Basics of Mammography

Breast compression and positioning are major considerations for obtaining higher-quality mammograms. Properly applied compression is one of the most neglected and most important factors affecting image quality in mammography. A primary goal of compression is to uniformly reduce thickness of the breast so it is more readily and evenly penetrated by the x-ray beam from the subcutaneous region to the chest wall. Without the compression of the tissues, the image is less clear and does not provide the same level of information. Advantages of adequate breast compression are to reduce geometric unsharpness by bringing the object closer to the detector, improve contrast by reducing scatter and enabling use of a lower kVp beam, diminish motion artifact by permitting shorter exposure times and immobilizing the breast, and reduce radiation dose by decreasing the thickness of breast tissue that needs to be penetrated. To achieve more uniform density, a homogeneous breast thickness prevents overpenetration of the thinner anterior breast tissues and underpenetration of the thicker posterior breast tissues. Adequate compression provides a more accurate assessment of the density of masses as normal glandular tissues are more easily compressed and denser masses are highlighted.

To separate superimposed breast tissues so that lesions are better seen, correct positioning is an important factor in evaluating clinical images. During a routine mammogram, each of the breasts is imaged separately with 2 different views of each breast. Each view shows somewhat different details and territory. The basic views are the craniocaudal (CC) view—from above a horizontally compressed breast (Fig. 1A) and the mediolateral (ML)-oblique—from the side and at an angle of a diagonally compressed breast (Fig. 1B). Other views may be taken for diagnostic purposes including lateromedial—from the outside toward the center; ML—from the center toward the outside; spot compression—compression on only a small area to get more detail (Fig. 1C); cleavage view—both breasts compressed, to see tissue nearest center of chest; and magnification—to see borders of structures and calcifications (Fig. 2).

The Different Types of Breast Tissue

The radiographic appearance of the breast on mammography varies among women and reflects variations in breast tissue composition and the different x-ray attenuation characteristics of these tissues. Fat is radiologically lucent and appears dark on a mammogram. Connective and epithelial tissues are radiologically dense and appear
light. These variations in appearance are commonly described as the percentage of the breast image that is radiologically dense or as percent mammographic density. The percent mammographic density is a strong and consistent risk factor for breast cancer. Women with dense tissue occupying more than 60%-75% of the breast are at 3-6 times greater risk of breast cancer than women with little or no dense tissue. Breast density is inversely associated with age, parity, and weight and is reduced by menopause and by tamoxifen.

To date, 5 principal methods have been used to assess mammographic density. Wolfe described 4 categories of breast density: N1 (predominately fat), P1 and P2 (ductal prominence in “less than one-fourth or more than one-fourth,” respectively, of the breast), and DY (extensive “dysplasia”). The American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) also has categories of mammographic breast density from 1-4. Other methods include visual estimation of the proportion of the breast occupied by radiologically dense breast tissue, planimetry, and computer-assisted methods of measurement that are based on interactive thresholding.

The Wolfe categories have largely been replaced in the literature by quantitative methods of classification or by the BI-RADS score. The classification method of BI-RADS has 4 categories of mammographic breast density.

ACR 1: breast tissue that is almost entirely fat (<25% glandular),
ACR 2: breast tissue that has scattered fibroglandular density (25%-50% glandular),
ACR 3: breast tissue that has heterogeneous density (51%-75% glandular),
ACR 4: breast tissue that is extremely dense (>75% glandular).

It is very easy to locate the lesion for breast composition type 1 (Fig. 3A and B). It is much more difficult to analyze

Figure 1 A 46-year-old woman with invasive ductal carcinoma in the upper outer quadrant of the right breast. The mass is not well shown in CC view (A) and MLO view (B) because of surrounding dense parenchyma. The mass with calcification is clearly shown in the spot compression (C), and we get more detail of the mass. MLO, mediolateral-oblique.

Figure 2 A 36-year-old woman with the artifact due to residue of plaster. Residue of plaster can be seen in the inner quadrant of the right breast (A). It is similar to microcalcification. After cleaning with water, the residue of plaster disappears (B).
Benign and Malignant Findings of Breast Lesions on Mammography

The characteristics and definitions of benign and malignant lesions on mammography are recommended by the established BI-RADS. Mass is the most common finding for benign and malignant lesions. A true mass is a space-occupying lesion persisting in 2 different projections after appropriate evaluation is completed. To successfully recommend appropriate management, several features of the mass should be evaluated. A description of the shape, margin, and density allows an organized analysis and recommendation.

The shape of a mass may be categorized as round, oval, lobulated, or irregular. The typically malignant mass has a stellate or starburst appearance with an irregular contour. The typical benign mass has a very different mammographic appearance, showing smooth contours and a round or ovoid shape. The presence of lobulation within a mass often complicates interpretation. Multinodular masses frequently prove to be malignant. These lesions should always be biopsied. On the contrary, most nodular masses represent fibroadenomas that have only 1 or 2 gentle lobulations, often not raising sufficient radiographic suspicion of malignancy to trigger biopsy.

The margin of a mass can be characterized as circumscribed, obscured, microlobulated, indistinct, and spiculated. Most benign lesions are characterized as circumscribed or well-defined lesions (Fig. 5). Margins of these lesions are sharply demarcated with an abrupt transition between the lesion and the surrounding tissue, which reflects the absence of infiltration. The edges of most breast cancers are poorly defined. A mass with fine lines radiating from its margins is said to be spiculated and is the most suspicious margin feature for malignancy (Fig. 6). For some lesions, some of the margins are seen to be very defined whereas others are obscured by the adjacent isodense tissue. This usually confounds mammographic interpretation, resulting in an equivocal or indeterminate diagnosis. A supplementary spot compression mammogram may prove helpful in this circumstance. Imaging with ultrasound or magnetic resonance imaging can provide additional characterization of such a mass.

Breast masses may be classified by density as either high density, isodensity, low density (excluding fat density), or fatty density. The x-ray attenuation of mass is related to the attenuation of an equal volume of fibroglandular breast tissue. Breast cancers are most often of equal or higher density than glandular elements. Fatty density masses include all lesions containing fat, such as lipid cysts, lipomas, and galactoceles as well as mixed lesions such as fibroadenomas.

Figure 3 A 61-year-old woman with invasive ductal carcinoma in the posterior outer quadrant of the left breast. Mass is clearly shown on the type 1 mammogram CC view (A) and MLO view (B). MLO, mediolateral-oblique.

Figure 4 A 49-year-old woman with invasive ductal carcinoma in the inner quadrant of the right breast. Mass is not very clear on the type 4 mammogram CC view (A) and MLO view (B). But the mass is displayed in the spot compression (C). MLO, mediolateral-oblique.
as hamartomas. Because there are no reported examples of fat-containing breast malignancies, the importance of this finding is obvious.

Calcifications are another important finding. In BI-RADS, calcifications are divided into 3 categories: typically benign, intermediate concern for malignancy, and high probability of malignancy. When reporting on calcifications, it is important to describe the morphology of each element of calcification as well as its distribution within the breast.

There are 10 types of benign calcifications. Dermal calcifications are typically lucent-centered deposits around the areola, axilla, cleavage line, and inframammary portions of the breast. They tend to be either clustered or diffuse with a regional distribution. Vascular calcifications occur as parallel tracks or linear tubular calcifications that are clearly associated with blood vessels. Coarse or popcorn calcifications are frequently larger than 2-3 mm in diameter, and these have the typical appearance of calcified fibroadenomas (Fig. 7). Large rodlike calcifications are benign. These calcifications form continuous rods that are occasionally branching and usually 1 mm or more in diameter. This is the type of calcification found in secretory disease and duct ectasia. Round calcifications may vary in size and are usually considered benign. When less than 1 mm, they are frequently formed in the acini of lobules. When less than 0.5 mm, they are considered punctate and warrant close follow-up or biopsy. Spherical or lucent-centered calcification deposits may range in size from less than 1 mm to more than 1 cm or more. They are smooth and round or oval with a lucent center. When the wall of these lucent-centered calcifications is thin, usually considerably less than 1 mm, the term rim or eggshell calcification may be used. They usually represent calcification of the wall of a cyst, lipid cyst, or fat necrosis. The varying appearance of calcifications on different mammographic projections is typical for milk of calcium. On the CC image, they are often less evident and appear as fuzzy deposits, yet on the horizontal beam lateral, they are sharply defined with a semilunar, crescent, or linear configuration. Milk of calcium occurs in cystic hyperplasia, which can be included in the broad classification of fibrocystic changes. Suture calcifications are typically linear or tubular in appearance, and knots are frequently visible. Dystrophic calcifications are usually macrocalcifications and coarse and irregular, often with lucent centers.

Calcifications of intermediate concern include amorphous and coarse heterogeneous calcifications. Approximately 20% of these calcifications turn out to be malignant.
Malignant calcifications may appear alone or be associated with a mass. Approximately 50% of invasive breast cancers contain malignant calcifications. The calcifications typically are small, heterogeneous, and pleomorphic. They have jagged and irregular borders and tend to be linear branching or segmentally distributed or in clusters (Fig. 8).

Architectural distortion is not an uncommon finding for breast lesions. It includes spiculation radiating from a point with no definite mass visible. This appearance can also include focal retraction or distortion of the edge of the breast parenchyma. If architectural distortion stands alone, it may indicate a benign lesion such as a postoperative scar. If architectural distortion is associated with a mass, asymmetric density, and calcifications, the possibility of malignancy is very high.

Figure 8 A 59-year-old woman with invasive ductal carcinoma with ductal carcinoma in situ of the right breast. Small, heterogeneous, and pleomorphic calcifications are shown. They are segmentally distributed.

Preoperative Localization for the Nonpalpable Breast Lesion

The large number of nonpalpable lesions detected mammographically has led to the increased use of preoperative localization techniques. This technique entails precise radiologic localization preoperatively to aid the surgeon in finding the lesion being biopsied and permitting its removal with the smallest amount of breast tissue possible so that the breast is not deformed by the biopsy. Before the lesion is localized, its location in both the CC view and ML views must be determined. If the lesion is shown in only a single view, localization may be very difficult. Various techniques for localization have been described by ultrasound, stereotactic, or x-ray guidance. At present, the use of combination needle and hooked wire technique, under x-ray guidance, is very common. Following insertion of the needle, correct placement is verified by mammography.

The localization procedure is usually performed with the patient sitting or standing and without premedication. A fenestrated compression grid can be used to help localize the lesion in a view (ML or lateromedial view is often used) before needle insertion. The skin is cleansed with Betadine solution or ChloraPrep. A 5 mL volume of 1% lidocaine local anesthetic is given at the site of needle insertion and in the tissues along the plane of the needle. The needle is inserted to enter the skin parallel to the chest wall. With the needle in place, a repeat mammogram is obtained to check position. The needle is adjusted and rechecked mammographically in another view (usually CC view). If a needle containing a hook wire is properly positioned, the needle is then removed while the wire is held in place. The wire hooks onto breast tissue, anchoring itself. A length of wire extends out beyond the skin. The mammogram is again repeated. This film is sent along with the patient to the surgeon.

An alternative method of needle localization uses methylene blue dye. The lesion or calcifications are

Figure 9 A 56-year-old woman with invasive ductal carcinoma in the inner upper quadrant of the left breast. A fenestrated compression grid is used to localize the lesion in the ML view and the needle is inserted to enter the skin parallel to the chest wall (A). With the needle in place, a repeat mammogram is obtained to check position (B). The needle is removed, the wire hooks onto breast tissue (C). After resecting the lesion, the specimen is checked (D). (Color version of figure is available online.)
localized using either a CC or a lateral approach. After cleansing the skin and administering local anesthetic, a 22-gauge spinal needle is advanced to the lesion or calcifications. Once adequate placement has been confirmed in 2 projections, approximately 0.3 mL of methylene blue dye is injected through the spinal needle into the breast. The needle is slowly withdrawn and the exit site on the skin is stained with a drop of methylene blue. The skin exit site is also marked with an indelible ink magic marker. The procedure can be performed the day of or day before surgery.

Other methods of breast localization described in the literature include preoperative radioactive seed implantation localization and intraoperative creation of an ice ball using a cryoprobe at the site of the lesion or calcifications. These techniques are not widely accepted as means of localization at the time of this publication but may be useful in a certain subset of patients in the future.

After tissue has been excised, the adequacy of excision for all lesions is checked with specimen radiography before the biopsy procedure is terminated. This step is essential. Its purpose is to understand if the targeted lesion was resected completely (Fig. 9A-D).

References