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I. Patient Positioning and Compression
1. INTRODUCTION

Breast positioning is an art that has undergone significant changes recently. Incorrect positioning is the most common problem encountered when evaluating clinical images. When mammography and xeromammography were performed with conventional X-ray equipment, positioning was limited to maneuvers in which the patient was turned while lying on her side or seated directly under the overhead tube. With the evolution of dedicated equipment that allows rotation of the X-ray tube, the possibilities for breast positioning became greater. Rather than relying on methods that were based on traditional radiographic projections (lateral and craniocaudal), the art of positioning has been refined by combining a better understanding of the breast’s anatomy and mobility with the greater versatility of modern dedicated equipment. In addition, it is now understood that breast positioning should be tailored to the patient’s specific habitus and breast problem. Today, the resourceful radiologist and technologist can rely on a great variety of positioning techniques to improve breast cancer detection and facilitate the evaluation of breast abnormalities.

This section provides a guide to performing: 1) the standard views for screening, 2) views used to localize the exact position of an abnormality in the breast, and 3) views used to better define the nature of an abnormality. Methods for performing mammograms under special circumstances, with challenging patients, for example, are also included. The views are named in accordance with new ACR recommendations for standardized mammographic terminology. Table 1 presents each of the views discussed in this section, along with its new recommended labeling code and its purpose.
## I. Patient Positioning and Compression

### Table 1. STANDARDIZED TERMINOLOGY AND ABBREVIATIONS FOR VIEWS

<table>
<thead>
<tr>
<th>Laterality</th>
<th>Labeling Code</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>R*</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>L*</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Projection/View</th>
<th>Labeling Code</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediolateral oblique</td>
<td>MLO</td>
<td>Standard View</td>
</tr>
<tr>
<td>Craniocaudal</td>
<td>CC</td>
<td>Standard View</td>
</tr>
<tr>
<td>90° Lateral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mediolateral</td>
<td>ML</td>
<td>Locate, define</td>
</tr>
<tr>
<td>Lateromedial</td>
<td>LM</td>
<td>Localize, define</td>
</tr>
<tr>
<td>Spot compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnification</td>
<td>M*</td>
<td>Define</td>
</tr>
<tr>
<td>Exaggerated craniocaudal</td>
<td>XCCL</td>
<td>Locate</td>
</tr>
<tr>
<td>Cleavage</td>
<td>CV</td>
<td>Locate</td>
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<tr>
<td>Axillary tail</td>
<td>AT</td>
<td>Localize, define</td>
</tr>
<tr>
<td>Tangential</td>
<td>TAN</td>
<td>Localize, define</td>
</tr>
<tr>
<td>Roll</td>
<td>RL (rolled lateral)†</td>
<td>Localize, define</td>
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<td>RM (rolled medial)†</td>
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<tr>
<td></td>
<td>RI (rolled inferior)†</td>
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<tr>
<td>Caudocranial</td>
<td>FB (from below)</td>
<td>Define</td>
</tr>
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<td>Lateromedial oblique</td>
<td>LMO</td>
<td>Define</td>
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<tr>
<td>Superolateral-to-inferomedial oblique</td>
<td>SIO</td>
<td>Define</td>
</tr>
<tr>
<td>Implant displaced</td>
<td>ID†</td>
<td>Augmented breast</td>
</tr>
</tbody>
</table>

* Used as prefix before projection (RMMLO = Right Magnification Mediolateral Oblique).  
† Used as suffix after projection (LCCRL = Left Craniocaudal upper breast tissue Rolled Laterally; RCCID = Right Craniocaudal Implant Displaced).
I. Patient Positioning and Compression

2. LABELING OF MAMMOGRAMS

Mammography films are important medical documents. Standardized labeling of mammograms is important to ensure that films are not lost or misinterpreted. Except for view and laterality, all labels should be placed as far from the breast as possible (See Figure 1). The following labeling guidelines are presented in three groups: (1) those that are currently required under the Mammography Quality Standards Act (MQSA) Final Rules, (2) those that are strongly recommended but are not required under the federal rules, and (3) those that are recommended but not required under federal rules.

REQUIRED. A permanent identification (ID) label that contains at least the following information: facility name, facility location (at a minimum the location shall include the city, state and ZIP code), patient name (first and last), and additional patient identification number (e.g., medical record number or social security number; date of birth is less desirable), and the date of the examination.

Radiopaque markers indicating laterality (R/L) and projection/view (MLO, CC) placed near the aspect of the breast closest to the axilla. These radiopaque markers should be placed on the cassette holder so that they can be read directly from overhead. They should not be so large as to be distracting, but large enough to be clearly read. Standardized abbreviations for mammography views have been developed, and these should be used to eliminate confusion from one facility to another (Table 1).

The technologist who performed the examination must be identified on the image. Technologist identifiers, such as unique initials, should be placed either on a designated place in the patient ID area or with radiopaque letters on the cassette holder. The facility should maintain a log of the technologists and their identifying initials.

Cassette/screen identification (usually designated by an Arabic numeral written or pressed on the screen). This is used to identify screens with artifacts or defects.

Mammography unit number (or other unique identifier) if there is more than one unit in the facility. Usually this is a Roman numeral.
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STRONGLY RECOMMENDED. A flash card patient ID system is strongly recommended because it is the most permanent. An advantage of flash labels over stick-on labels is that flash labels reproduce on copy films. The ID should fit squarely in its designated space, near the edge of the film. A flash system is not acceptable if any information is illegible, does not fit, or is lopsided, causing cut-off of information. If the flash system does not meet these requirements, the radiologist should request the film manufacturer's help in putting together a satisfactory one.

Figure 1. Proper film identification and labeling.
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RECOMMENDED. Separate date stickers are recommended, as they allow for the date to be easily read with overhead light. They can be color-coded by year to facilitate the sorting of examinations.

It is also recommended that technical factors appear on the film: target-filter, kVp, mAs, exposure time, compression force, compressed breast thickness, and degree of obliquity.

MQSA REQUIREMENTS:
Mammographic image identification. Each mammographic image shall have the following information on it in a permanent, legible, and unambiguous manner and placed so as not to obscure anatomic structures:
(i) Name of patient and additional patient identifier
(ii) Date of examination
(iii) View and laterality. This information should be placed on the image near the axilla. Standardized codes specified by the accreditation body and approved by the FDA shall be used to identify view and laterality.
(iv) Facility name and location. At a minimum, the location shall include the city, state, and zip code of the facility.
(v) Technologist identification
(vi) Cassette/screen identification
(vii) Mammography unit identification, if there is more than one unit at a facility

Except for view and laterality, labels should be placed as far as possible from the breast so as not to distract from evaluating the breast image. Collimating close to the surface of the breast is not recommended because light transmitted through clear areas of the film adversely affects film viewing (Figure 2A). Collimating close to the edge of the breast does not significantly improve image contrast since there is virtually no X-ray scatter from air. Therefore, collimation should be to the edge of the film so that as much of the film as possible will be exposed (Figure 2B).
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Figure 2A. Incorrect collimation. Image is collimated too close to the breast, leaving a large amount of unexposed film, which results in excessive ambient light from the viewbox reaching the radiologist’s eyes. Film labeling is also incorrect.
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Figure 2B. Correct collimation with proper laterality/view marker.
3. BREAST COMPRESSION

Breast compression and patient positioning are major considerations in obtaining consistently high-quality mammograms. Properly applied compression is one of the most neglected and most important factors affecting image quality in mammography. The primary goal of compression is to uniformly reduce the thickness of the breast so it is more readily and uniformly penetrated by the X-ray beam from subcutaneous region to chest wall (Figures 3A and B). This is best achieved with a rigid

Figure 3A. Inadequate compression. MLO view shows inadequate separation of the fibroglandular tissues, motion blurring of the linear structures, and underexposure. Each of these findings is related to inadequate compression.
I. Patient Positioning and Compression

A compression device with a 90° angle between the posterior and inferior surfaces. A compression device with a rounded or gently sloping posterior edge will not uniformly compress the deep breast tissue or hold it firmly in place during exposures. In addition, a straight rather than rounded contour along the posterior surface of the compression device is required. This is because compression of the breast tissue should be uniform along the posterior aspect of the mammography film, which is straight and not curved. During compression, the compression plate should remain parallel to the plane of the image receptor. Under MQSA, it may not deflect by more than 1 cm, unless designed to do so. This is particularly important with the low-energy (25-30 kVp), less-penetrating X-ray beams that are used in mammography.

There are other important reasons why proper compression is essential for mammography. Compression reduces the object-to-image receptor distance, reducing geometric blurring. Compression separates structures within the breast. Proper compression results in more uniform film optical density by flattening the breast to a more uniform thickness, facilitating the distinction between more compressible, less dense benign structures such as asymmetric normal tissue and cysts, and less compressible, denser malignant lesions. By reducing the breast thickness, proper compression reduces the breast dose needed for a proper exposure and improves contrast by decreasing scattered radiation. Furthermore, proper compression immobilizes the breast, lessening the chance of motion blurring (Figure 3B).

A well-designed and properly applied compression device, combined with a technologist’s skill in gently but firmly pulling the breast onto the receptor, will maximize the amount of breast tissue that can be imaged. Mammographic systems that feature some type of foot pedal to control the downward movement of the compression device enable the technologist to use both hands for breast positioning. All mammography units will be required to have power-driven compression by October 28, 2002.

Because the use of proper compression is so crucial, it is important to define the amount of compression desired in mammography today. In some cases, in an attempt to be kind to the patient, the technologist does not apply adequate breast compression, resulting in poor image quality and higher patient dose. The overall result is not beneficial to the patient. On the other hand, if compression is too vigorous, women will find the examination unacceptable—a disincentive to return for periodic screening mammograms. Ideally, the degree of compression should be determined by two factors: the maximum degree to which the
I. Patient Positioning and Compression

individual patient’s breast can actually be compressed and the amount of compression that the patient can tolerate at that time. Ideally the breast should be compressed until the tissue is taut: gentle tapping will not indent the skin when breast compression is taut. At a maximum, compression should be less than painful.

Figure 3B. Adequate compression. MLO view of another patient shows separation and uniform density of fibroglandular tissues and good detail of the linear structures.
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Patients can often tolerate more compression if they are prepared for it and if it is applied slowly rather than unexpectedly and all at once. Before beginning the examination, it is critical that the technologist establish a rapport with the patient. The informed patient, educated as to what compression is, how long it will last, and why it is important, will tolerate more compression. It should be explained that compression may be uncomfortable, but should not be painful, and that compression will greatly improve the quality of the examination. For some women, the breasts may become very sensitive just before or during menstruation or occasionally at other times in the menstrual cycle. For these women, mammography should be scheduled at a time when the breasts are least sensitive. For patients whose breasts are particularly sensitive, medications that relieve breast tenderness, such as those with ibuprofen, may be taken prior to the mammographic examination.

The compression device and top of the cassette holder (“bucky” assembly) should be cleaned after each patient. The manufacturer’s specific recommendations should be followed in order to avoid damage to the compression plate. See Section VI of the Radiologic Technologist’s Section of this manual.
I. Patient Positioning and Compression

4. PATIENT POSITIONING

STANDARD VIEWS

The mediolateral oblique and craniocaudal views are routinely performed for all mammographic examinations, and these two views suffice for a screening examination. Since they may be the only views done, it is essential that they be performed optimally. Proper breast positioning is based on an understanding of the normal anatomy and the normal mobility of the breast. The mobile aspects of the breast are the lateral and inferior margins; the medial and superior margins are fixed. The principle of mobile versus fixed tissue is used in breast positioning to maximize the amount of tissue that can be visualized. The objectives are to (1) move the mobile tissues rather than the fixed tissues and, (2) avoid moving the compression plate against the fixed tissues.

While it is desirable to have the nipple in profile on the routine views, the primary goal in breast positioning is to show as much tissue as possible. Therefore, breast tissue should not be sacrificed to show the nipple in profile. The nipple should be shown in profile in at least one view. When the nipple is not shown in profile on any view, an extra view for nipple profile can be done.

MEDIOLATERAL OBLIQUE (MLO)

The properly performed mediolateral oblique (MLO) view offers the best opportunity to visualize the maximum amount of breast tissue in a single view. For the MLO, the plane of the cassette holder is angled 30° to 60° from the horizontal, so that the cassette is parallel to the pectoral muscle. The X-ray beam is directed from the superomedial to the inferolateral aspect of the breast. In order to image the maximum amount of tissue, it is imperative that the angle of the image receptor is parallel to the angle of the pectoral muscle of the individual patient (Figure 4A). To determine the angle of the pectoral muscle, the technologist places her fingers in the patient’s axilla behind the muscle. The patient’s shoulder should be relaxed in neutral rotation. The technologist gently moves the pectoral muscle forward to accentuate the movable lateral border (Figure 4B). Tall, thin patients will require a steeper (50°–60°) angle than short, heavy patients (30°–40°). Patients of average height and weight will require an angle between 40° and 50°. Using an angle that is not parallel to the pectoral muscle will result in less tissue being imaged. Except in rare cases, the positioning angle is the same for both breasts. Some facilities record the angle used for the MLO on the film so that it can be reproduced for the next examination.
I. Patient Positioning and Compression

Figure 4A. Mediolateral oblique. Aligning the angle of the bucky to the pectoral muscle.

Figure 4B. Mediolateral oblique. Determining the angle of the pectoral muscle.
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Applying the principle of moving the mobile tissue toward the fixed tissue, lift the breast, then pull both breast tissue and pectoral muscle anteriorly and medially (Figure 4C). The patient’s hand on the side being imaged should be resting on the handlebar. Move the patient’s shoulder as close to the center of the bucky as possible. This will place the corner of the cassette holder posterior to the axilla, behind the pectoral muscle, but in front of the latissimus dorsi (Figure 4D). The patient’s arm is draped behind the cassette holder with the elbow flexed to relax the pectoral muscle. Rotate the patient toward the cassette holder so that the edge of the cassette holder replaces your hand in maintaining the

*Figure 4C. Mediolateral oblique. Moving the breast and pectoral muscle anteriorly and medially.*
I. Patient Positioning and Compression

Figure 4D. Mediolateral oblique. The corner of the bucky will be positioned in the posterior aspect of the axilla.
breast and muscle in its mobilized position (Figure 4E). Hold the breast out and up, away from the chest wall to prevent overlapping of tissue (Figure 4F). Begin to apply compression. After the compression paddle passes the sternum, continue to turn the patient until her hips and feet are facing the mammography unit. The upper corner of the compression paddle should be just below the clavicle. While moving your hand out of the field, continue to support the anterior aspect of the breast with your hand until there is enough compression to maintain the breast in this position (Figure 4G). We call the combined hand movements

Figure 4E. Mediolateral oblique. The edge of the bucky will replace your hand, maintaining the breast and muscle in their mobilized position.
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the “out-and-up” maneuver. The importance of the out-and-up maneuver cannot be overemphasized. If the hand supporting the breast is removed too soon the breast will fall, resulting in inadequate separation of tissues (Figures 4H and I). The final step involves pulling abdominal tissue down in order to open the inframammary fold (Figure 4J). The entire breast, from inframammary fold to axilla, should be centered on the cassette holder. (Figures 4K and L). There will be cases where the whole breast cannot be adequately compressed on a single MLO view; and in these cases an additional anterior compression view, either at the same obliquity or at a 90° angle, should be performed.

Figures 4H & I. Mediolateral oblique. Two mammograms of the same patient illustrating the importance of the out-and-up maneuver. Improper performance (H), with hand removed before sufficient compression is applied, results in poor separation of tissues and downward sloping of the breast contour, giving the breast the appearance of a “camel’s nose.” Note inferior skin fold in H (arrow). Properly executed out-and-up maneuver maximizes separation of breast structures (I).
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Figure 4J. Mediolateral oblique. Opening the inframammary fold.

Figure 4K. Mediolateral oblique. Improper centering. The mound of the breast is centered, which results in exclusion of superior tissue.

Figure 4L. Mediolateral oblique. Proper centering of the breast.
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Criteria on the mammogram indicating that positioning for the MLO is optimal include: (1) pectoral muscle is wide superiorly with a convex anterior border, extending to or below the posterior nipple line; (2) fat is visualized posterior to all of the fibroglandular tissues; (3) deep and superficial breast tissues are well separated; (4) close inspection shows no evidence of motion blur; and (5) the inframammary fold is open (Figure 4M).

Figure 4M. Mediolateral oblique. Properly positioned MLO.
The craniocaudal view should be done in such a manner as to ensure that any tissue that may have been missed on the MLO will be depicted on the CC. If any tissue is missed on the MLO, it is likely to be the medial tissue. Therefore, it is necessary to demonstrate as much of the medial tissue as possible on the CC projection. This should be done along with visualizing as much lateral tissue as possible and can be accomplished without excessive exaggeration to the medial or lateral side by performing the CC in the following manner.

The technologist will have more control over patient positioning if she stands on the medial side of the breast being examined. As with the MLO, the principle of mobile versus fixed margins is used. Lift the mobile inframammary fold (IMF) as high as its natural mobility will allow (Figures 5A and B). This distance may range from 1-1/2 to 7 cm from the neutral position. Raise the cassette holder to meet the edge of the elevated IMF. With one hand under the breast and the other on top of the breast, gently pull breast tissue away from the chest wall and position the nipple in the center of the cassette holder (Figure 5C). This two-hand technique gently pulls the breast tissue away from the chest wall to maximize the amount of breast tissue visualized. With one hand placed on top of the breast near the chest wall, hold the breast in this position.
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Figure 5B. Craniocaudal. Elevating the IMF.

Figure 5C. Craniocaudal. Using both hands for positioning. Both hands pull the breast onto the bucky.
position (Figure 5D). Lift the contralateral breast, rotating the patient until the chest wall edge of the bucky is flush against the sternum (Figure 5E). Drape the contralateral breast over the corner of the cassette holder (rather than placing it behind the cassette holder). Bring the patient’s head

Figure 5D. Craniocaudal. Using both hands for positioning, the technologist uses one hand to hold the breast in place.

Figure 5E. Craniocaudal. While lifting the contralateral breast to rotate the patient until the sternum is against the bucky.
forward around the tube assembly. This will enable the patient to lean into the machine, in order to position the superior breast tissue over the image receptor. Bring the patient’s arm on the side not being imaged forward to hold onto the handlebar. These maneuvers will improve visualization of medial tissue.

The next maneuver will improve visualization of the posterior lateral tissue. Using the hand that is on top of the breast, reach past the chest wall edge of the cassette holder to lift the posterior lateral aspect of the breast onto the cassette holder. This should be done without rotating the patient (Figure 5F). The technologist’s arm is placed behind the patient’s back with her hand resting on the shoulder near the base of the neck of the side being examined (Figure 5G). This allows the technologist to use her hand to keep the patient’s shoulder “relaxed down” while at the same time applying gentle pressure to her back to prevent her from pulling away from the mammography unit. Using the fingers of the hand on the shoulder, slide the skin up over the clavicle to relieve any pulling sensation on the patient’s skin during subsequent compression. As compression is applied, move the hand holding the breast toward the nipple while smoothing lateral tissue forward to eliminate folds. On the side being imaged, the patient’s arm hangs relaxed by her side with the humerus externally rotated (Figure 5H). This arm position will also

Figure 5F. Craniocaudal. Lift and pull the posterior lateral aspect of the breast onto the bucky.
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Figure 5G. Craniocaudal. The technologist’s arm is placed behind the patient’s back with the hand on the patient’s shoulder.

Figure 5H. Craniocaudal. Correct position of breast with compression applied.
remove skin folds. If skin folds are still present, slide your finger under the compression device and use it to roll out the skin fold laterally. (Figure 5I).

Incorrect positioning for the CC will result in a significant loss of tissue in the image (Figure 5J). Criteria on the mammogram indicating optimal positioning for the CC include: (1) all medial tissue visualized, (2) nipple centered on the image, and (3) posterior nipple line (PNL) measures within 1 cm of the MLO, or visualization of pectoral muscle (Figure 5K).

Figure 5I. Craniocaudal. The technologist rolls her finger out laterally to remove skin folds.
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Figure 5J. Craniocaudal. Improper positioning of the CC view. The cassette holder is at the level of the neutral IMF and the breast tissue was placed, not pulled, onto the image receptor. Note the significant amount of superior and posterior breast tissue behind the lip of the compression plate. Measurement line on tape, indicating the position of the nipple, shows that less breast tissue is included than in the properly positioned CC in Figure 5H. Comparing the distance from the shoulder to the lip of the compression plate to that in Figure 5H provides additional evidence of the difference in the amount of breast tissue that will be depicted.
I. Patient Positioning and Compression

Figure 5K. Craniocaudal. Properly positioned mammogram. Note that all medial tissue is visualized in the image. In this case, pectoral muscle (arrow) and its medial insertion (arrowhead) are visualized.
5. ADDITIONAL VIEWS

90° LATERAL

The 90° lateral (true lateral, straight lateral) view is the most commonly used additional view. This view is used in conjunction with the standard views to triangulate the exact location of lesions in the breast. The 90° lateral view is also used to demonstrate gravity-dependent calcifications (milk of calcium). When an abnormality is seen on the MLO/CC view but not on the standard craniocaudal view, it should first be determined whether it is real, superimposed tissue, artifact on the film, or in the skin. Sometimes, repeating the oblique view with a slightly different angulation or obtaining a 90° lateral view will provide this information.

A change in location of a lesion relative to its distance from the nipple on the 90° lateral view can be used to determine whether the lesion is in the lateral, central, or medial aspect of the breast. For example, if on the 90° lateral view the lesion moves up relative to the nipple or is higher than on the MLO, the lesion is in the medial aspect of the breast. If on the 90° lateral film the lesion moves down relative to the nipple or is lower than in the MLO, the lesion is in the lateral aspect of the breast. If the lesion does not shift significantly in MLO versus 90° lateral films, it is located in the central aspect of the breast.

When an abnormality has been identified, the most appropriate lateral view, medial-to-lateral versus lateral-to-medial, is the one that provides the shortest object-to-image receptor distance, to reduce geometric unsharpness.
MEDIOLATERAL (ML)  

For the mediolateral (Figure 6A) view, the tube arm is rotated 90°. The patient’s arm on the side being examined is abducted 90° resting across the top of the cassette holder. Again using the principle of mobile versus fixed margins, pull breast tissue and pectoral muscle anteriorly and medially. Lift the breast out and up while gently pulling the breast away from the chest wall. Rotate the patient toward the cassette holder and begin compression. When the compression paddle has passed the sternum, continue rotating the patient until the breast is in a true lateral position centered on the cassette holder. Continue to hold the anterior breast in position while applying compression. Open the inframammary fold by gently pulling abdominal tissue down.

Figure 6A. 90° Lateral. 90° mediolateral.
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LATEROMEDIAL (LM)

For the lateromedial (Figure 6B) view, the tube arm is rotated 90° with the top of the cassette holder at the level of the suprasternal notch. The patient is positioned with her sternum against the edge of the cassette holder, her neck extended with her chin resting on the top of the cassette holder. Pull the mobile lateral and inferior tissue up and toward the midline. Begin rotating the patient toward the cassette holder. Bring the compression paddle down past the latissimus dorsi. After the compression paddle has passed the latissimus dorsi, lift the patient’s arm on the side being imaged over the cassette holder. The elbow should be flexed to relax the pectoral muscle. Continue rotating the patient until the breast is in a true lateral position centered on the cassette holder. Open the inframammary fold by gently pulling abdominal tissue down.

Figure 6B. 90° Lateral. 90° lateromedial.
SPOT COMPRESSION

Spot or coned compression is a simple technique that merits more frequent application. Spot compression views are especially helpful with obscure or equivocal findings in areas of dense tissue. Compared with whole breast compression, spot compression allows for greater reduction in thickness of the localized area of interest, and improves separation of breast tissues (Figure 7A). Spot compression requires collimation to the area of interest. This collimation, combined with the decreased breast thickness, results in higher contrast and more precise evaluation of findings (Figures 7B and C). Variably sized spot compression devices, especially the smaller ones, can facilitate more effective localized compression. Using the original mammogram, the technologist determines the placement of the small compression device by determining the location of the lesion. To determine the location of the lesion, measure (1) the depth relative to a line drawn directly posterior from the nipple,

Figure 7A. Spot compression. This technique allows for greater localized compression and displaces tissues overlying the area of interest.
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Figure 7B. Spot compression. CC mammogram shows a suspicious density with irregular margins (arrow) that was not present on the MLO.

Figure 7C. Spot compression. With spot compression, the density is no longer present, indicating that it represented superimposition of normal tissues.
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(2) the distance from that line to the lesion in the superior-to-inferior or medial-to-lateral direction, and (3) the distance from the lesion to the skin surface (Figures 7D and E). Then reposition the patient, using your hand to simulate compression. Transfer the three measurements to the breast and use a marker to identify the location of the lesion (Figures 7F, G and H). Reposition to center the spot compression device over the lesion. Spot compression is often combined with magnification using the small focal spot to improve resolution of detail within the breast.

Figures 7D & E. Spot compression. Applying the three measurements in the MLO (D) and the CC (E) projection. (1) The depth relative to a line drawn directly posterior from the nipple, (2) the distance from that line to the lesion in the superior-to-inferior or medial-to-lateral direction, and (3) the distance from the lesion to the skin surface.
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**Figure 7F.** Spot compression. The location of the lesion is determined from the original films by its distance from the nipple.

**Figure 7G.** Spot compression. The distance from that line to the lesion in the lateral direction.
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Figure 7H. Spot compression. The distance from the lesion to the skin measured before compression is applied.
MAGNIFICATION (M) Magnification views with or without spot compression can be helpful in differentiating benign from malignant lesions by permitting a more precise evaluation of margins and other architectural characteristics of a focal density or mass. Magnification views also permit better delineation of the number, distribution, and morphology of calcifications. This technique may also reveal unexpected findings that were not evident on routine views. It requires an X-ray tube with a microfocal spot in order to offset the geometric unsharpness resulting from the increase in the magnification of breast structures. It also requires a magnification platform (Figure 8) to separate the compressed breast from the cassette for 1.5 to 2 times magnification (the greater the magnification, the smaller

Figure 8. Magnification setup.
the focal spot required). With magnification mammography, it is critical that the patient remain still for the relatively longer exposure times resulting from the use of the unit’s small focal spot. The air gap resulting from separation of the breast from the image receptor prevents a significant amount of scattered radiation from reaching the film, and a grid is not used.

An exaggerated craniocaudal view (Figures 9A through C) will depict deep lesions in the outer aspect of the breast including most of the axillary tail. Begin positioning the patient as for the routine CC. After elevating the inframammary fold, rotate the patient until the lateral aspect of the breast is positioned on the cassette holder. If the shoulder is in the way of the compression paddle, a 5° lateral tube angle can be used to allow the compression paddle to clear the humeral head. Do not push the shoulder down. Both shoulders should be at the same level. (Figures 9B and C).

Figure 9A. Exaggerated craniocaudal. Patient is rotated to bring deep lateral tissues onto the bucky.
I. Patient Positioning and Compression

Figure 9B. Exaggerated craniocaudal. Pushing the shoulder down will distort the lateral aspect of the breast.

Figure 9C. Exaggerated craniocaudal. Both shoulders should be at the same level.
I. Patient Positioning and Compression

CLEAVAGE (CV) The cleavage view (valley view, double breast compression view) is performed to visualize deep lesions in the posteromedial aspect of the breast. The patient’s head is turned away from the side of interest. This positioning can be done with the technologist standing behind the patient and wrapping her arms around the patient to reach her breasts (Figure 10A) or with the technologist standing in front of the patient on the medial side of the breast being imaged. Whether standing behind or in front of the patient, be sure to elevate the inframammary folds and position both breasts on the cassette holder. Remember to pull all of the medial tissue of both breasts anteriorly in order to image the cleavage. Automatic exposure can be used by placing the breast of interest over the photocell with the cleavage slightly off center (Figure 10B). Manual technique must be used if the photocell is under an open cleavage.

Figure 10A. Cleavage. Standing behind the patient, the technologist places both breasts onto the cassette holder.
I. Patient Positioning and Compression

Figure 10B. Cleavage. Breast of interest is placed over the photocell with cleavage slightly off center.
AXILLARY TAIL (AT)  The axillary tail view may be used to demonstrate the entire axillary tail as well as most of the lateral aspect of the breast. The tube arm is rotated to an angle that will place the cassette holder parallel to the axillary tail (Figure 11A). The patient is turned to bring the axillary tail in contact with the cassette holder. The patient’s arm on the side being imaged is draped behind the top of the cassette holder with the elbow flexed and the hand resting on the handlebar. Gently pull the axillary aspect of the breast out and away from the chest wall and place it on the cassette holder. Hold the axillary tail in place while slowly applying compression (Figure 11B).

Figures 11A & B. Axillary tail. The patient remains upright and the C-arm is rotated parallel to the axillary tail of the individual patient.
I. Patient Positioning and Compression

TANGENTIAL (TAN)  
The tangential view is used for palpable lesions that are obscured by surrounding dense glandular tissue on the mammogram. The C-arm is rotated and the patient is turned so that the X-ray beam is tangential to the palpable lump. Performing tangential views can be facilitated by placing a lead marker (BB) directly over the lump and directing the X-ray beam tangential to the lead marker. This maneuver places the palpable lump directly over the subcutaneous fat, which often allows visualization of the abnormality.

Tangential views can also be used to verify that calcifications seen on a mammogram are located within the skin. Using a fenestrated plate with radiopaque alphanumeric indicators or a hole plate for guidance, place a lead marker (BB) on the breast over the calcifications (Figure 12A). It is important to place the marker on the correct side of the breast, e.g., superior versus inferior, medial versus lateral surface. Rotate the C-arm or the breast tissue until the lead marker is tangential to the X-ray beam (Figures 12B and C). Seeing a shadow of the marker on the cassette holder indicates that the area of concern will be tangential to the X-ray beam.

Figure 12A. Tangential view. A BB is placed directly over the suspected skin calcifications.
I. Patient Positioning and Compression

Figure 12B. Tangential view. Make a mound of the breast with the nipple at one end and the marker at the other end.

Figure 12C. Tangential view. The breast is correctly positioned for a view tangential to the BB.
ROLL (RL, RM)

The roll view is used to separate superimposed breast tissues. The purpose is to confirm the presence of an abnormality, to better define a lesion, or to determine the location of a finding seen on only one of the standard views. The patient is repositioned using the same projection that demonstrated the abnormality. Placing your hands on either side of the breast, “roll” the tissue in opposite directions (Figures 13A and B). Compression will maintain the breast in the “rolled” position. A radiopaque marker indicating the direction of the roll should be placed on the film.

Figures 13A & B. Roll view. (A) The technologist’s hands are used to “roll” the breast. (B) The lesion (X) will be seen to move according to its location in the breast.
6. SPECIAL CIRCUMSTANCES

CAUDOCRANIAL (FB) The caudocranial (reverse CC) view will improve visualization of lesions in the uppermost aspect of the breast due to the reduced object-to-film distance (Figures 14A through D). Since the compression device comes from below, this view will not exclude the fixed posterior tissue in the superior aspect of the breast (Figures 14B and C). It can also be used during needle localization to provide a shorter route to an inferior lesion. This view can also be used to maximize the amount of tissue visualized in the male breast or in a woman with kyphosis.

Figures 14A & B. Reverse craniocaudal (caudocranial position). A patient presented with a palpable mass high in the breast. The mass (arrow) was barely visible on lateral (A) and CC (B) views.
Rotate the tube arm 180°. The patient will face the unit with one leg on either side of the tube head. Elevate the inframammary fold, then adjust the height of the tube arm so that the superior border of the breast will be in contact with the cassette holder. With one hand on top of the breast and the other hand under the breast, gently pull the tissue away from the chest wall and center the breast on the cassette holder (Figure 14E). Slowly apply compression.

Figures 14C & D. Reverse craniocaudal. The caudocranial view improves the depiction of the spiculated mass by placing it closer to the film and also shows its posterior margin completely (C). Spot compression combined with magnification improves the depiction of the mass in the lateral projection (D).
I. Patient Positioning and Compression

Figure 14E. Reverse craniocaudal. Caudocranial position.
LATEROMEDIAL OBLIQUE (LMO)

The lateromedial oblique (true reverse oblique) view is performed with the X-ray beam directed from the lower-outer to the upper-inner aspect of the breast, the exact reverse of the MLO. This view will improve visualization of the medial breast tissue due to the reduced object-to-film distance. The cassette holder is placed parallel to the plane of the pectoral muscle, optimizing the amount of breast tissue that is depicted. The lateromedial oblique can be used to more comfortably position the breast and therefore visualize more tissue in a patient with pectus excavatum, a patient who has had recent open heart surgery, or a patient with a prominent pacemaker.

The tube arm is rotated to the appropriate angle with the beam at an inferolateral to superomedial direction. Adjust the height of the cassette holder so that the breast is centered. The patient should lean forward to place the edge of the cassette holder against the sternum. The patient’s arm will be draped over the top of the cassette holder, with the elbow flexed (Figure 15). Gently pull the breast out and up from the chest wall, making sure all medial tissue is in front of the cassette holder. Begin to rotate the patient toward the film. Bring the compression device down beyond the latissimus dorsi, then finish rotating the patient forward until all the breast tissue is centered on the film. After the breast is fully compressed, open the inframammary fold by gently pulling abdominal tissue down.

Figure 15. Lateromedial oblique also known as reverse oblique.
I. Patient Positioning and Compression

SUPEROLATERAL-TO-INFEROMEDIAL OBLIQUE (SIO)

An oblique view can also be performed with the central ray directed upper Outer to lower-inner (see Figure 16). This view has been incorrectly termed a reverse oblique. As a whole-breast projection it has limited usefulness.

Figure 16. Superolateral-to-inferomedial oblique.
I. Patient Positioning and Compression

THE AUGMENTED BREAST (ID)

Imaging the augmented breast presents special problems and challenges to the radiologist and technologist and requires special consideration. The routine CC and MLO implant-included views require manually set exposure factors, and the degree of compression is limited by the compressibility of the implant (Figure 17A). In addition to these routine views, patients with augmented breasts should have modified CC implant displaced and modified MLO implant displaced view. In the modified implant displaced views, the prosthesis is displaced posteriorly and superiorly against the chest wall while gently pulling the breast tissue anterior to the prosthesis onto the image receptor and holding it in place with the compression device (Figures 17B through D).

Figures 17A, B, C, & D. Imaging the augmented breast. (A) Compression of the breast and the undisplaced prosthesis. (B-D) Displacement of the prosthesis and compression of only the breast.

For a CC implant displaced view, the tissue superior and inferior to the prosthesis will be pulled forward, as will all the anterior tissue. For an MLO implant displaced view, the tissue superomedial and inferolateral will be pulled forward with the anterior tissue. This procedure can greatly improve visibility of breast tissue (Figures 17E and F).

Figures 17E & F. MLO views including the implant (E) and with the implant displaced (F).
I. Patient Positioning and Compression

There are five essential steps for positioning the CC and MLO implant displaced views. The five steps for the CC view are:

1) Have the patient bend forward from the waist, use your fingers to pull the breast tissue forward while displacing the implant posteriorly, and then have the patient stand again.

2) Have the patient place her contralateral hand under her breast and firmly against the ribs.

3) Gently pull the breast tissue onto the cassette holder and place the edge of your fingers, holding the inferior tissue, against the edge of the bucky.

4) Ask the patient to push her body against her hand (which results in further displacement of the implant).

5) Apply compression (a spatula can be used to hold the tissue forward and will facilitate the compression).

The five steps for the MLO implant displaced view are:

1) Have the patient bend forward from the waist, use your fingers to pull the breast tissue forward while displacing the implant posteriorly, and then have the patient stand again;

2) Ask the patient to place her hand on the handlebar with the corner of the bucky posterior to the axilla.

3) Place the edge of your fingers, holding the lateral tissue, against the edge of the bucky.

4) Ask the patient whether she feels the bucky against her ribs or against her breast. If she replies “breast” then ask her to lean her body against the bucky; if she replies “ribs” you should start over because the implant is not sufficiently displaced.

5) Apply compression.
The steps described above are more easily performed on breasts with subpectoral implants, implants placed behind the pectoral muscle. Implants that are placed in front of the muscle, also called subglandular or retromammary implants, are more susceptible to capsular contraction, which makes it difficult to displace the implant. It may also be difficult to perform implant displacement views on patients who have very little native breast tissue. If the implant cannot be adequately displaced, a 90° lateral with the implant included should be added to the routine CC and MLO implant-included views.
7. POSTMASTECTOMY IMAGING

Imaging the postmastectomy side is controversial. Those who recommend this procedure might include an MLO projection of the skin over the mastectomy site, a spot view of any area of concern, and an anteroposterior view of the axilla.
I. Patient Positioning and Compression
1. INTRODUCTION

Peer review of clinical images by radiologists with special expertise and training has been an important component of the ACR Mammography Accreditation Program since its inception in 1987. The clinical image evaluation includes an assessment of positioning, compression, artifacts, exposure, contrast, sharpness, noise, and labeling. For accreditation purposes, the standard MLO and CC views of each breast of a woman with primarily fatty breasts and of a woman with primarily dense breasts are evaluated for each mammography unit. The two types of breast tissue compositions represent different imaging challenges. Due to the variations in the body habitus of patients and their ability to cooperate, it is not possible to attain ideal breast positioning and compression in all women. Therefore, facilities are requested to submit what they consider to be their best representative images. Clinical image evaluation is complementary to phantom image evaluation in assessing the overall quality of mammography at a facility applying for accreditation. Failure to pass clinical image review is the most common reason for failing to obtain accreditation.

It should be emphasized that clinical image evaluation is not intended to be an activity that takes place only at the time of accreditation. On the contrary, technical assessment of clinical images should be an ongoing, daily quality assurance activity performed by the radiologist interpreting mammograms. It is important that radiologists provide regular feedback to the radiologic technologists who perform mammography, including positive reinforcement and constructive criticism about the technical quality of examinations. Learning to recognize specific deficiencies in images and their possible cause will allow the radiologist and radiologic technologist to address image deficiencies quickly.

MQSA REQUIREMENTS:
Interpreting physicians. All interpreting physicians interpreting mammograms for the facility shall (A) follow the facility procedures for corrective action when the images they are asked to interpret are of poor quality, and (B) participate in the facility’s medical outcomes audit program.
II. Clinical Image Evaluation

2. MEDIOLATERAL OBLIQUE VIEW POSITIONING

To ensure that the greatest possible amount of tissue has been included in the image, a generous amount of pectoralis muscle should be visualized. It is desirable for the inferior extent of the muscle to be visible down to the posterior nipple line (PNL) (Figures 18A and B). The latter criterion can be achieved in more than 80% of women. The PNL is drawn at an angle approximately perpendicular to the muscle, extending posteriorly from the nipple to the pectoralis muscle or the edge of the film, whichever comes first. Depiction of retroglandular fat posterior to all of the fibroglandular tissue is indirect evidence that all the fibroglandular tissue has been included. The pectoralis muscle should also be sufficiently wide (Figures 19A and B).

Figures 18A & B. On a properly positioned MLO view, the inferior aspect of the pectoral muscle should come to the posterior nipple line (PNL). A convex anterior margin to the pectoral muscle (A) is preferable to a concave margin (B) because the latter may exclude posterior breast tissue.
Figures 19A & B. Signs of better positioning in (A) compared with (B) include extension of the pectoralis muscle below the posterior nipple line, greater inclusion of the pectoralis muscle, and inclusion of more posterior breast tissue. Because the breast is better positioned in (A) there is more breast tissue behind the calcification. Film (A) also exhibits improved compression and therefore less superimposition of breast tissue yielding improved visualization of fibroglandular tissues.
II. Clinical Image Evaluation

If proper maneuvers have been performed prior to and during the application of compression the breast will not be sagging (Figures 20A and B). An open inframammary fold (Figures 21A and B) also indicates proper positioning and compression. Skin folds at the posteroinferior aspect of the breast should be minimal or absent (Figures 22A and B).

Figures 20A & B. (A) The breast is sagging because it was not pulled out and up prior to compression. Consequently, there is less posterior tissue (including inframammary tissue), and the breast cannot be well compressed. Compare with the better positioning and compression shown in (B).
II. Clinical Image Evaluation

Figures 21A & B. (A) The open inframammary fold (IMF) indicates adequate inclusion of lower posterior breast tissue. (B) Absence of the IMF in the same patient indicates exclusion of tissue from that region of the breast.
II. Clinical Image Evaluation

**Figures 22 A & B**  
(A) The skin fold in the inframammary area prevents adequate visualization of that region.  
(B) The same breast with skin fold eliminated.

It is important to have image receptors and compression devices available in both $18 \times 24$ cm and $24 \times 30$ cm sizes for each mammography unit and to use the appropriate size for each view. If a large breast is imaged on the smaller image receptor, either the axillary or inferior aspect of the breast is likely to be excluded from the image (Figures 23A and B). Significant problems are also encountered when using the large image receptor for a small breast, including inability to achieve adequate compression and sagging of the breast on the MLO view. These problems occur because the patient’s arm, shoulder or abdomen becomes superimposed between the breast and the large image receptor, preventing effective breast compression.

**MQSA REQUIREMENTS:**

Image receptor sizes. Systems using screen-film image receptors shall provide, at a minimum, for operation with image receptors of $18 \times 24$ cm and $24 \times 30$ cm.
Figures 23A & B. Inappropriate use of a small (18 × 24 cm) image receptor size (A) for a large breast may include less inferior breast tissue and/or less upper axillary tissue than would be included with (B) a larger 24 × 30 cm image receptor.
3. CRANIOCAUDAL VIEW POSITIONING

Even when the CC is properly performed, the pectoralis muscle is only visualized in about 30% to 40% of patients. When the pectoralis muscle is not seen, the best indicator of the amount of posterior tissue included on the CC is the measurement of the PNL (Figure 24). On the CC view the PNL is drawn directly posterior from the nipple to the edge of the film. The general rule is that the length of the PNL on the CC view should be within 1 cm of its length on the MLO when the MLO

![Figure 24](image-url)  

*Figure 24. If the posterior nipple line (PNL) measured from the back of the nipple to the edge of the film on the CC view is within 1 cm of its length on the MLO view, sufficient posterior tissue has been included on the CC view (same patient as in Figure 18B).*
II. Clinical Image Evaluation

is properly positioned. Usually the length of the PNL is greater on the MLO than on the CC; however, in approximately 10% of patients the length of the PNL will be greater on the CC. Visualization of the pectoralis muscle on the chest wall directly behind the nipple means that sufficient posterior breast tissue has been included on the CC view (Figure 25). Proper positioning techniques will maximize the likelihood

Figure 25. Presence of pectoralis muscle along the posterior nipple line on a CC view indicates adequate inclusion of breast tissue in the AP direction on this projection.
II. Clinical Image Evaluation

that lesions in the far posterior breast are included on the image (Figures 26A and B).

The posteromedial breast tissue is the area most likely to be excluded on an MLO. For this reason it is of paramount importance to include the posteromedial aspect of the breast on the CC. When the positioning is done properly, all of the fibroglandular tissue of the medial aspect of the breast can be included in the image without exaggerating to the medial or lateral side. Although as much lateral tissue as possible should be included on the CC, lateral tissue should never be included at the expense of medial tissue.

*Figures 26A & B.* (A) Proper positioning of a post-lumpectomy patient allows inclusion of more posterior breast tissue than (B), where CC positioning was suboptimal. Note visibility of additional surgical clips in (A).
II. Clinical Image Evaluation

Assuming that the right and left breasts are the same size, the extent of tissue in the AP direction should be similar for right and left breasts in both CC images and similar for right and left breasts in both the MLO images. Portions of the breast should not project beyond the margins of the image. Although it is not always possible to position the nipple in profile when including a maximum amount of breast tissue, large variations in nipple location, especially when right and left sides are compared, usually signify inconsistencies in positioning.
II. Clinical Image Evaluation

4. COMPRESSION

Compression decreases breast thickness, which reduces dose, scattered radiation, and object unsharpness. By making the breast more uniform in thickness, film optical density differences are more likely to correspond to subtle attenuation differences in the breast rather than differences in breast thickness. Compression also eliminates motion by holding the breast still.

Inadequate compression is manifested on clinical images by overlapping breast structures, non-uniform exposure of fibroglandular tissues, poor penetration of thicker portions of the breast, overexposure of thinner areas, and motion unsharpness. It is useful to observe whether structures are less well separated on MLO views than on the CC views, since the former images often will be less satisfactorily compressed. Underexposure of a single image, especially when phototimed, is often a reliable sign that the particular view was not done with optimal compression. Detection of a breast cancer within dense fibroglandular tissues requires separation and exposure of these tissues with compression. Motion blurring resulting from inadequate compression is more commonly seen on the MLO views. Motion may be manifested by blurring of the thin linear structures in the inferior aspect of the breast or blurring of calcifications. Motion blurring may be seen throughout the entire image or may be localized to only a portion of the breast.

After the breast is properly positioned for an MLO, compression is used to maintain the breast upright on the image receptor. If compression is inadequate, the breast may be sagging, the so-called “camel’s nose” appearance (Figures 20A and 27A and B).

The most common cause of undercompression is the use of inadequate compressive force by the technologist. Although this may reflect patient discomfort, technologists can usually limit the degree of discomfort by applying compression slowly. Variations in the degree of compression between the right and left sides for the same projection suggest a lack of attention on the part of the technologist.

Poor compression on the MLO may result when the focus of compression is on adjacent body parts rather than the breast. This may be seen on the image if a large quantity of axillary or abdominal tissue is included when compression of the breast itself is poor. If the arm is visualized with corresponding undercompression of the breast, inclusion of the arm is almost certainly the cause of poor results. An unsuitable or faulty compression device will not compress the breast uniformly. Consistently lower exposure levels near the chest wall are suggestive of this defect.
Figures 27A & B.  (A) Better compression can be identified by better spreading out of the breast markings.  (B) Fewer horizontal breast markings are one indication that the breast is sagging.  Also note that the IMF is absent.
II. Clinical Image Evaluation

5. EXPOSURE

Exposure should be evaluated with good viewing conditions. Appropriate viewing conditions include adequate viewbox luminance, low ambient room light to minimize light reflected off the surface of the film, and masking of films to eliminate viewbox light that has not passed through the exposed area of the film from reaching the eye (see Measurement of Viewbox Luminance and Room Illuminance in the Medical Physicist’s Section of this manual). When images are adequately exposed it will be difficult to see the skin and subcutaneous tissues until the images are masked so that extraneous viewbox light is blocked out.

NOTE: Exposure should be monitored in each clinical image by both the radiologic technologist and the radiologist. To accomplish this effectively, the technologist’s viewing conditions must match the radiologist’s viewing conditions.

Underexposure is the most common problem in mammography. It is often manifested by underexposure of dense fibroglandular tissue making it impossible to perceive details within the fibroglandular tissue (Figures 28, 29, 30). Underexposure results in decreased radiographic contrast wherever optical densities are low (below 1.0), limiting visualization of certain fine detail, especially microcalcifications, and low-contrast lesions. Underexposure that is present only in the densest portions of the breast will limit the detection of microcalcifications and lesions within those dense, glandular tissues. Areas of the film with optical densities below 1.0 are underexposed. Fibroglandular areas should show variable optical density within the “gray” range of the film. A uniformly washed-out appearance in fibroglandular areas signifies underexposure. The pectoralis muscle is one of the densest structures on the MLO and may have optical densities below 1.0 on a well-exposed mammogram. It is important, however, that the muscle be exposed sufficiently to show underlying breast tissues (Figure 31).
Figures 28A & B. (A) Inadequate exposure of dense tissue occurred because the AEC detector was placed under the posterior fatty tissue rather than under the anterior denser tissue in this breast. (B) Placement of the detector under the dense tissue resulted in better penetration.
Figures 29A & B. Better exposure is evident from better penetration of the denser fibroglandular tissue in (A) than in (B). The improved compression in (A) also contributes to the better exposure. This case represents an example of exposure differences that are less striking than those in Figure 28.
Figures 30A & B. Better exposure of the dense fibroglandular tissue provides better contrast in (A) compared with (B). This will require high-intensity viewboxes or even bright lighting to visualize the fatty tissue. An image such as (A) should not be considered overexposed.
II. Clinical Image Evaluation

Figure 31. Underexposure of the pectoralis muscle may prevent visualization of underlying structures in the breast. Also note the lint artifact.
Causes of underexposure include processing deficiencies, inadequate compression, poor automatic exposure control (AEC) function, or improper AEC setting. When AEC (phototiming) is used, undercompression may result in underexposure if the phototimer does not compensate adequately for the different breast thicknesses. Poor phototimer compensation or phototimer variability may also account for different exposure levels on the CC and MLO views. Not infrequently, the optical density levels on mammograms reflect the preference of the radiologists who interpret the examinations. Underexposure in order to visualize the skin line without a bright light is an error. Underexposure is probably the leading cause of false-negative mammograms in dense breasts (Figures 32A and B).

*Figures 32A & B. Better exposed image (A) shows a 2-cm, poorly defined carcinoma in the mid breast (arrow) that cannot be identified in (B) due to underexposure of glandular tissues.*
II. Clinical Image Evaluation

Overexposure is recognized by too much blackening of portions of the breast that are thin or composed of fat. Overexposure is sometimes a “recoverable” error that can be overcome by using high illumination and masking (i.e., “hotlighting”). Underexposure, on the other hand, is an unrecoverable error, in that lost contrast cannot be restored in the light areas of the film, and the film has to be repeated with greater film exposure. Extreme cases of overexposure will result in decreased radiologic contrast.
6. CONTRAST

Radiographic contrast can be defined as the differences in optical density between adjacent areas of the film. Contrast allows us to see subtle attenuation differences in the breast (Figures 33 and 34). Contrast is usually highest in thinner breasts and lowest in thicker breasts due to more scattered radiation and greater tissue absorption of low kVp radiation in thicker breasts.

Figures 33A & B. Two CC views of the same breast taken 1 year apart (A and B). Improved contrast can be attributed to better compression, proper exposure, and higher contrast film (B).
II. Clinical Image Evaluation

If a mammographic examination does not have sufficient contrast, the breast tissues will have a rather uniform appearance, regardless of the complexity of the underlying anatomy. In such cases, parenchymal tissues of different thicknesses may have very similar optical densities. Ready visualization of the skin line can be a sign of poor image contrast.

Causes of poor contrast include inadequate exposure, processing deficiencies, inadequate compression, use of low-contrast film, inappropriate target material and/or filtration, failure to use a grid, and excessive kVp. Although excessive kVp will reduce contrast, many current mammography films have significantly higher inherent contrast allowing the use of higher kVps without sacrificing image contrast.

Figures 34A & B. Better compression, proper exposure, and higher contrast film provided some improvement in contrast on comparison of MLO views of the same breast taken 1 year apart (A and B). The latter image (B) also shows a greater inclusion of the pectoralis muscle, presence of the IMF, inclusion of more posterior-inferior breast tissue, and improved sharpness.
II. Clinical Image Evaluation

Images that are either underexposed or overexposed will have suboptimal contrast. To ensure adequate contrast, fatty tissues should have at least an optical density of 1.2; however, optical densities of 1.5 to 2.0 are preferable. Glandular tissues should have an optical density of at least 1.0. Generalized underexposure is a common cause of decreased image contrast. When generalized underexposure is present, it is difficult to assess other potentially coexistent contrast-related defects.

Proper processing is essential for proper image contrast. Selection of an appropriate combination of film, processing chemicals, processing cycle and temperature, and processing quality control are discussed in the Radiologic Technologist’s Section of this manual.

Inadequate compression can result in beam hardening and in increased scatter, both of which cause decreased contrast. To ensure that the breast is compressed sufficiently, compression should be applied until the skin is taut. Some breasts, however, are relatively incompressible despite their mammographic appearance.

Use of a mammographic grid improves contrast by decreasing the amount of scattered radiation that reaches the image receptor. Moving grids are preferable to fixed grids since the latter will produce grid lines on the image.

Although an increase in kVp may reduce contrast, this effect is relatively minor when optical density is constant. On the other hand, kVp has a major effect on exposure time and dose. For example, when kVp is increased from 26 to 28, exposure time decreases 50% and dose decreases 15%–20%. Therefore, in some instances, an increase to 28 or 30 kVp may be necessary to achieve adequate exposure with a sufficiently short exposure time. An increase in kVp might obviate long exposures that would either be beyond the capabilities of the mammographic unit or that would lead to motion unsharpness.

Excessive contrast is less frequently encountered than insufficient contrast. If fatty tissues require bright light viewing, and fibroglandular tissues are near the base plus fog density level, the contrast of the image is too high. Prominent radiopacity of the pectoralis muscle, limiting visualization of overlying structures, on a film that is otherwise well exposed, may also indicate that contrast is too great. Although high contrast is desirable, excessive contrast may preclude visualization of both thin and thick tissues in the same image. Thus, a balance has to be found between contrast and latitude when selecting film for mammography.
II. Clinical Image Evaluation

7. SHARPNESS

Sharpness is the ability of the mammographic system to capture fine detail in an image, such as the edges of spiculations. Unsharpness is often referred to as “blur.” In the image, unsharpness is manifested by blurring of the edges of fine linear structures, tissue borders and calcifications (Figure 35). Types of blur that may be encountered in mammograms include motion blur, poor screen-film contact, screen unsharpness, geometric unsharpness, and parallax unsharpness.

Patient motion is the most commonly encountered cause of readily detectable image unsharpness. Blurring from motion unsharpness usually has a unidirectional character that is readily recognized and distinguished from generalized unsharpness that may be due to recording system or geometric effects. Breast compression may prevent motion unsharpness by reducing breast thickness to allow shorter exposure times and by immobilizing the breast. Motion unsharpness is more likely to be seen when the exposure times exceed 2 seconds. Therefore, the mammography generator should have sufficient output to adequately expose large breasts and dense breasts in reasonably short exposure times. Unsharpness on only one portion of an image is often due to motion and suggests

Figures 35A & B. Magnification. Motion unsharpness of vascular calcifications, mass margins, and linear structures (A) compared with (B) is due to the longer exposure time: 4.0 seconds versus 1.5 seconds. Underexposure (A) was due to inability of the mammographic unit to compensate adequately for lower kVp by sufficiently increasing mAs. Despite a lower kVp, (A) has less contrast than (B) due to underexposure.
non-uniform breast compression. As mentioned under the section on breast compression, motion unsharpness is more likely to occur on the MLO than on the CC view.

Localized unsharpness of an image also may be seen with poor screen-film contact, which is due to the further spread of light from the screen before reaching the film. This form of unsharpness can usually be differentiated from motion unsharpness by the more localized, symmetrical nature of the blurring and the more geometric margination of the unsharp area.

Causes of poor screen-film contact (Figure 36) include poorly designed or damaged cassettes, improper placement of the film in the cassette, and dirt lying between the film and the screen. Air trapped between the film and the screen during loading can also cause poor screen-film contact.

Figure 36. Regional area of blurring due to poor screen-film contact.
Cassettes are designed so that trapped air will be evacuated after cassette closure, but complete removal of the air may take several minutes. Therefore, it is suggested that the radiologic technologist wait at least 15 minutes after loading before exposing many types of cassettes (consult cassette manufacturer for specific wait times).

Mild, generalized, unsharpness in mammographic images may be difficult to detect and assess. Such unsharpness is most likely due to characteristics of the screen-film combination used or to geometric factors. Faster screens usually have thicker phosphor layers and therefore exhibit greater light spread, and so greater unsharpness. Screen unsharpness should affect all structures in the image uniformly. Screen unsharpness results from a single X-ray absorbed in the screen being converted to a large number of visible light photons. These produced photons spread as they travel from the point of X-ray interaction in the screen to the area where they are absorbed by the film. Steps taken to produce faster screens, such as making the screen thicker or placing a reflective coating behind the screen, result in greater photon spread and, as a result, a greater degree of screen unsharpness.

An increase in focal spot size, an increase in object-to-image receptor distance, or a decrease in source-to-image receptor distance increases geometric unsharpness. Over the last decade, the focal spot sizes of dedicated mammography units have been decreased to reduce geometric blurring in both contact and magnification mammography.

Parallax unsharpness refers to the blurring due to the use of double-emulsion films. The image captured on each side of a double-emulsion film is separated by the width of the film base. If the image is viewed from a distance different than the focal spot-to-film distance, the slight offset of the two emulsions results in image blur. Because of this effect, double-emulsion films have not been widely accepted in mammography, despite the benefits of lower radiation dose, shorter exposure times and longer tube life.
8. NOISE

Noise, or radiographic mottle, (Figure 37) decreases the ability of the interpreting physician to discern tiny structures, such as calcifications. The major cause of noise on most mammograms is quantum mottle. Quantum mottle is due to the statistical fluctuation in the number of X-ray photons absorbed at individual locations in the intensifying screen. The fewer X-ray photons that are used to make the image, the greater the amount of quantum mottle that results. Thus underexposure, extended processing and faster image receptors are associated with increased noise. Faster screen-film systems decrease breast dose but yield noisier images, which can reduce the detection of low-contrast structures within the breast. Ironically, quantum mottle is more likely to be seen on high-contrast films, since high-contrast makes the mottle more visible.

In mammography, unlike most other radiographic studies, fluctuations related to film grain also represent a sizable component of the total radiographic noise, often being comparable to quantum mottle in magnitude. Processing can also introduce noise, both random and structured (e.g., roller marks, wet pressure marks) into the image.

Figure 37. Noise can be identified by an inhomogeneity in the background density. There is a resultant unsharpness and loss of visualization of low-contrast breast structures.
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9. ARTIFACTS

An artifact is any density variation on an image that does not reflect true attenuation differences in the subject. Artifacts can be a sign of problems in darkroom cleanliness, film handling, screen maintenance, processing, or X-ray equipment. The presence of multiple artifacts on images is a sign of deficient quality control. Examples of artifacts are dust or lint (Figure 31), dirt, scratches, fingerprints (Figure 38), and fog. Many of these artifacts are avoided by careful attention to darkroom conditions, including general cleanliness, film handling, regular cleaning of the cassettes and screens, light leaks and safelights.

![Figure 38. Fingerprints result from manual handling of the film or fluorescent screen surface prior to exposure.](image-url)
Grid lines and grid non-uniformities are some of the most common equipment artifacts (Figure 39). When using a moving grid, grid lines should not be visible on images. If grid lines are observed regularly, the drive mechanism should be repaired or replaced. Two images of a uniform phantom acquired identically and processed at right angles to each other may be required to determine if artifacts are due to a faulty grid or processor. (See Artifact Evaluation in the Medical Physicist's Section of this manual). Processor artifacts (Figure 40) can usually be distinguished from grid lines. Improper size or alignment of the compression device can also lead to artifacts on the image.

Figure 39. Grid lines are thin, multiple, and run perpendicular to the long axis of the film.
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Figure 40. Roller marks from processor. These tend to be broader, fewer in number, and spaced further apart than grid lines.
10. COLLIMATION

The X-ray beam should be collimated as close as possible to the edges of the film, not to the breast. Collimating close to the surface of the breast may result in cut-off of part of the image of the breast. The use of round collimators prevents satisfactory masking of images at the viewbox.

Breast tissue may be excluded from the image if the collimation does not permit the X-ray field to extend slightly beyond the edge of the film on the chest wall side. Breast tissue also may be excluded from the image due to improper placement of the film in the cassette, poor fit of the cassette within the cassette holder or bucky, and misalignment of the compression device so that the posterior lip of the compression paddle is superimposed on posterior breast tissue.

MQSA REQUIREMENTS:
All systems shall have beam-limiting devices that allow the entire chest wall edge of the X-ray field to extend to the chest wall edge of the image receptor and provide means to assure that the X-ray field does not extend beyond any edge on the image receptor by more than 2% of the SID.

If a light field that passes through the X-ray beam limitation device is provided, it shall be aligned with the X-ray field so that the total of any misalignment of the edges of the light field and the X-ray field either the length or the width of the visually defined field at the plane of the breast support surface shall not exceed 2% of the SID.

The chest wall edge of the compression paddle shall not extend beyond the chest wall edge of the image receptor by more than 1% of the SID when tested with the compression paddle placed above the breast support surface at a distance equivalent to standard breast thickness. The shadow of the vertical edge of the compression paddle shall not be visible on the image.
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11. LABELING

Standardized labeling can facilitate the interpretation of images from other facilities and reduce the likelihood of films being lost or misinterpreted. Guidelines for labeling mammography films are divided into three categories: required, highly recommended, and recommended. These are described in Section I of the Clinical Image Quality Section of the manual. The required items include a label identifying patient and facility, a view and laterality marker (e.g., MLO, CC), the cassette number (usually an Arabic numeral), the initials of the radiologic technologist who performed the examination, and an identifier for the mammography unit used when there is more than one dedicated unit (usually a Roman numeral). The identification label should contain the following: facility name and address (at a minimum city, state, and ZIP code), examinee’s first and last name, and a unique ID number (e.g., medical record number, social security number, or less preferable, date of birth). It is strongly recommended that the identification label be “flashed” on the image to make it as permanent as possible and so that it will be transferred onto copy films. The view and laterality marker should always be placed near the axilla to facilitate orientation of the image.

Additional recommended film labeling includes a date sticker and a record of the technique factors used to make the image. Date stickers, which are used by over 40% of mammography facilities, allow for more efficient sorting of examinations by date because they can be read with overhead light and they are color coded by year. A record of the technical factors used for each image helps the technologist perform quality control checks on image quality and is useful when subsequent mammograms are performed on the same patient.
12. **CONCLUSION**

Peer review of clinical images performed on each mammography unit is required for a facility applying for mammography accreditation. Clinical image evaluation is also an important daily quality control activity that should be performed by every radiologist who interprets mammograms. It involves the scrutiny of mammograms for technical deficiencies, including an assessment of breast positioning and compression, image quality, and artifacts.

The radiologist’s evaluation of clinical images on a daily, ongoing basis is complementary to other quality control activities in the facility. Feedback to the radiologic technologist concerning deficiencies in images is an effective method for maintaining high-quality mammography. Part of the clinical image evaluation process involves recognizing the most likely causes of image deficiencies so that they can be addressed quickly and efficiently.
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REFERENCES


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