RESEARCH ARTICLE

Are All Views with and without Displacement Maneuver Necessary in Augmentation Mammography? Putting Numbers Into Perspective

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Abstract

Objective: Augmentation implants pose a challenge for radiologists. Displacing the implant allows slightly more breast tissue to be visualized than the standard compression views. The objective of this study was to verify the agreement between craniocaudal (CC) views and CC with implant displacement (CC-ID), mediolateral oblique (MLO) and MLO-ID and the inter- and intraobserver agreement of mammographic images for finding abnormal images. **Methods:** The main outcomes [BI-RADS® normal=1,2; abnormal=3,4,5)] were analysed by 3 readers (reader1; reader 2, 1st round, reader 2, 2nd round) in 360 women with breast implants. Comparison between CC/CC-ID and MLO/MLO-ID, and degree of agreement for mammographic images between researchers were made using Kappa index. Proportions were calculated using a 95% confidence interval (95%CI). **Results:** A total of 87 abnormal findings were identified by reader 2, 2nd round. Abnormal findings were observed in CC-ID=18.8% (68 out of 360; 95%CI=15.1%-23.2%) compared to CC=10.8% (39 out of 360; 95%CI=8%-14.4%, k=0.49); in MLO=10.5% (38 out of 360; 95%CI=7.7%-14.1%) compared to MLO-ID=15.8% (57 out of 360; 95%CI=12.4%-19.9%, k=0.55). The CC-ID was the view that singly identified more abnormal findings (20 out of 87; 23%; 95%CI=15.4% to 32.8%) and the CC was the view that least detected abnormal findings (1 out 87; 95%CI=0.2% to 6.2%). The inter- and intraobserver agreement between readers views was 0.67 and 0.74 respectively. **Conclusions:** In women with breast augmentation implants, all views are necessary to identify breast tissue abnormalities. In our sample, the inter- and intraobserver agreement were "substantial".

Keywords: Breast- breast cancer- mammography- breast augmentation- breast implants

Introduction

Implants have been routinely used for breast augmentation and reconstruction, and have been available for more than 50 years. The number of women with breast augmentation implant has been increasing exponentially (ASPS, 2019). These implants do not appear to increase the risk of breast cancer (Noels et al., 2015), but, among asymptomatic women, they decrease the sensitivity of screening mammography (Miglioretti et al., 2004), a method that has been considered as a valuable tool for early detection of breast cancer (IARC, 2021). However, augmentation implants pose a challenge for radiologists. For instance, all implants appear radiopaque on mammographic images and a substantial amount of parenchymal tissue, i.e., between 22% and 83%, is obscured by an implant (Smalley, 2003).

In order to increase the amount of breast tissue imaged

and to improve clarity without risking the integrity of the implant, Eklund et al. developed displacement and compression techniques specifically for women with breast implants (Eklund et al., 1988). This technique, known as implant displacement (ID), supplements the standard craniocaudal (CC) and mediolateral oblique (MLO) views with two more CCs and MLO views. In all of these additional views, the implant is pushed back against the chest wall and the breast tissue pulled forward. With the posterior displacement of the implant, breast compression can be applied in front of the implant. Standard MLO views have been used to evaluation of the axillary tail and establish the position of the implant (i.e., subpectoral or subglandular). This helps to decide on further images made with subjects.

If the implant is subglandular, standard craniocaudal (CC) views are obtained with the implant as far back as possible against the chest wall. According to the NHS

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Breast Screening Programme statement, if the implant is subpectoral, it is still considered beneficial to perform both standard CC views and CC-ID views, the only difference being that the implant edge is less likely to be felt during positioning (Phes et al., 2017). Displacing the implant allows slightly more breast tissue to be visualized than the standard compression views (Shah and Jankharia, 2016). In addition, mammography of women with mammary implants gives higher radiation doses when compared with those without implants. The mean glandular dose median for standard views is higher than ID views due the greater compressed breast thickness, was found 3.3 mGy for CC and 1.2 mGy for CC ID in a previous study (Couto et al., 2019). However, there are scant data available to support these additional views. It would be important to known how many radiologic findings are found when one or both views are used to support the NHS Breast Screening Programme statement (Phes et al., 2017). These data may provide a percentage of abnormalities that are missed and identified by these views, both combined and individually, according to the position of the breast implant. Furthermore, we were not able to find any relevant data assessing the inter- and intraobserver variability of BI-RADS® classification in mammograms with breast augmentation, only in breasts without implants (Lee et al., 2017; Masroor et al., 2016; Lazarus et al., 2006; Abdullah et al., 2009; Skaane et al., 1997).

Thus, this study was intended to compare the identification of abnormal findings using CC and CC-ID views in augmentation mammography. As secondary objectives, we added the MLO and MLO-ID views to the craniocaudal views and verified the inter- and intraobserver agreement of mammographic findings in women with breast implants.

Materials and Methods

Study design

This is a retrospective cross-sectional study for analyzing mammographic images of female patients with breast implants.

Setting

The mammographic exams were performed from July 1st, 2015, through November 30th, 2017, in a private clinic located in the city of Goiânia, GO, Brazil.

Participants

Women were included in analyses if they came for a mammography examination and had prior breast augmentation. Standard and implant displacement views were performed in all subjects. Those with normal or abnormal findings were included. Patients who had previously undergone surgery due to breast cancer, those with tissue expanders or reconstruction, those with a contraindication for performing the maneuver (capsular contracture) and those who had a request from their attending physician to avoid implant displacement were excluded.

Variables

The presence or absence of abnormal radiologic findings in the CC and CC-ID views in both breasts were the main outcome. Abnormalities were classified according to the 5th edition of the American College of Radiology (ACR) lexicon BI-RADS® (ACR, 2013). Data were further divided according to the position of the implant (subglandular or subpectoral) in order to compare the percentage of abnormal findings identified in each view.

Data source

Mammographic exams were initially screened from the database by a radiologist/author (LSC). Mammographic exams were performed by experienced radiologic technologist with continuous training using a fully digital FujiFilm Amulet FDR MS-1000 in accordance with international standards (IAEA, 2011). Images were stored and accessed from an OsiriX MD database with Picture Archiving and Communication System server (PACS; version 3.02) and a DICOM (Digital Imaging and Communication in Medicine) storage system. Images were analyzed using Coronis display (Coronis 5MP LED MDCG-5221 display, Barco, Kortrijk, Belgium) Mammographic incidences were obtained according to the American College of Radiology (ACR, 2018); in brief, craniocaudal (CC) and mediolateral oblique (MLO) views, without implant displacement were obtained. Next, the same views, but with displacement of the implant (MLO-ID and CC-ID), were acquired, yielding a minimum of eight images per patient.

Measurement

Readings were performed using a standard questionnaire by two radiologists/authors (SPB and LU). Briefly, a) the position of the implant, b) ACR BI-RADS® findings were recorded, and c) each finding was assigned to one of the views.

Bias

In order to reduce bias, mammographies were blindly examined by two radiologists/authors (SPB and LU) to assess inter- and intraobserver variability. To assess intraobserver variability, mammographic views were blindly analyzed by a senior radiologist/author (SPB) and then a second time after 90 days. Both radiologists/authors are board certified radiologists and nationally renowned for their expertise as experienced mammographers. Due to seniority, readings from SPB were considered for interobserver variability. For intraobserver variability, the second reading performed by the senior radiologist/author (SPB) was considered for comparison, due to the training effect of the first reading.

Study size

Sample size was based on previous reports on kappa statistic for mammographic interpretations (Lazarus et al., 2006; Abdullah et al., 2009; Skaane et al., 1997) and calculated according to the literature (Temel and Erdogan, 2017). With an expected overall kappa of 0.58 (0.52 to 0.66) for the analysis of mammography, and by

considering an alpha error=0.001 and a beta error=0.2, a minimum of 268 cases would be necessary.

Sample size for comparing two proportions was calculated as described in the literature (Hulley et al., 2013) considering an expected proportion of 29% (±10%) of abnormal radiological findings in mammograms and a confidence level of 95%. These figures yielded a minimum of 335 cases.

Quantitative variables

BI-RADS® findings were divided into two classes: those that were normal (i.e, BI-RADS® 1 or 2), and those that were abnormal (i.e, BI-RADS® 3, 4 or 5). The binary outcome was chosen in order to simplify clinical importance and statistical analysis. Representative images of abnormal findings are depicted in Figures 1 and 2.

Statistical methods

Cohen Kappa was used for inter- and intraobserver agreement calculation between readers and CC and CC-ID views. Kappa agreement was considered as previously reported (Landis and Koch, 1977), briefly, "poor" ($\kappa < 0.0$), "slight" ($0.0 \le \kappa \le 0.2$), "fair" ($0.21 \le \kappa \le 0.4$), "moderate" ($0.41 \le \kappa \le 0.6$), "substantial" ($0.61 \le \kappa \le 0.8$), and "almost perfect" ($0.81 \le \kappa \le 1.0$) agreement among raters. Proportions were calculated using a 95% confidence interval. Calculations were performed using GraphPad Prism version 8.1.2 for Mac (GraphPad Software, San Diego, California, USA).

Ethical Aspects

The study was conducted in compliance with the governing principles of the Helsinki Convention. The Institutional Ethics Committee approved the study protocol and all individuals signed the informed consent form.

Results

Participants

A total of 2876 subjects were initially evaluated from the database. Of these, 1,574 had a previous surgery related to breast cancer with breast prosthesis or capsular contracture, yielding 1302 subjects with inclusion criteria. From these, consecutive mammograms, using a 3:1 ratio (normal:abnormal) was used until reaching the estimated sample size. Finally, 360 patients were obtained, yielding 2880 views for further analysis.

Descriptive data

These 2880 views were sent to two radiologists/authors (readers) for analysis. Details of the mammographic findings by these two readers are depicted in Table 1. A total of 360 subjects (720 views) from CC and CC-ID were analyzed. Reader 2, in the second round, was able to identify 59 subjects with a subpectoral implant, 299 with a subglandular implant and two were undefined (Table 1).

Reader 2, in the second round, was able to identify 87 abnormal findings. BI-RADS® 3, 4 or 5 findings are depicted in Table 1.

Main results

The inter- and intraobserver agreement between readers for the presence or not of abnormal findings in all mammographies was 0.67 (95%CI=0.586 to 0.765) and 0.74 (95%CI=0.654 to 0.825), respectively.

The degree of agreement between CC and CC-ID views and between MLO and MLO-ID were moderate (k= 0.49 and 0.55, respectively), for reader 2, in the second round (Table 3). Reader 2, in the second round, identified 87 abnormal mammographic findings in all views. The combination of CC and CC-ID views (examples in Figure 1 and 2), revealed 77 abnormalities; i.e., 68 on the CC-ID + 9 in the CC (Table 3). Abnormal findings

Table 1. Characteristics of the Mammogram Findings According to Different Readers and Times of Assessment. Numbers are n (%) Derived from 360 Subjects. All mammographic views were considered.

Characteristic	Reader		
	Reader 1	Reader 2 (1st round)	Reader 2 (2nd round)
Implant Position			
Undefined	13 (3.6)	3 (0.8)	2 (0.6)
Subglandular	259 (71.9)	291 (80.8)	299 (83.1)
Subpectoral	88 (24.4)	66 (18.3)	59 (16.4)
Abnormal finding			
No	272 (75.6)	298 (82.8)	273 (75.8)
Yes	88 (24.4)	62 (17.2)	87 (24.2)
Findings			
Asymmetry	3 (3.4)	10 (15.9)	23 (26.4)
Grouped calcification	17 (19.3)	9 (14.3)	18 (20.7)
Grouped calcification + abnormal lymph node	1 (1.1)	0 (0.0)	0 (0.0)
Non-surgical architectural distortion	1 (1.1)	0 (0.0)	0 (0.0)
Abnormal lymph node	2 (2.3)	2 (3.2)	2 (2.3)
Lumps	64 (72.7)	41 (65.1)	44 (50.6)
Lumps + abnormal lymph node	0 (0.0)	1 (1.6)	0 (0.0)

Table 2. Percentage of Abnormal Findings (BI-RADS 3, 4 or 5) Identified by Craniocaudal (CC) and by Craniocaudal + implant Displacement (CC-ID) Views According to the Breast Implant Position. Readings were based according to reader 2 in the 2nd round. Numbers are mammographic views by 360 subjects.

Position of the implant	BI-RADS abnormalities, n (%) [95% confidence interval]		
	CC	CC-ID	n (all views)[a]
Subglandular	30 (76.9)	50 (73.5)	68
	[61.7 to 87.4]	[62 to 82.6]	
Subpectoral	8 (20.5)	17 (25)	18
	[10.8 to 35.5]	[16.2 to 36.4]	
Undefined	1 (2.6)	1 (1.5)	1
	[0.5 to 13.2]	[0.3 to 7.9]	
Total[a]	39	68	87[a]

[a], number of abnormal findings in the study population

Table 3. Mammographic Findings by Reader 2, in 2nd Round, Considering the Right and Left Breast (360 exams), According to Different Views Considered in Craniocaudal and Mediolateral Oblique

All views, subpectoral, subglandular and undefined			
	Craniocaudal + Implant Displacement		
Craniocaudal*	Abnormal	Normal	Total
Abnormal	30	9[a]	39
Normal	38	283	321
Total	68a	292	360
	Mediolateral Oblique + Implant Displacement		
Mediolateral oblique**	Abnormal	Normal	Total
Abnormal	29	9[b]	38
Normal	28	294	322
Total	57b	303	360

*Kappa=0.491 (95%CI= 0.368 to 0.613) SE=0.06; **Kappa=0.554 (95%CI= 0.428 to 0.68) SE=0.06; [a], Total number of abnormal findings = 68 + 9 = 77 in both views; [b], Total number of abnormal findings = 57 + 9 = 66 in both views

were observed in 18.8% of the CC-ID views (68 out of 360; 95%CI=15.1% to 23.2%) compared to 10.8% in the CC views (39 out of 360; 95%CI=8% to 14.4%,

k=0.49); in MLO=10.5% (38 out of 360; 95%CI=7.7% to 14.1%) compared to MLO-ID=15.8% (57 out of 360; 95%CI=12.4%-19.9%, k=0.55). The CC-ID was the view that singly identified more abnormal findings (20 out of 87; 23%; 95%CI=15.4% to 32.8%) and the CC was the view that least detected abnormal findings (1 out 87; 95%CI=0.2% to 6.2%).

Among the 77 abnormal findings identified by reader 2 in CC and CC-ID views, only 30 findings (39%; 95%CI=28.8% to 50.1%) were identified in both CC and CC-ID views; 38 (49.3%; 95%CI=38.5% to 60.3%) were only seen in the CC-ID views, while 9 (11.7%; 95%CI= 6.3% to 20.7%) were only seen in the CC (Table 3).

Similar results were seen in the comparison between MLO and MLO-ID. Among the 66 abnormal findings, only 29 (43.9%; 95%CI=32.6% to 55.9%) were identified in both MLO and MLO-ID. The MLO-ID was able to reveal 57 abnormal findings (86.4%; 95%CI=76.1% to 92.7%), while the MLO, 57.6%; 95%CI=45.6% to 68.8%). Further details can be seen in Table 3.

From all the lesions identified by reader 2 in the second round (n=87), only one abnormal finding was uniquely viewed in the CC view (1 out of 87, 1.1%; 95%CI= 0.2% to 6.2% - Table 4).
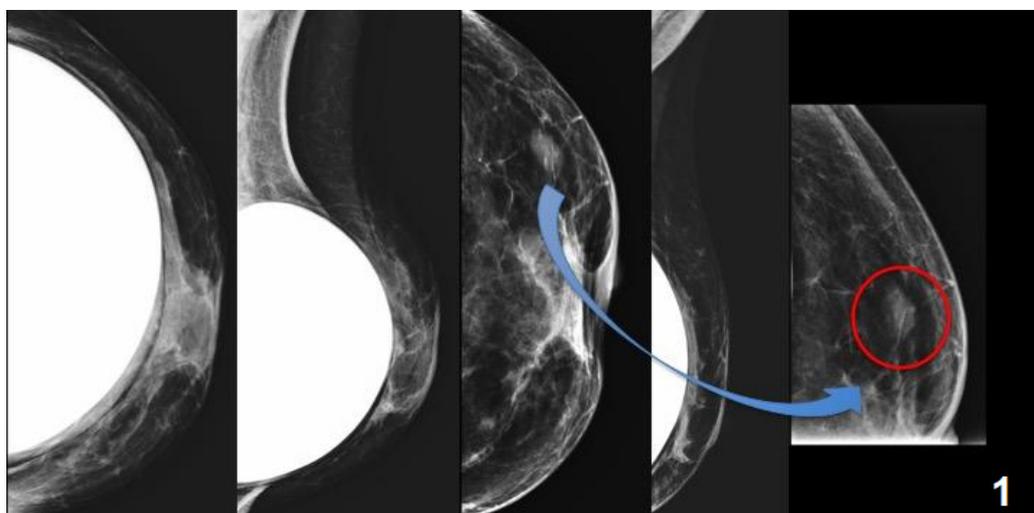

Figure 1. Mass was Detected Only in the CC-ID View

Table 4. Number of Lesions Detected in Only One of the Four Views/Projections in 360 Women (720 Breasts) with Augmentation Implants

	Lesions detected	Number of lesions detected exclusively in only one view			
	Total	CC	CC-ID	MLO	MLO-ID
		n (%)	n (%)	n (%)	n (%)
Reader 1	88	3 (3.1%)	8 (9%)	4 (4.5%)	6 (6.8%)
Reader 2, 1st round	62	2 (3.2%)	8 (13%)	7 (11.2%)	4 (6.4%)
Reader 2, 2nd round	87	1 (1.1%)	20 (23%)	6 (6.0%)	4 (4.6%)
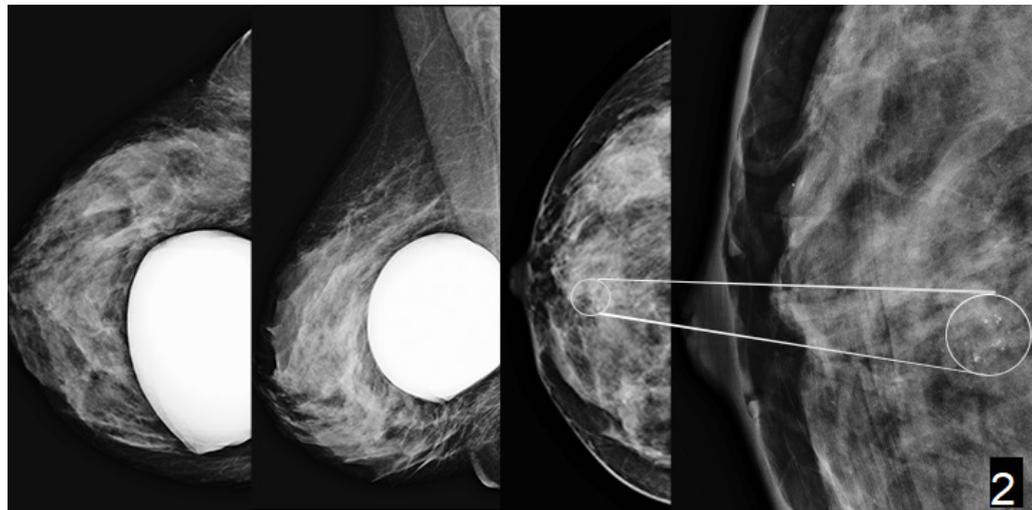
Figure 2. Grouped Calcifications Detected Only in the ID Views

Discussion

Key results

Previous studies reported that the CC-ID technique increased the amount of breast tissue visualized, compared with the traditional CC view (Eklund et al., 1988; Sá dos Reis et al., 2020; Silverstein et al., 1990). Herein, we provide the percentage of abnormal findings by obtaining this extra amount of breast tissue. By performing only CC-ID views, only 68 out 77 abnormal findings would be identified, i.e., 11.6% would be missing in the CC-ID, while with the CC view, 50.7% would be missing. Likewise, in the MLO-ID and MLO views, 13.6% and 42.4% would be missing, respectively (Table 3). These data, related to the percentage of missing radiologic findings are new and may be used to support the need to perform additional views, as recommended in the literature (Phes et al., 2017). The degree of agreement for finding an abnormality was moderate (k=0.49 and 0.55) and this figure did not change whether the analysis was performed according to the implant position (data not shown).

The degree of agreement between radiologists was 0.675 (95%CI=0.586 to 0.765), which is similar to the k=0.58 found by Skaane et al. (Skaane et al., 1997). We did not perform a comprehensive analysis between readers in the first and second readings, since a moderate agreement was found. Furthermore, it has been shown by others that there is a wide variation (from 0.36 to 0.82) when such comprehensive comparisons are made (Al-Khawari et al., 2010); our findings are in the same range.

Although many countries follow the American protocol, which guide to execute the implant displacement maneuver in the two views (CC and MLO), this is not a uniform conduct in many places around the world (Sá dos Reis et al., 2020). In Australia, a recent survey assessed radiologists' current practices with regard to imaging of augmented breasts. For the screening and diagnostic scenarios, full examination with eight incidences was reported by 64% and 59% of respondents, respectively (O'Keefe et al., 2020). Thus, these data reinforce the need to develop evidence-based protocols for women with breast implants. Currently, women with breast augmentation are not guaranteed that they will undergo exams with the lowest radiation dose and maximum breast coverage.

Our data have some limitations. Only two experienced radiologists performed the analyses and we excluded those who had undergone oncologic surgery. No follow-up was done in order to check the outcomes of the abnormal findings; the majority of findings, however, may have no clinical importance, e.g., asymmetry (Table 1). We tried to overcome this problem by combining low (BI-RADS 1 and 2).

The strengths of this study can be seen by the practical aspect of the mammograms. Mammographic positioning was performed by several radiologic technologists and this is closer to the real scenario in clinical practice. We provided an adequate sample size for analysis. Both radiologists were unaware of the outcomes of each case and reader 2 had an interval of 90 days, between the first and second analysis. These methodological aspects may reduce bias.

Interpretation

Neither the CC nor the CC-ID views were able to identify all 87 abnormalities independently of the position of the implant. Although more abnormal findings were seen in the CC-ID view (Table 3), a clinically important percentage (i.e., almost 12%) of abnormal findings would be missing if only CC-ID views were performed. Outcomes were similar when implant position was analyzed. If only the CC-ID view was performed with subglandular implants, 26.5% would be missing (Table 2). In contrast, in the subpectoral implant cases, 5% would be missing if only CC-ID was performed (Table 2). These data support the NHS recommendation to perform both incidences (Phes et al., 2017). The inter- and intraobserver agreement was "substantial", in both scenarios, which is in accordance with the literature (Skaane et al., 1997).

Generalizability

Our results may be applied to women without previous surgery for breast cancer and had silicone implants.

In conclusion, we showed that the implant displacement views significantly identified more abnormal findings than the standard views, while a small, but relevant, number of findings was identified by only CC views. This justifies the need for all views. Further studies are necessary to evaluate the cost analysis of these additional mammographic views to identify an abnormal finding and the radiation impact for these patients. If there is any benefit in performing these exams without any view, this work provides objective data of the impact of this choice.

Author Contribution Statement

All authors contributed to the study conception and design. Material preparation and data collection were performed by LSC, RSC, SPB, MVL, JLOCF, LABDU and RFS. Data analysis were performed by RSC, SPB, MVL, JLOCF, LABDU, LRS and RFJ. The first draft of the manuscript was written by LSC, LRS, RFS, RFJ and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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