Breast Imaging has undergone many changes since the early years of mammography. Screening mammography is credited with contributing to the substantial decrease in breast cancer mortality through early detection. Screening mammography programs allow depiction of nonpalpable, suspicious findings requiring histologic evaluation, but most of which eventually are proved benign. Wide-spread acceptance of percutaneous breast biopsy techniques represents the most important practice-changing development in breast imaging. The radiologist now plays a vital role not only in the detection and evaluation of breast disease, but also in the diagnosis and management of breast cancer. Descriptions of the advantages of percutaneous breast biopsy and the techniques of performing breast intervention are the focus of this review.

The development and widespread use of percutaneous image-guided breast biopsies has expanded the role of breast imaging and changed the management of breast disease. Validation of the safety, accuracy, and cost-effectiveness of these biopsies has led to their replacement of the surgical biopsy for most breast lesions requiring a tissue diagnosis (1–17). The advantages of the minimally invasive core-needle biopsy (CNB) over surgical biopsy include less scarring, fewer complications, lower cost, and faster recovery. The success of a breast CNB program depends on both the performance of the procedure and the appropriate postbiopsy management. In this article, we outline a general approach to the image-guided percutaneous breast biopsy and discuss specifics of the various acquisition devices and imaging modalities used for guidance.

Validation of Percutaneous Image-guided Biopsy

Approximately 70%–90% of the 1.6 million breast biopsies performed annually in the United States are image-guided percutaneous procedures (18,19). Majority (approximately 80%) of the results will be benign (4). Confidence in benign, concordant image-guided CNB findings allows avoidance of unnecessary surgery. In 1994, using long-throw spring-loaded 14-gauge needles, Parker and colleagues showed an overall 1.5% false-negative rate for percutaneous breast biopsy (4). Other authors have confirmed the accuracy of CNB, demonstrating excellent histologic agreement between CNB and excised specimens (5,13,20). In fact, several studies have demonstrated a lower “miss” rate for CNB (1.6%), compared with surgery (2.5%) with larger gauge needles and vacuum assistance (15,16). Nonetheless, sampling error can lead to histologic underestimates. Careful review of the pathology results, with recommendation for excision of lesions known to be subject to upgrade (eg, atypical ductal hyperplasia), is necessary. Discordance between imaging and pathology results also requires excisional biopsy (21–24).

The safety of image-guided breast biopsy has been well demonstrated. Some centers prefer to stop administering blood-thinning agents prior to biopsy. Patients are instructed to discontinue aspirin and nonsteroidal anti-inflammatory agents 1 week prior to biopsy. Coumadin is discontinued 3 days prior to biopsy, and an international normalized ratio level of less than 1.4 is confirmed the day of the biopsy. However, other centers proceed with biopsy without altering the patient’s anticoagulation regimen, as there is some evidence to suggest this is a safe practice (25). Parker and colleagues (4) showed a 0.2% incidence (six of 3765 cases) of clinically important complications with use of large-core (14-gauge) needles. Similar results have been found with vacuum-assisted biopsy devices and larger (7–11-gauge) needles (13).

The cost-effectiveness of percutaneous breast biopsy is due, in large part, to the ability to avoid surgery if benign, concordant results are obtained (8–10,13,15). However, cost savings are also realized when CNB findings show malignant results. A patient whose cancer is diagnosed with percutaneous biopsy can expect to undergo fewer surgeries than a patient whose cancer is diagnosed with open surgical biopsy (1.25 vs 2.01) (17). Preoperative verification of malignancy allows definitive surgical therapy in one setting.

Current Procedures

The decision to perform an image-guided biopsy includes selection of the imaging modality to guide the biopsy and the type of biopsy device to be used. Stereotaxis, ultrasonography (US), and magnetic resonance (MR) imaging are most frequently used for biopsy guidance. Newer aging modalities that use nuclear metabolic agents such as fluorodeoxyglucose and somatostin have necessitated the development of biopsy methods for these modalities, though they are infrequently used at this time (26,27). In general, the modality used for imaging guidance should be the one that best demonstrates the lesion. On the other hand, because of the numerous advantages of US guidance, attempts are made to identify US correlates to most lesions warranting biopsy (28,29). Particularly in the case of lesions identified at MR imaging and metabolic imaging, identification of a US correlate greatly simplifies the biopsy procedure. Ensuring that targets are concordant between the imaging techniques requires expertise and experience in imaging to translate expected lesion appearances and positions from one modality to another.

Most image-guided biopsies are performed with either a spring-loaded or vacuum-assisted device (VAD). Fine-needle aspiration is seldom used for evaluation of breast lesions. Acquisition of cytologic material with a fine-needle aspiration technique rather than acquisition of histologic material with a large-
core needle is associated with a high rate of insufficient samples, higher false-negative rates, inability to differentiate between invasive and noninvasive cancers, and lack of sufficient tissue to define tumor biomarker status (30,31).

**Preprocedural Considerations**

Written informed consent is required before all breast interventions. The risks explained to the patient include bleeding and infection. Anticoagulation is a relative contraindication to all biopsies, and patients are usually asked to discontinue therapy for a short time prior to the biopsy. Local anesthetics are usually adequate for addressing the pain related to these procedures. Lidocaine 1% is frequently used. Superficial anesthetic buffered with sodium bicarbonate (bicarbonate-to-lidocaine ratio of 1:9) decreases the burning sensation related to initial skin and subcutaneous injection. Deeper anesthetic does not require buffering, but is usually administered with epinephrine (1:100 000) to prolong the anesthetic effect and to aid in hemostasis. The patient should be informed of the potential benefits of the biopsy, including avoidance of surgery with benign results or preoperative confirmation of malignancy, which allows definitive surgical treatment in one surgical setting.

An additional potential complication of US-guided biopsy is pneumothorax. However, with proper technique, this is an exceedingly rare complication (32). A few contraindications to MR-guided biopsy exist. Patients with implanted metallic or electronic devices and those with an allergy or renal risk factors related to the contrast material cannot undergo MR imaging or biopsy. Presumably, the patient has already safely undergone a diagnostic breast MR imaging, but screening for any contraindications to MR imaging should still be performed prior to the biopsy procedure. Claustrophobia is another relative contraindication that is specific to MR imaging but can be problematic. Finally, for both stereotactic and MR-guided biopsies, there is a weight restriction for the biopsy table, and the patient must be able to fit into the MR gantry.

For all three biopsy techniques, gentle handling of the biopsy specimens is necessary to avoid disruption and fragmentation of the tissue. In the case of stereotactic biopsy, specimen radiographs are usually obtained by laying the tissue on a moist paper or petri dish. The tissue samples are then placed in a 10% formalin solution with patient identification. Specimens from US- and MR-guided biopsies are immediately placed in formalin for transportation to the pathology suite.

The biopsy procedure for men is performed in the same manner as for women. Most male breast cancer manifests as a mass and is amenable to US-guided biopsy. Because of the small size of the male breast, stereotactic and MR-guided biopsies are more difficult.

**Stereotactic Biopsy**

*Indications.*—A stereotactic technique is used to guide biopsy of suspicious (Breast Imaging and Reporting Data Systems [BI-RADS] category 4) or highly suspicious (BI-RADS category 5) lesions seen only, or most conspicuously, on mammograms (33). This primarily includes suspicious microcalcifications, but it also includes masses, asymmetries, or areas of architectural distortion not identified at US. If multiple suspicious findings are present, biopsy of as many targets as are needed to outline the full extent of malignant disease and direct management should be performed.

*Equipment.*—X-ray imaging is used for localizing and targeting the lesion. Both dedicated prone tables and upright systems are available. Most centers use a dedicated table on which the patient is positioned prone, with the index breast placed dependently through an opening in the table. Imaging and biopsy equipment are located beneath the table (Fig 1). The horizontal patient position and the visual barrier to the biopsy equipment for the patient result in less motion and fewer vasovagal reactions. However, the dedicated prone tables require more space and are more costly than the upright alternative. In addition, there are weight restrictions for the dedicated tables, and prone positioning may be difficult for some patients. The upright units are added onto standard mammography equipment, which eliminates the need for a dedicated room or equipment for biopsy purposes only. Therefore, there are less costly systems. Patients may be positioned sitting upright, semireclining, or in a lateral decubitus position, often allowing better access to the most posterior breast tissue (Fig 2). However, the upright patient is at greater risk for a vasovagal reaction. Both types of systems are effective and can be successfully used for stereotactic biopsy (34,35).

Although early stereotactic biopsies were performed by using spring-loaded CNB devices, the VAD is now the standard choice. The VAD retrieves a larger volume of tissue compared with the spring-loaded device, minimizing the rate of histologic upgrades. The histologic evaluation of microcalcifications can be more problematic than that of masses. Since calcifications represent the most common target for stereotactic biopsy, the greater volume of tissue acquired with the VAD is vital in ensuring a successful stereotactic biopsy (21,24,36–40).

*Technique.*—The biopsy needle approach is made by reviewing the mammographic images and determining which projection provides the best visualization of the lesion and the shortest distance from skin to lesion. The breast is positioned in either the mediolateral or craniocaudal position and is compressed such that the target is present within the open window of the compression paddle. A scout view is obtained, providing localization of the lesion in the x- and y-axes. Stereotactic images are then obtained 15° from midline in both the positive and negative directions. The depth of the lesion, or the z-axis coordinate, is determined by calculating the parallax shift (apparent shift) of the target on the stereotactic images compared with the target location on the reference, or scout image (Fig 3). It is important to determine whether there is adequate breast tissue to position the needle at the lesion without the needle penetrating the posterior aspect of the breast and striking the image receptor. A distance of more than 4 mm from the needle tip...
Figure 1: Dedicated stereotactic breast biopsy table. The patient is positioned prone on the table, with imaging and biopsy equipment located below the table.

Figure 2: Add-on stereotactic unit. The patient undergoes biopsy in the upright or decubitus position.

Figure 3: Stereotactic biopsy images. (a) Scout image obtained with the x-ray tube perpendicular to the detector shows. The clustered microcalcifications centered in the field of view represent the biopsy target. Paired stereotactic images obtained (b) +15° and (c) −15° from perpendicular resulting in parallax shift of the calcifications. Paired stereotactic images at (d) +15° and (e) −15° in the prefire position and the needle tip at the cluster of calcifications. (f) Single postbiopsy stereotactic image with the needle partially withdrawn demonstrates removal of the targeted calcifications, postbiopsy gas, and a tissue marker.
to the distal surface of the breast is considered adequate, and this distance is called the stroke margin. Once the computer coordinates have been determined, the information is transferred from the computer to the stereotactic table, and the biopsy needle is moved into place. Accurate needle placement is confirmed by obtaining additional pre- and postfire stereotactic images. Vacuum suction pulls the targeted tissue into the open sample notch of the needle, and the inner cutting cannula shears off the tissue specimen, which is then transported retrograde through the biopsy needle to the collection chamber. The biopsy needle remains in place throughout the procedure, with rotation of the sample notch after each tissue specimen is obtained, allowing multiple contiguous samples to be obtained with a single needle insertion.

The number of samples obtained depends on the needle size, with 12 samples being the standard for 10–11-gauge needles, and four samples being the standard for 7–9-gauge needles. In general, specimens are retrieved by rotating the needle around its 360° radius. However, sampling of one region of the lesion can be achieved by directing the sample notch of the needle to a more specific targeted region. When the targeted lesion contains calcifications, a specimen radiograph is obtained to document the presence of calcifications within the tissue cores. It is important to verify that the targeted calcifications have been sampled by comparing the specimen radiograph to the initial mammographic images of the calcifications and to estimate whether the entire radiographic lesion has been removed (Fig 4). It is helpful to separate and mark the cores containing the calcifications prior to submitting the tissue for pathologic examination. In most cases, a tissue marker is placed at the completion of the biopsy to identify the biopsy site in case of removal of the imaging target and to facilitate follow-up on subsequent mammograms. If there is sampling of more than one site, markers of different shapes will facilitate identification of these areas (ie, oval, knot, or ribbon shape). Many markers currently in use consist of a titanium clip, which is MR compatible, embedded in a collagen or polyvinyl material, which is sonographically visible for several weeks. This allows subsequent MR imaging and US-guided preoperative localization in the event of a malignant diagnosis. However, there have been reports of inflammatory reactions due to collagen-embedded markers. Therefore, some centers prefer to use stainless-steel markers, which are also usually MR compatible (41).

Manual compression over the biopsy site for 5 minutes is usually adequate to achieve hemostasis. The skin incision is closed with steri-strips. A postprocedure two-view mammogram is obtained and evaluated to ensure accurate sampling of the target and marker placement (Fig 5). The first postbiopsy mammographic image is obtained in the same projection as that used for the biopsy due to the potential of delayed accordion effect (42). If marker migration has occurred, either due to the accordion effect upon release of breast compression or to hematoma formation and resultant displacement of breast tissue, this should be carefully outlined in the biopsy report.

Potential Challenges.—A number of potential problems can occur with stereotactic biopsy. These include a negative stroke margin, posterior and axillary lesions, and targeted calcifications not seen at pathologic evaluation.

A patient with thin or small breasts may not have adequate tissue depth after compression to permit the biopsy needle to be positioned for targeting without passing entirely through the breast and striking the image receptor distally. This is termed a negative stroke margin. The same problem arises in the patient with a lesion that lies close to the distal skin surface. There are a number of approaches to remedy a negative stroke margin. First, the planned approach can be changed. With the breast compressed in the orthogonal position, the location of the lesion relative to the skin surface may change sufficiently to allow safe insertion of the needle. Alternatively, injection of an additional amount of anesthetic or saline into the tissues may add sufficient depth to remedy a stroke margin that is only slightly negative. Another option is to position the needle with the sample notch slightly proximal to the targeted location. Although this places the lesion in the distal aspect of the sampling notch, rather than centered within the sampling notch, adequate tissue samples of the lesion can still be obtained. Bolstering the breast is another technique that may be helpful in thin breasts. Compression is applied from the nipple toward the chest wall with a wide tape, an ace bandage, gauze, or other material to thicken the breast and allow safe insertion of the biopsy needle. Manufacturing adaptations that may help alleviate the negative stroke margin include the use of a lateral arm to perform biopsy from an approach orthogonal to the compressed breast (Siemens, Munich, Germany) or 180° rotation of the biopsy device (Hologic, Bedford, Mass). Last, the air-gap technique may be used. This involves placing a second compression plate between the distal aspect of the breast and the image receptor, with the open biopsy window of both compression plates in line with the lesion. Once inserted, the needle tip can be identified as it tenses the skin at the distal aspect of the breast. Care is taken to not allow the needle tip to pierce the distal skin, but if the needle
Lesions close to the chest wall or high in the axillary tail of the breast may be difficult to sample using the prone stereotactic technique. By rolling the patient toward the table aperture and passing the arm and shoulder through the opening, more of the posterior and axillary tissues can be brought into the biopsy window, allowing successful targeting.

When a biopsy is performed for microcalcifications, a specimen radiograph should be obtained to confirm the calcifications within the tissue cores. It is helpful to the pathologist to separate and mark the specific tissue cores that contain calcifications. If microcalcifications cannot be found histologically, radiographs of the paraffin blocks should be obtained to direct additional sections for the pathologist, and a polarized lens may be used to identify unstained calcium oxylate crystals. One study (43) showed disappearance of calcifications when tissue specimens were preserved in formaldehyde, presumably due to dissolution of the water-soluble calcium compounds. Consequently, they recommend using nonaqueous fixative solutions when core biopsies are performed for microcalcifications.

US-guided Biopsy

Indications.—US-guided biopsy offers several advantages over stereotactic and MR imaging-guided biopsy methods. US-guided biopsy is a real-time procedure that allows visualization and verification of accurate targeting and faster procedure times. It requires no breast compression and allows more comfortable positioning for the patient compared with other methods. Finally, no ionizing radiation is used and there are no modality-based contraindications as compared with MR imaging. Generally, when a suspicious lesion is identified for biopsy, if a sonographic correlate can be identified, US-guided biopsy should be chosen (44,45). Susicious calcifications usually undergo biopsy with stereotactic guidance. However, calcifications can be identified on US scans obtained with high-frequency transducers, particularly when associated with a mass. In these cases, US-guided biopsy may be performed instead of stereotactic biopsy, and specimen radiography should be performed to document calcifications in the tissue cores. US guidance also allows safe core biopsy of suspicious axillary lymph nodes, allowing identification of metastatic nodes preoperatively, thereby eliminating the need for sentinel node biopsy and allowing the surgeon to pro-

Figure 5: Postbiopsy (a) mediolateral and (b) craniocaudal digital mammograms of the left breast show different tissue markers to differentiate between the biopsy sites. Thick arrow = clip marker, thin arrow = ribbon marker.
ceed directly to axillary dissection, when indicated (Movie [online]).

Equipment.—High-quality scanning is necessary for successful US imaging and biopsy. A linear-array, high-resolution transducer with a center frequency of at least 10 MHz is used (46). A variety of biopsy needles are available. Whereas stereotactic biopsies are performed with a VAD, automated biopsy needles can also be utilized in US-guided biopsies. These needles work by using a spring-loaded mechanism and a rapid two-step firing action. The inner needle is fired first; it contains a recessed sampling notch, which enters the targeted tissue. Second, a hollow cutting cannula fires over the notched needle, shearing off the tissue. These needles require a multipass technique in that the needle must be removed from the breast to obtain the tissue sample; then it is retargeted and refired for each subsequent tissue sample. The most commonly used automated biopsy device for the breast is a 14-gauge needle with a 22-mm throw. Hand-held versions of the VAD are also available for US-guided biopsies. The needle is positioned deep to the lesion, pulling the targeted tissue down into the sample notch with vacuum suction. As with stereotactic biopsies, VADs allow single insertion, directional sampling, and retrieval of larger tissue cores. However, while the advantages of larger samples have been confirmed when stereotactic guidance is used, it is not validated whether larger cores are as important for accurate pathology results for most lesions that are selected to undergo US-guided biopsy, that is, largely noncalcified masses (47). Nonetheless, many centers have adopted the VADs for US-guided biopsies due to their speed and ease of use. In addition, complex lesions containing both cystic and solid components are best sampled by using the VADs. Sampling of the solid component is most important for accurate pathology results. If multiple passes are made with a spring-loaded needle, and the fluid component is drained, the solid portion of the lesion may be difficult to visualize and target sonographically.

Technique.—For a solid lesion, patient positioning for the biopsy depends on the location of the lesion. For lesions located in the superior, lateral, or inferior breast, the patient is placed in the supine oblique position. For medially located lesions, the patient is usually positioned supine. The ipsilateral arm is raised over the head to decrease the tissue depth of the breast and tighten the overlying skin. The technologist and US machine are positioned on one side of the examination table, with the physician on the other side of the table. The patient is positioned on the examination table with the index breast closest to the physician. US imaging is performed to identify the target and plan the needle approach. The skin entry site is generally 1–2 cm from the edge of the transducer, but will vary depending on the depth of the lesion. The best needle visualization occurs with a needle route parallel to the transducer (Fig 6). As the anesthesia is delivered, the planned entry site, approach, angle, and trajectory of the biopsy needle can be confirmed. A scalpel is used to make a skin nick at the entry site. Although many biopsy needles are sharp enough to penetrate the skin, a dermatotomy provides a cleaner incision and allows a smoother entry into the skin. Although some operators use a coaxial system (48), our preference is not to use any type of introducer. Air introduced through the coaxial system causes artifacts, and movement of the introducer, requiring adjustment with each needle pass, counteracts any potential advantages of having to target only once.

Once the needle has been inserted, real-time scanning is used to identify the needle tip. With US visualization, the needle is then guided to the lesion. The entire length of the needle and its tip must be visualized to achieve an accurate trajectory through the lesion, as well as to avoid inadvertent passage through the chest wall, resulting in a pneumothorax. If the transducer and needle remain parallel, that is, along the same longitudinal axis, the needle will be completely visualized (Fig 7).

With a spring-loaded device, the needle is advanced to the edge of the target. The operator should ensure that there is adequate tissue beyond the lesion, along the trajectory of the needle,
to allow safe firing. A prefire image should be obtained to document positioning. The needle is then fired into the lesion, and an image is obtained demonstrating the needle traversing the lesion on this and all subsequent passes (Fig 8). Determining the adequacy of the samples is accomplished by visualizing air tracts within the lesion and by obtaining firm intact cores. Generally, three to five cores are obtained (49).

If a VAD is used, the needle is positioned along the deep margin of the lesion. The sample notch is opened, and then needle position is adjusted, if necessary, to center the lesion within the opening of the sample notch. As sampling proceeds, the lesion becomes visibly smaller as tissue is shaved from the inferior aspect of the lesion (Fig 9). Although the goal of the procedure is to obtain a sufficient amount of tissue for accurate histopathologic analysis, the ease and speed with which the samples can be obtained allow the operator to remove most of the lesion, if desired. Although not necessary for diagnosis, this often renders a palpable mass no longer palpable and can simplify imaging follow-up for benign results.

Once the operator is confident that adequate tissue has been retrieved, a tissue marker should be placed directly in the lesion. The same markers are used as with stereotactic biopsy. All are radiopaque on mammograms because of the presence of the titanium clip. The clip is MR compatible and can be identified on MR images by a small signal void. However, some clips are not well visualized on US scans. Therefore, markers composed of the titanium clip embedded in collagen or polyvircyl material are recommended. When a marker is deployed, a postprocedure mammogram is obtained in the orthogonal mediolateral and craniocaudal projections to assess marker placement. This allows confirmation that the US-identified target corresponds to the mammographic lesion. In the case of malignant results, marker placement is required for patients undergoing neoadjuvant chemotherapy. The presence of a clip ensures that a target for excision remains visible, even if the patient has a complete imaging response to therapy. In the case of a benign result, the presence of a marker can assure future imagers that the lesion has been previously subjected to biopsy. Marker migration occurs much less frequently with US-guided biopsies compared with stereotactic biopsies due to the lack of compression. However, any deviation of the marker from the targeted lesion should be carefully described in the biopsy report.

Some lesions require a special approach (50). Biopsy of deep lesions may be difficult, particularly if they lie near the chest wall. A remote skin entry site can be used to allow a parallel needle approach, but this often requires traversing a large distance of tissue and may be limited by the length of the device. Another approach is to use a standard entry site, initially directing the needle at a steep angle toward the lesion, and then, as the needle nears the target, flattening the needle so that it approaches the lesion in a horizontal position.

Targets that lie directly on the pectoralis muscle or an implant may be elevated away from these structures by instilling local anesthetic and creating a safe zone (Fig 10). This same technique can be used for very superficial lesions to create space between the skin and anterior surface of the lesion.

In some cases, very dense breast tissue can make needle placement difficult. Use of local anesthetic to "dissect" the tissues can be helpful. In extreme cases, firing and advancing a spring-loaded device in a stepwise manner toward the lesion may assist in biopsy needle placement. The needle is inserted as far as possible and then is fired to create a path for further needle insertion. This technique is repeated until the needle reaches the targeted lesion.

Simple cysts are benign lesions that do not require intervention. However,
aspiration may be performed for symptomatic relief. Since the purpose is merely to drain the fluid and not to obtain tissue for diagnosis, a standard 22-gauge hypodermic needle attached to a 6-mL syringe is used. We do not recommend the use of extension tubing. It decreases the amount of negative pressure to the needle and can make aspiration of inspissated cyst contents difficult. Even without tubing, a cyst may be encountered that cannot be completely evacuated. A larger needle may be required, or even a core biopsy needle, to ensure complete evacuation.

If the cyst is completely collapsed at aspiration and yields nonbloody fluid, the fluid is discarded, and the patient is returned to routine follow-up. If bloody fluid is obtained, or the cyst cannot be completely drained, a tissue marker is placed and the fluid is sent for cytologic analysis, or a core biopsy of the residual lesion is performed. If aspiration has been performed to verify concordance between a mammographic mass and the cyst, a postprocedure mammogram should be obtained to ensure that the mammographic mass has resolved.

MR-guided Biopsy

Indications.—Breast MR imaging is a highly sensitive technology for detection of breast cancer, commonly finding lesions occult on mammograms and US scans. Using the three-dimensional location information from MR imaging, some lesions can be identified with targeted US and can be sampled by using US guidance. However, this requires a good working knowledge of both modalities, the ability to translate the expected lesion position and appearance from one modality to another, and meticulous radiologic-pathologic correlation when the results are returned to ensure that the US finding truly represents the lesion identified at MR imaging. If the lesion is only visualized with MR imaging, then MR-guided biopsy is performed (51–57).

Equipment.—As with other types of image-guided biopsies, high-quality image acquisition is critical for successful biopsy completion. There is great variability in imaging protocols and image quality among facilities performing MR imaging. However, there are a number of parameters that are considered essential to adequate visualization of breast tissue. Magnet strength of 1.5 T or greater is recommended. Use of a dedicated breast coil is required. As with stereotactic biopsies, use of a VAD is standard practice (58). This maximizes the volume of tissue that can be quickly retrieved and decreases the chance of insufficient tissue. This is especially important with MR-guided biopsies, in which lesions tend to be smaller than those detected with other modalities. There is no confirmatory method, such as specimen radiography, to ensure sample adequacy, and real-time monitoring, as occurs with US, is not routinely performed at this time.

Technique.—A team approach is used in performing an MR-guided biopsy. Both the interventional technologist from the breast imaging department and the MR technologist are members of the MR imaging biopsy team. The breast interventional technologist is well versed in positioning patients for biopsies, the biopsy device equipment, and the anxiety issues experienced by the patients. His or her assistance in the MR suite is invaluable.

The patient is placed prone on the MR imaging table, with the index breast positioned in the biopsy grid. The location of the lesion within the breast is known from the original diagnostic MR imaging study, and this information is used to optimally position the breast within the biopsy grid. The breast is minimally compressed between the compression plate and the biopsy grid to prevent motion and to minimize breast deformity during needle placement. However, care is taken to not compress the breast enough to impede vascular perfusion of the breast and thus contrast enhancement, potentially interfering with lesion visualization.

Most biopsy systems are designed for the breast to be compressed in the medial-lateral direction, and most lesions are approached laterally. However, some guidance systems allow a mediolateral approach by working under the table from the contralateral side. On some systems, this can be cumbersome, and lesions posteriorly positioned in the medial breast may not be accessible. If the patient’s body habitus

Figure 10: Creation of a safety zone prior to US-guided biopsy of a mass abutting the pectoral muscle. (a) US image of a small mass positioned against the pectoral muscle. (b) US image of the anesthetic needle inserted posterior to the mass. The anesthetic will lift the mass away from the pectoral muscle, facilitating safe biopsy.
permits, we prefer to position the torso obliquely and place the index breast in the contralateral breast coil opening, which permits a lateral approach to a medial lesion. In addition, newer coils also allow a craniocaudal approach to the breast.

A fiducial is placed in one of the grid openings, or fiducials built into the biopsy grid are used. We usually place the fiducial in the center posterior opening of the grid (Fig 11). Precontrast images are then obtained. By using landmarks from the original MR imaging study, the expected location of the lesion can be determined and confirmed to lie within the confines of the biopsy grid. If necessary, adjustments in positioning can be made prior to contrast material injection.

We use an abbreviated, but otherwise similar, scanning protocol for the biopsy scan as is used for diagnostic MR imaging. By replicating the diagnostic imaging technique, we have better success in re-identifying the lesion. Nonetheless, in approximately 12% of cases, nonvisualization of the target occurs at the time of planned biopsy (55). Delayed images are obtained, and it is important to ensure that there is no over compression of the breast interfering with perfusion. Subtraction images may be helpful in identifying small or subtle lesions. If the lesion is still not demonstrated, it is usually attributed to normal hormonal changes in the breast, which have resolved at a different point in the menstrual cycle. However, short-term follow-up is recommended in these cases, usually at 6 months.

Once the lesion is confidently identified on the postcontrast images, it can be targeted by various methods. Most simply, a cursor is placed on the lesion on the computer monitor and the images are scrolled back to the grid image and the fiducial. The appropriate biopsy grid opening for the needle insertion is then determined by comparing the grid opening marking the lesion and the location of the fiducial. The appropriate biopsy grid opening for the needle insertion is then determined by comparing the grid opening marking the lesion and the location of the fiducial. Because of differences in the orientation of the breast displayed on the monitor and the position of the patient, it is important to determine these differences in anatomic terms (eg, caudad/cephalad, toward nipple/toward chest, rather than left/right, up/down). The specific portion of the grid opening needed for needle placement is determined by where the cursor lies within the opening (eg, in the center of the opening, in a corner, etc). Finally, the depth of the lesion is to undergo biopsy the targeting process is performed for both locations, carefully distinguishing between the lesions and performing the biopsy steps sequentially. Computer-aided detection systems are available that automatically perform these calculations and depict the appropriate grid opening and location pictorially.

Once the lesion is identified and the needle insertion site is determined, a sharp metal trocar is inserted, through a plastic introducer sheath, into the breast to the measured depth. The trocar is removed and replaced with a plastic obturator to allow scanning. The tip of the obturator corresponds to the center of the needle’s sample notch and should lie at the center of the lesion on the prebiopsy images. We generally target the lesion along the nipple aspect, allowing gravity and the vacuum device to pull the lesion down into the sample notch. Sagittal images will show the obturator in cross-section as a dot that ends at the lesion. Axial images will show the obturator along its full length and are useful in ensuring adequate breast tissue beyond the lesion and the planned needle position (Fig 12).

Once adequate positioning of the obturator is confirmed, the obturator is removed and the biopsy needle is placed through the stationary introducer sheath. Most biopsy procedures are performed with a 7–9-gauge needle and four to six tissue specimens are obtained. Then, the needle is exchanged, through the introducer, for the obturator, and postbiopsy images are obtained. Although the tissue retrieval portion of the biopsy procedure occurs quickly, the overall procedure is scheduled for 1 hour to allow screening for MR imaging safety, informed consent, insertion of the intravenous catheter, positioning, scanning, and the biopsy procedure. Removal or partial removal of the lesion helps confirm accurate targeting, although washout of contrast material may falsely appear as complete removal of the lesion. Use of landmarks within the breast and relating them to the position of the gas cavity is the most useful method of confirming accurate sampling. We always place a tissue marker after MR-guided biopsy, even if there is visible lesion remaining. Any subsequent intervention can then be performed with mammographic or US guidance, and follow-up for benign lesions will be facilitated.
Postprocedure Considerations

At the completion of each biopsy, hemostasis is achieved with manual compression, usually for 5 minutes. A postprocedure mammogram is obtained, and a sterile dressing is applied to the wound. The patient is instructed about normal postbiopsy sequelae (minor pain and bruising), given contact numbers for any concerns or problems, and is informed about how and when she or he will receive the biopsy results.

Tissue samples are placed in preservative and hand-delivered to pathology department. Accurate specimen labeling is critical, particularly if there has been biopsy from more than one site. It is important to communicate with the pathologist regarding the type of lesion (mass, distortion, calcifications) and the likelihood of malignancy. By using the American College of Radiology Breast Imaging Reporting and Data System, the level of suspicion can be indicated as 4A, low suspicion for malignancy, 4B, moderate suspicion, 4C high suspicion, and 5, extremely high suspicion for malignancy.

A written report of the procedure should be constructed that describes the type of lesion and its location, the imaging method used for guidance, the biopsy device used, the number of tissue specimens obtained, whether a tissue marker was placed, whether any complications occurred during the procedure, and the results of the postbiopsy mammogram, including the relationship of the tissue marker to the index lesion. The procedure report is amended when the pathology results are returned, with either concordance or discordance noted, and further management recommendations are outlined. If discordant results are returned, arrangements for repeat image guided biopsy or surgical biopsy should be made. If the pathology results are malignant, review of the entire case should be performed, including both the index and opposite breast, to determine if other findings now require closer scrutiny and additional intervention. For patients with malignant and high-risk results, arrangements for surgical consultation are made. Benign concordant results are generally followed with 6-month imaging. It is best for the physician who performed the biopsy to take responsibility for informing the patient of her biopsy results. Follow-up recommendations can be discussed with the patient at that time as well.

Summary

Image-guided percutaneous breast biopsy is a safe, accurate, and cost-effective method of establishing a tissue diagnosis of breast abnormalities. It has replaced surgical biopsy as the initial method of diagnosis for most breast lesions, obviating surgery when benign pathology results are demonstrated or allowing for definitive single-stage surgical treatment in most malignant cases.

Stereotactic, US, and MR guidance are all effective methods for performing image-guided biopsy. However, US-guided biopsy is the preferred method due to its speed, cost, patient comfort, and real-time capabilities. With all biopsy methods, careful attention to technique and radiologic-pathologic concordance are needed for a successful outcome.

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