a 70% compression reduction, [mean = 53.18, SD = 6.88]). Group 2, the participants who had a 60% compression reduction, (mean = 54.78, SD = 6.72) did not differ significantly from either Group 1 or Group 3 in terms of the anxiety level.

The mean (SD) compression force and thickness for standard compression were 80.30 N (SD 22.00) and 51.10 (SD 8.96), respectively, whereas the values for the reduced compression were 28.62 N (SD 10.74) and 55.35 (SD 9.26), respectively. The difference between the two

Table 2: Kendall's-tau-B correlation coefficients between demographic factors and study variables

Socio-demographic factors	Pain	Anxiety	Outcome Anxiety
Age	0.088	−0.056	−0.172[a]
Breast size	0.102	−0.033	0.093
Education	0.045	0.149[a]	0.229[a]
Previous Mamography Experience	0.188[a]	0.029	−0.015
Participants who consumed HRT	0.087	0.098	−0.164[a]
Family history of breast cancer	−0.089	−0.079	0.064

[a]P < 0.001 (two-tailed)

Table 3: Results of the anxiety and pain level

Research Variables	Mean (SD)		*t* value	*P* value
	Standard Compression	Reduced Compression		
Anxiety during the procedure (N = 130)	57.15 (8.18)	47.23 (6.85)	15.44	P < 0.001*
Pain during the procedure (N = 130)	2.13 (0.69)	0.69 (0.74)	26.34	P < 0.001*

*P < 0.001 (two-tailed).

compression thicknesses was 4.25 mm. For ICS and BI-RADS scoring, both radiologists scored the standard and reduced compression images as equal, with scores of 87.5% and 92.5%, respectively (Table 4). The inter-rater agreement using the BI-RADS score was moderate (k = 0.65) (16). Moreover, the intra-rater agreement was good for both radiologists (k = 0.81 and 0.78).

Discussion

This study is an extension of previous research on pain and anxiety levels in mammography with additional values of compression. Several important findings emerged, including a strong correlation between education level and pain and anxiety levels (10). Previous mammography experience exhibited a correlation. However, only 53.2% of participants had experience with mammography, and 82.5% had no family history of breast cancer. Although some studies suggested that the pain level influences the mammography screening, one study stated that those who underwent mammography felt that the pain was not as severe as what they envisioned. This finding proved that the pain was not the main reason that women avoid screening mammography (17). Breast size was independent of anxiety and pain levels in the present study; this finding is contrary to the study by Keemers et al. (2000) (18). Nevertheless, several studies have also demonstrated no correlation between pain and breast size (17,19).

The level of pain perception varies from person to person, as it is by nature a subjective feeling. However, in this study, the reduction in applied compression during mammography caused lower pain and anxiety levels, which is similar to an earlier study using 50% compression (10). A lack of skills in radiographers who perform mammography can contribute to the patient's pain. For the present study, only a single radiographer performed the mammography (20).

The present study revealed significant differences between the total score of anxiety levels before (57.15 (SD 8.18)) and after (47.23 (SD 6.85)) mammography ($P < 0.001$). Increases in anxiety levels were due to feeling tense, being worried about possible misfortunes, fear of pain and being nervous, and these levels are reduced with previous experience (21). Highly educated women were less anxious due to existing knowledge regarding mammography (10). However, this study demonstrated that highly educated women were more anxious, and this phenomenon may be due to Internet overexposure, especially open-access websites. Therefore, there is an urgent need to increase awareness and knowledge among Malaysian women, especially those in rural areas (21,22) who receive less exposure to information, as well as to educated women to ensure that they receive the correct information.

Most of the participants in the present study had a reduced anxiety level with a reduction in compression but an increase in the outcome anxiety score with a rating of 5 and above, indicating a moderate to high level of outcome anxiety. It is possible that the participants were anxious about the interpretation of the mammogram, which may indicate breast cancer. However, older women were less anxious (10,11). Increased levels of anxiety during mammography screening correlated with the fear of outcomes, such as false positive results and exposure to ionizing radiation (23). Anxiety was also correlated with the possibility of recalls in mammography (24).

The results of the correlation between anxiety and pain levels are supported by previous studies that demonstrated increased correlation after mammography (10). The results revealed that anxiety was due to the experience of pain, as anxiety increased linearly with pain. Each patient who undergoes screening mammography is unique, and the radiographer must provide adequate care. Older participants tend to be more relaxed compared with younger participants due to their ability to control their anxiety levels (10).

Table 4: BI-RADS score for two radiologists

Compression	BI-RADS score (n)			
	Rater 1		Rater 2	
	Same evaluation (%)	Different evaluation (%)	Same evaluation (%)	Same evaluation (%)
Standard Compression vs Reduced Compression	87.5 (118)	12.5 (12)	92.5 (120)	7.5 (10)

The present findings were consistent with previous studies, which stated that pain and discomfort increased as the anxiety level increased (11).

Several studies have suggested that allowing the patient control over the compression force reduces the anxiety level; however, this method was not practised in the present study (25). Other studies have suggested effective communication skills and comprehensive information for reducing patients' anxiety levels, which was of utmost importance in this study (26). Fallowfield et al. (1990) suggested the use of the Health Beliefs Model of Rosenstock (HBM), which provides a positive mind set for mammography screening and reduced anxiety levels (27). Moreover, HBM convinces more women to undergo screening for early detection of breast cancer. Health campaigns to promote screening should encompass HBM to improve health-seeking behaviour and readiness for screening among women.

A study indicated that it was appropriate for screening mammography to be performed using a reduced force of 90 N instead of the standard compression force of 120 N if the patient is in pain (14). However, the compression used in this study was in the range of 28 to 43 N with the use of a 50%, 60% or 70% reduction of compression and with no degradation of image quality for diagnostic interpretation (13). Excessive compression only causes pain to the patient without changes in breast thickness and image quality (13). Nevertheless, a theory states that optimum breast compression reduces breast thickness and average glandular dose while allowing excellent image quality (28).

The ICS established by The European Commission sets guidelines for standard radiographic images. Both radiologists evaluated the standard and reduced compression mammogram images as equal, with a few rejected images. The differences in image quality using the BI-RADS for mammograms of standard and reduced compression were negligible due to the diagnostic value (13). It was satisfactory to reduce the amount of compression for sensitive patients (29). The limitations in this study were the time constraint to perform the procedure and the selection of patients for the study.

Conclusion

The present study recommends DBT performed with less compression to reduce anxiety and pain levels without compromising the image quality. Thus, with reduced compression, more women would choose to undergo screening.

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Conflict of Interest

None.

Funds

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Authors' Contributions

Conception and design, provision of study materials or patient: SAAS, KKC
Analysis and interpretation of the data, drafting of the article, statistical expertise: SAAS, MA
Critical revision of the article for the important intellectual content: AM, MA, KKC
Final approval of the article: MA, KKC
Obtaining of funding: KKC
Administrative, technical or logistic support: AM
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