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Mammographic Positioning: Evaluation from the View Box[1]

To evaluate the quality of breast positioning for mediolateral oblique (MLO) and craniocaudal (CC) views, a prospective study of 1,000 consecutive bilateral screening mammographic examinations was performed. Six criteria were tested, including depth of tissue seen, inferior extent of the pectoral muscle relative to the posterior nipple line, presence of fibroglandular tissue at the posterior edge of the film, and whether the nipple was in profile. Pectoral muscle was depicted to within 1 cm of the nipple line or below it on 1,612 of the 2,000 MLO mammograms (81%); all fibroglandular tissue was depicted on 1,532 MLO mammograms (77%). The depth of tissue depicted on the CC mammogram was within 1 cm greater or less than the depth on the MLO mammogram on 1,586 CC mammograms (79%); the pectoral muscle was seen on 646 CC mammograms (32%). The nipple was in profile in 1,769 MLO mammograms (88%) and 1,783 CC mammograms (89%) but not in profile in either view in 83 cases (4%). Overall improvement was seen in 400 of 587 examinations (68%) when new mammograms were compared with previous mammograms. These criteria can be used to evaluate positioning performance and for quality control.

Index terms: Breast radiography, quality assurance, 00.11 • Breast radiography, technology, 00.11 • Radiology and radiologists • Technologists

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BREAST positioning for mammography is an art that has undergone considerable change in recent years. The improvements are intended to maximize the amount of breast tissue seen on the screening study (1–3). The screening examination includes two views, rather than one, to increase sensitivity and specificity (4–6). The two standard views recommended for screening are the mediolateral oblique (MLO) and craniocaudal (CC) (7). The use of dedicated breast imaging equipment, which includes a fully rotational C-arm, has greatly improved and expanded possible positioning maneuvers. In addition, new positioning maneuvers take into account the individual patient's body habitus and an understanding of the principle of fixed and mobile borders of the breast (1–3). As a result, the amount of tissue depicted in mammograms has greatly increased. However, the examples shown in publications usually represent ideal results and may not provide a realistic guide to what should be expected in daily practice. Due to varying breast sizes and shapes and body habitus (eg, obesity or kyphosis), all women cannot be positioned with equal facility. To establish reasonable guidelines for what should be expected of technologists, we tested a set of image criteria that could be used by radiologists to evaluate the quality of breast positioning for both the MLO and CC views from the view box. These criteria were tested in a prospective study of 1,000 consecutive bilateral screening mammographic examinations.

MATERIALS AND METHODS

Six experienced mammography technologists attended courses that provided hands-on instruction in the new standardized methods for breast positioning. In brief, the following methods were used to obtain the MLO views: orienting the cassette holder ("Bucky") parallel to the patient's pectoral muscle, pulling the mobile lateral border of the breast toward the fixed medial border, and using an "up-and-out" maneuver to hold the breast up while compression was applied until the breast was taut (1,2). The CC views were obtained with the following methods: (*a*) lifting the mobile inframammary fold as high as its natural mobility would allow, (*b*) imaging as much medial tissue as possible by means of maneuvers such as having the technologist position from the medial side of the breast being examined, and (*c*) draping the opposite breast over the corner of the cassette rather than placing it behind the cassette (3).

The following criteria were used to evaluate the MLO view (Fig 1): (*a*) depth of tissue seen, determined by means of an oblique line that extended from the nipple to the pectoral muscle or the edge of the film, whichever came first (2); (*b*) inferior extent of the pectoral muscle relative to the oblique nipple line; (*c*) adequacy of compression, based on uniform tissue exposure levels, separation of tissues, upright position of the breast, and absence of motion artifact (Fig 2); (*d*) presence of fibroglandular tissue at the posterior edge of the film and thus partial exclusion of such tissue from the image; (*e*) whether the nipple was in profile; (*f*) presence of skin folds overlying breast tissue; and (*g*) depiction of the posterior extension of the inframammary fold. The inferior extent of the pectoral muscle was recorded on a scale of 1 to 5, in which 5 indicated that the muscle was depicted more than 1 cm below the nipple line; 4, that muscle was seen within 1 cm above or below the nipple line; 3, that muscle extended below the axilla but was not within 1 cm of the nip-

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Abbreviations: ACR = American College of Radiology, CC = craniocaudal, MAP = Mammography Accreditation Program, MLO = mediolateral oblique.

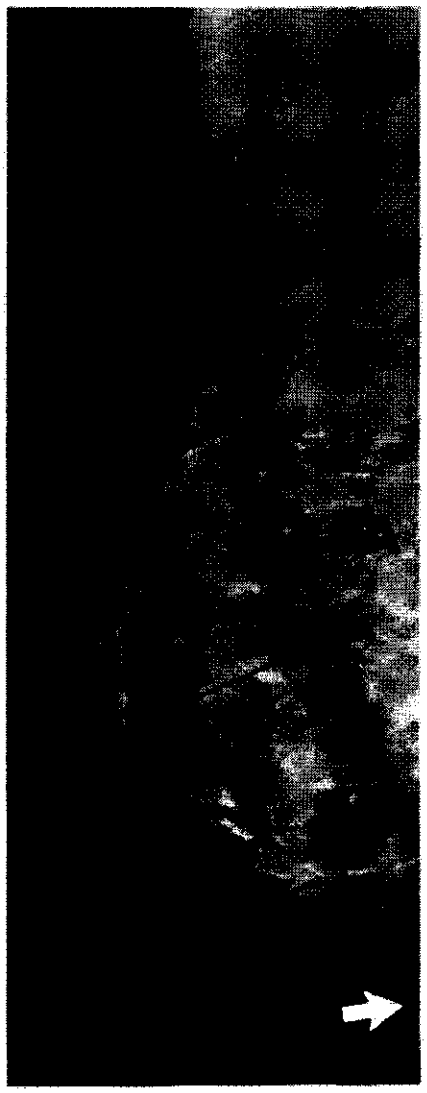
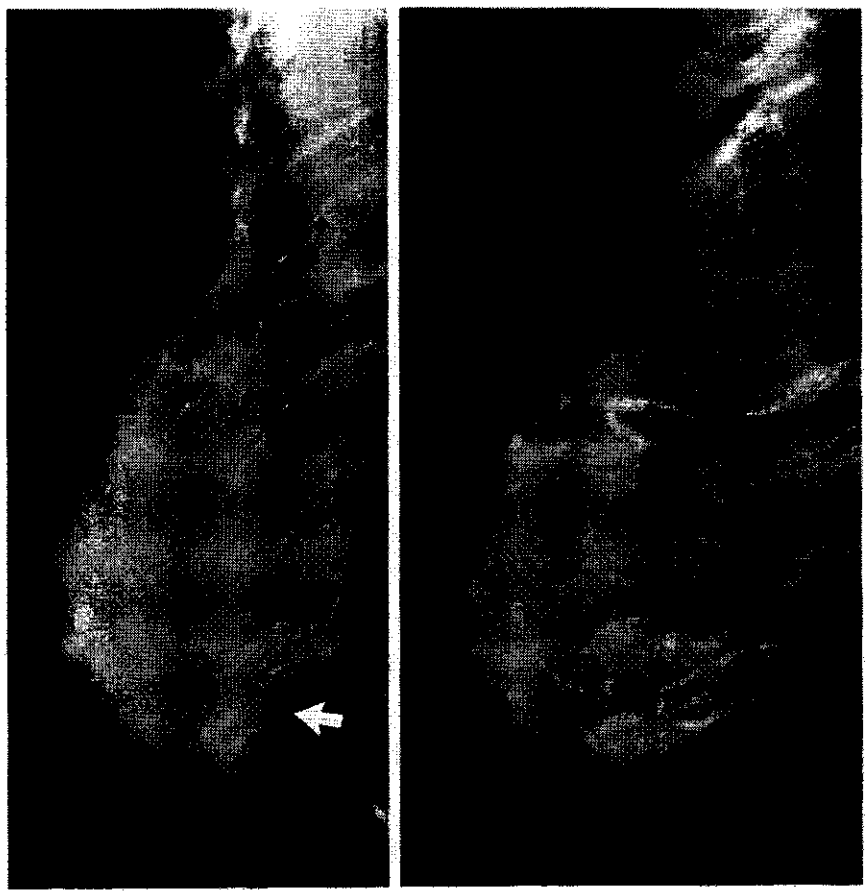


Figure 1. MLO mammogram. The arrowhead indicates the inferior extent of the pectoral muscle (*A*). The depth of tissue included in the MLO is measured along an oblique line (the posterior nipple line) (long arrow by *B*) perpendicular to the pectoral muscle and extending from the nipple to the muscle, or the edge of the film, whichever comes first. Depiction of the retroglandular fat (*C*) is evidence that the deep fibroglandular tissue has been included in the image. The short arrow points to the posterior extension of the inframammary fold.



a. **b.**

Figure 2. Evaluation of breast compression on MLO mammogram. **(a)** Inadequate compression. Nonuniform exposure and inadequate separation of fibroglandular tissues, sagging of the breast contour, and blurring of linear structures (arrow) inferiorly due to motion are seen. **(b)** Adequate compression of the same breast as in **a**. Dense breast tissue is uniformly exposed and well separated, the breast contour is upright, and no motion unsharpness is seen.

ple line; 2, that muscle was depicted only within the axilla; and 1, that no pectoral muscle was present on the image.

The following criteria were used to evaluate the CC view (Fig 3): (*a*) depth of tissue visualized, determined by a line drawn posteriorly from the nipple to the pectoral muscle or edge of the film, whichever came first; (*b*) presence of pectoral muscle; (*c*) whether all medial fibroglandular tissue was included, based on visualization of retroglandular fat and the absence of fibroglandular tissue at the edge of the film; (*d*) whether all lateral fibroglandular tissue was included; (*e*) whether the nipple was in profile; and (*f*) presence of skin folds.

Using the above criteria, one of three radiologists who worked exclusively in the breast imaging section at our institution (L.W.B., I.A.H., or N.D.) prospectively evaluated each MLO and CC view of 1,000 consecutive bilateral screening mammographic examinations performed by the six technologists. To ensure consistency, the three radiologists often reviewed cases together. No substantial disagreement occurred in the evaluation of cases. Immediately after they developed their films, the technologists evaluated their images for quality. If they considered the quality unacceptable, they repeated the examination before they submitted the images to the radiologist for interpretation. Based on a monthly analysis by the chief technologist, the repeat rate was consistently below 5%.

The new mammograms were compared with previous mammograms obtained at our institution within the previous 2 years whenever these previous mammograms were available. The overall comparison of the two examinations was based on the above criteria, especially the depth of tissue depicted. On the basis of the above criteria, especially the amount of tissue depicted, the radiologist decided whether the new mammograms were better than, the same as, or inferior to the previous ones.

RESULTS

The following results were obtained for each of the two standard views:

MLO Mammograms

The pectoral muscle was depicted within 1 cm of the nipple line or below it on 1,612 of the 2,000 MLO mammograms (81%), with a range of 71%–98% for the individual technologists. It extended further than 1 cm below the nipple line on 502 MLO mammograms (25%). Pectoral muscle depiction was limited to the axillary area on 44 MLO mammograms (2%) only. Compression was considered

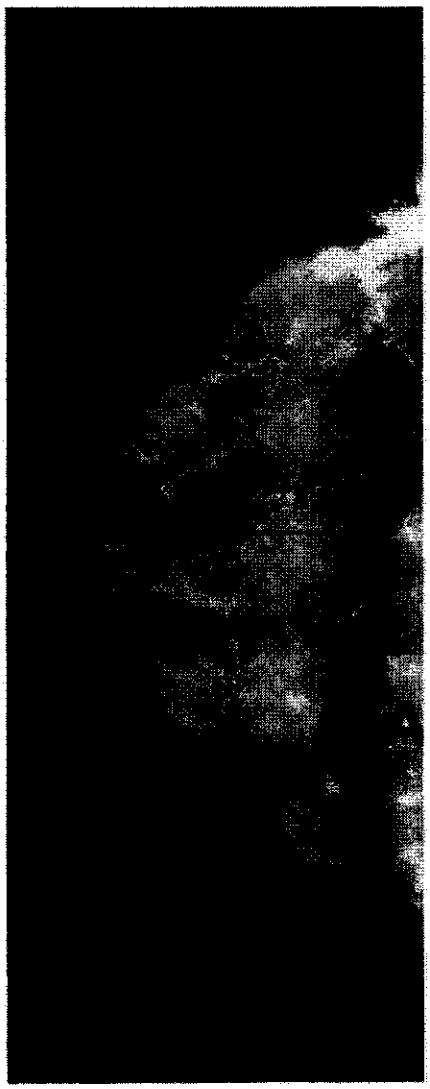


Figure 3. CC mammogram. The pectoral muscle (*A*) is seen in the posteromedial aspect of the breast. The depth of tissue included in the CC is measured along a line (*B*) that extends directly posteriorly from the nipple to the pectoral muscle or the edge of the film, whichever comes first. The presence of the retroglandular fat (*C*) provides evidence that all of the medial fibroglandular tissue is included. The fibroglandular tissue at the lateral aspect of the breast (short arrow) extends beyond the edge of the film.

adequate on 1,974 MLO mammograms (99%). All fibroglandular tissue was depicted on 1,532 MLO mammograms (77%; range, 66%–83%). The nipple was in profile on 1,769 MLO mammograms (88%; range, 79%–97%). The posterior extension of the inframammary fold was seen on 982 MLO mammograms (49%). Skin folds overlying parenchymal tissue were identified in 305 breasts (15%); most of these folds were confined to areas near the axilla.

CC Mammograms

The depth of tissue depicted on the CC mammogram was within 1 cm greater or less than the depth on the MLO mammogram on 1,580 of 2,000 CC mammograms (79%); the depth of tissue shown on the CC mammogram was within 0.5 cm of that on the MLO mammogram in 1,073 CC mammograms (54%). The depth of tissue seen in the MLO mammogram was greater than or equal to that on the CC mammogram in 1,800 MLO mammograms (90%), with a range of 88%–94% for different technologists, while more tissue was seen on the CC mammogram in 194 CC mammograms (10%). The pectoral muscle was present in 646 CC mammograms (32%; range, 22%–60%). All medial tissue was depicted on 1,622 CC mammograms (81%; range, 79%–87%); all lateral tissue, on 740 CC mammograms (37%; range, 30%–45%). The nipple was in profile on 1,783 CC mammograms (89%). Skin folds were seen overlying parenchymal tissue, usually in the posterolateral aspect of the breast, on 203 CC mammograms (10%).

The nipple was not in profile on both the MLO and CC mammograms in 83 of 2,000 breasts (4%).

Comparison with Previous Mammograms

In 587 of the 1,000 examinations reviewed (59%), previous mammograms had been obtained at our institution within the previous 2 years. Based on the same image criteria, overall improvement was seen in 400 of 587 examinations (68%) when new mammograms were compared with the previous ones. No significant difference was seen in 176 examinations (30%). Two percent of the new examinations were considered inferior in comparison with previous mammograms.

DISCUSSION

The standard views for screening mammography are the MLO and CC. The MLO view shows the greatest amount of breast tissue (8,9), because it includes the axillary tail, which is not seen completely on a 90° lateral or CC view, but may contain breast cancers. However, even a well-positioned MLO view may fail to depict deep tissue in the medial aspect of the breast (10). Therefore, it is now believed that the craniocaudal view should include as much breast tissue as possible, but with particular emphasis on depiction of all of the medial tissue (1–3). Recently, interest in the art of breast positioning has been revitalized, resulting in improved techniques, and radiologists and technologists all across the United States are currently learning these new methods.

Clinical image evaluation is one of the components of the American College of Radiology (ACR) Mammography Accreditation Program (MAP) (11), and deficiencies in clinical images are the leading cause of failure to pass the accreditation process (12). Evaluation of patient positioning and adequacy of compression are important aspects of the clinical image evaluation. As we have shown, the quality of positioning and compression can be evaluated at the view box on the basis of image criteria. The quality determinants for positioning of the MLO and CC views used in this study were derived from a review of the radiology literature and consultation with expert technologists. These determinants, parameters currently used in the ACR MAP, are based on positioning methods described in the ACR mammography quality control manuals (3). Among the most important of these parameters are the inferior extent of the depicted pectoral muscle on the MLO mammogram, breast compression, and the depth of tissue seen on the CC mammogram. Ideally, the pectoral muscle should extend to the nipple line or below it on the MLO mammogram (Fig 1), the breast should be well compressed (Fig 2), and the depth of tissue depicted on the CC mammogram should be within 1 cm of that on the MLO mammogram (Fig 3). These criteria are goals that we should try to attain, but it is understood that they will not be met in all four views in all patients. In our study, these ideal criteria were met in all four views in 640 examinations (64%). It is also important to emphasize that in addition to positioning and compression, clinical image evaluation encompasses many other aspects of image quality, including exposure level, collimation, contrast, sharpness, noise, artifacts, and labeling (13).

Because the breast lies on top of the pectoral muscle, one of the most useful determinants of a properly obtained MLO mammogram is the amount of pectoral muscle depicted on the image. In our study, the pectoral muscle was depicted within 1 cm of the nipple line, or below it, in 81%

of MLO mammograms. Of course, depiction of the lower extent of the pectoral muscle is not the only criterion for a well-performed oblique view; the muscle should also be wide in its anteroposterior diameter on the film.

The nipple was not in profile in 12% of MLO mammograms and 11% of CC mammograms. It was not in profile on both the MLO and CC mammograms in 83 breasts (4%). In positioning the breast for mammography, inclusion of the maximum amount of breast tissue should be emphasized; depiction of the nipple in profile is a secondary consideration. However, the nipple should be seen in profile in at least one view to assess the subareolar area. Therefore, a third view, either a 90° lateral or spot compression view with the nipple in profile, may sometimes be required when the nipple is not in profile in either the MLO or the CC view. According to our results, this additional mammogram would need to be obtained in only 4% of breasts that are examined.

It is currently recommended that the posterior extension of the inframammary fold be visible on the MLO mammogram (3) (Fig 1). This is usually achieved by pulling the skin under the breast gently downward after compression is complete. This procedure, combined with the up-and-out maneuver and adequate compression, opens the inframammary fold. The posterior extension of the inframammary fold, the continuation of the inferior surface of the breast to the anterior chest or abdominal wall, was seen in only 49% of patients. Therefore, our own technologists have been instructed to pay special attention to this area without sacrificing depiction of other breast tissues. Further study is warranted to determine the real importance of depiction of the posterior extension of the inframammary fold.

The depth of tissue included in the CC view was determined by a line extending posteriorly from the nipple to the pectoral muscle or the edge of the film, whichever came first. It has been reported that the length of this line should be within 1 cm of the corresponding posterior nipple line on the MLO mammogram (2) (Figs 1, 3). Seventy-nine percent of our CC mammograms met this criterion, confirming its usefulness as a reasonable measure of how well the CC examination was performed. In fact, the depth of tissue measured on the CC mammogram was within 0.5 cm of the depth measured on the MLO mammogram in 54% of mammograms, and the depth of tissue depicted on the CC mammogram exceeded the depth on the MLO mammogram in 10%. Inclusion of all medial tissue was determined when retroglandular fat could be seen posterior to all the medial tissue; this was achieved in 81% of the cases. Depiction of the pectoral muscle on the CC mammogram was considered to be additional evidence of the depiction of deep breast tissues. Pectoral muscle was seen on 32% of CC mammograms. Although depiction of the pectoral muscle suggests that deep tissues were imaged, the value of this sign is unproved, and it is not as consistent a determinant as measurement of the posterior nipple line.

This study provided an opportunity to compare new positioning techniques with those we had used previously. Using the positioning criteria described herein, we compared the overall results of the new examinations with those performed in the same patients 1–2 years previously. Our study confirmed that the new positioning techniques are superior, with an overall improvement in 68% of patients. Only 2% of the new examinations were considered inferior to previous examinations performed in the same patients.

The image criteria for evaluation of positioning at the view box tested in our study can be of practical value. The results can be used to assess the overall performance of a facility and thereby identify aspects of positioning that need improvement. In our practice, the mammography technologists have been instructed in the evaluation of their examinations on the basis of these positioning criteria. As a result, they can determine when repeat mammograms need to be obtained for technical reasons. One technologist is the designated quality control technologist, and she reviews positioning deficiencies and repeat rates for individual technologists with the supervising radiologist every month. As a result, radiologists in our practice rarely have to recall a patient for positioning deficiencies. Radiologists can also use these criteria to assess the skills of recently hired technologists. These criteria can also be used as an objective method to evaluate the effectiveness of educational programs for technologists. The radiologist has an ongoing responsibility to provide frequent and consistent positive and negative feedback to technologists about the quality of their images (3), and assessment of positioning from the view box based on these criteria should be a part of that regular feedback process. ■

References

1. American Society of Radiologic Technologists. Fundamentals of mammography: the quest for quality positioning guidebook. Albuquerque, NM: Educational Foundation of the American Society of Radiologic Technologists, 1993.
2. Eklund GW, Cardinosa G. The art of mammographic positioning. Radiol Clin North Am 1992; 30:21–53.
3. American College of Radiology Committee on Quality Assurance in Mammography. Patient positioning. In: Hendrick RE, Bassett L, Dodd GD, eds. Mammography quality control. Reston, Va: American College of Radiology, 1992; 57–99.
4. Muir BB, Kirkpatrick AE, Roberts MM, Duffy SW. Oblique-view mammography: adequacy for screening. Radiology 1984; 151:39–41.
5. Sickles EA, Weber WN, Galvin HB, Ominsky SH, Sollitto RA. Baseline screening mammography: one vs two views per breast. AJR 1986; 147:1149–1153.
6. Bassett LW, Bunnell DH, Jahanshahi R, Gold RH, Arndt RD, Linsman J. Breast cancer detection: one versus two views. Radiology 1987; 165:95–97.
7. Mammography: a user's guide. Washington, DC: National Council on Radiation Protection and Measurements, 1986; 8–13.
8. Lundgren B. The oblique view at mammography. Br J Radiol 1977; 50:626–628.
9. Bassett LW, Gold RH. Breast radiography using the oblique projection. Radiology 1983; 149:585–587.
10. Andersson I. Mammography in clinical practice. Med Radiogr Photogr 1986; 62:10–16.
11. McLelland R, Hendrick RE, Zinninger MD, Wilcox PA. The American College of Radiology mammography accreditation program. AJR 1991; 157:473–479.
12. Hendrick RE. Quality assurance in mammography. Radiol Clin North Am 1992; 30:243–255.
13. Bassett LW, Jessop NW, Wilcox PA. Mammagraphy film-labeling practices. Radiology 1993; 187:773–775.