Breast Intervention

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Introduction

Breast intervention has evolved over the last two decades from being confined to image guidance for surgical excision biopsy of nonpalpable abnormalities to minimally invasive per cutaneous biopsy procedures performed under mammographic, ultrasound, and MRI guidance. The rate of open surgical biopsy has seen a dramatic drop during this time period and is now used for specific indications only.

This chapter provides an overview of breast interventional procedures in four sections:

- Ultrasound-guided breast biopsy
- MRI-guided biopsy
- Presurgical needle wire localization
- Stereotactic breast biopsy

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Ultrasound-Guided Breast Interventional Procedure

Ultrasound-guided breast interventional procedures may be performed for either diagnostic or therapeutic purposes. Diagnostic indications include sampling of suspicious lesions, and therapeutic indications include cyst aspiration and abscess drainage. Ultrasound-guided core needle biopsy is the current method of choice for performing breast biopsies of most sonographically visualized lesions.

Image-guided percutaneous biopsy is safe, accurate, and minimally invasive. It causes minimal breast deformation and scarring, has few complications, and is faster and less expensive than surgical biopsy. Women diagnosed with breast cancer by core needle biopsy require significant fewer surgical procedures than those diagnosed by open surgical biopsy [1–9]. Image-guided percutaneous biopsy has become increasingly common as the number of nonpalpable breast lesions found on screening exams has increased. The majority (70–80 %) of breast lesions referred for biopsies are benign [4].

As per the American College of Radiology Practice guidelines, the indications for US-guided intervention in the breast include:

1. Simple and complicated cysts
2. Complex and solid masses
3. Repeat biopsy
4. Presurgical localization
5. Biopsy of axillary/axillary tail lymph nodes in known or suspected malignancy

US-Guided Core Needle Biopsy

Ultrasound in particular offers many advantages over other guidance techniques. These include nonionizing radiation, low cost, visualization of the needle in real time, accessibility, patient comfort, and speed. Percutaneous biopsy devices and techniques have evolved over time. What began with

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simple fine-needle aspirations progressed to large core needles, then to automated spring-loaded (ASL) core needles, and on to vacuum-assisted (VA) core needle biopsy. Ultrasound-guided core needle biopsy (CNB) is used to evaluate ultrasound-detected suspicious and highly suspicious (BI-RADS 4 and 5) lesions to establish a diagnosis and to optimize surgical planning or neoadjuvant therapy when indicated. For probably benign lesions (BI-RADS 3), ultrasound-guided CNB allows patients to avoid more costly, invasive surgical biopsy.

A rapid, accurate evaluation of suspicious and highly suspicious lesions is extremely important. Studies have shown that the period surrounding the diagnosis of breast cancer is one of the most stressful times for women [10]. Reducing the period of uncertainty between the discovery of a breast tumor and histological diagnosis significantly decreases a woman's anxiety. Since the majority of woman will have a benign diagnosis, breast teams strive to provide an answer as soon as possible. And for patients with a malignant diagnosis, the uncertainty period may be decreased to allow for focus on therapy and treatment options. Ultrasound-guided CNB has a sensitivity of 92–97.5 %, a specificity of 99–100 %, and an accuracy of 96–99 %. False-negative rates overall are 0.4 %, with a range from 0 to 9 %. The false-negative rate correlates well with the false-negative rate of surgical biopsy of non-palpable lesions, 2 % (range 0–8 %) [2, 6, 9, 11–14].

There are very few contraindications for ultrasound-guided CNB. Inability to visualize the lesion sonographically is the only absolute contraindication. Patients must be able to cooperate. Patients with severe psychiatric disorders or combative patients may not be able to safely undergo biopsy. Rarely, very superficial lesions or certain lesions in patients with implants or other implanted devices may make ultrasound-guided intervention challenging. Although anticoagulation is not an absolute contraindication to biopsy, temporarily holding or altering anticoagulation when clinically feasible is preferred. Consultation with the referring physician is advised to assess the risks/benefits of holding or altering anticoagulation.

Principles and Techniques of US CNB

Equipment Needed

A high-resolution ultrasound unit with a 12.5-MHz linear array transducer should be used to perform optimal ultrasound-guided CNB. (ACR guidelines call for a minimum of a 10-MHz transducer [15].) Multiple commercially available automated spring-loaded (ASL) core needle devices (aka biopsy guns) are available (Fig. 12.1). These devices obtain tissue by firing a stylet at high speed into the target lesion, rapidly followed by a cutting cannula (Fig. 12.2). Although many variations are available, a 14 G with a throw of 2.2 cm is the "gold standard" [16] and the most commonly used [2]. Cores obtained with a 14 gauge are sustainably larger than those obtained with a 16 gauge (Fig. 12.3). Several handheld vacuum-assisted (VA) core needle devices are also available. Like spring-loaded devices, many sizes are available, with 10–12 G commonly used. After the needle is positioned, the vacuum pulls the tissue into the biopsy aperture. An internal rotating cutter then shears off a tissue specimen. The specimen is then transported to the specimen port for collection. Currently at our institution we employ either a 14-gauge Max-Core® device (Bard, Tempe, AZ) or a 12-gauge ATEC® device (Hologic, Indianapolis, IN).

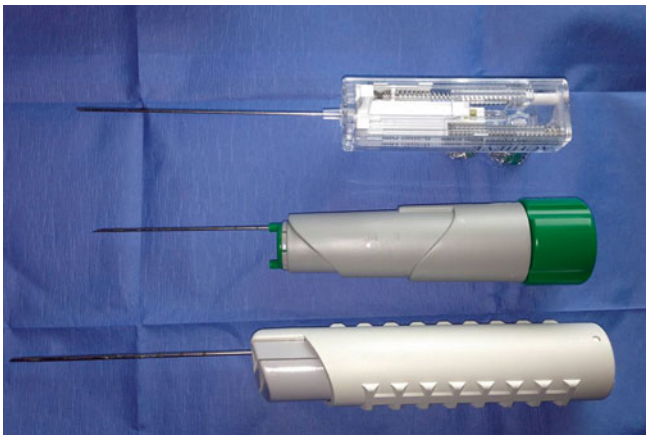

Fig. 12.1 Multiple automated spring-loaded biopsy guns are commercially available. Gauges range from 12 to 18

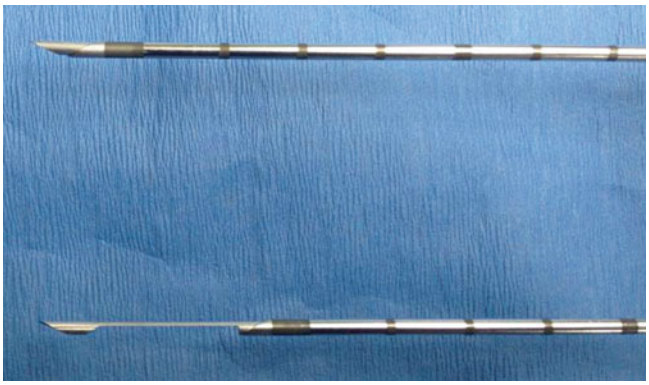

Fig. 12.2 Automated spring-loaded core needle tip in the unfired (*top*) and fired (*bottom*) position

Patient Preparation

Explanation, Stress Reduction, and Consent

Undergoing a breast biopsy can be a very stressful event for a patient. Typically the psychological stress is far more bothersome than the physical discomfort experienced during the procedure. Although we routinely offer premedication with anxiolytics for our stereotactic patients, premedication of our US patients is more variable. Music is routinely used in our

procedure rooms or patients may bring in their own music/listening devices. Studies have shown both music and anxiolytics decrease procedure-related anxiety in breast biopsy patients [17]. 5–10 mg of valium or 0.25–0.5 mg of alprazolam are often used for outpatient procedures. Medications are given in the department approximately 30 min prior to the procedure and after informed consent has been obtained. We require all patients to have someone available to drive them home.

In our department patients usually undergo a prebiopsy consultation, ideally performed the same day as the diagnostic imaging that resulted in a biopsy recommendation. The aim is to discuss the biopsy, answer any questions, go over consents, address stress reduction techniques, etc. Patients are instructed to avoid aspirin and NSAIDs (such as ibuprofen) prior to biopsy. Patients referred from outside facilities may be consulted over the phone. When the patient arrives in the biopsy suite, the procedure is discussed in detail with the patient, if this has not been done ahead of time. Informed consent must be obtained from the patient. Risks, benefits, and alternatives should be discussed as well as a thorough discussion of what the patient should expect during the biopsy. Immediately prior to the procedure, a universal "time-out" is performed.

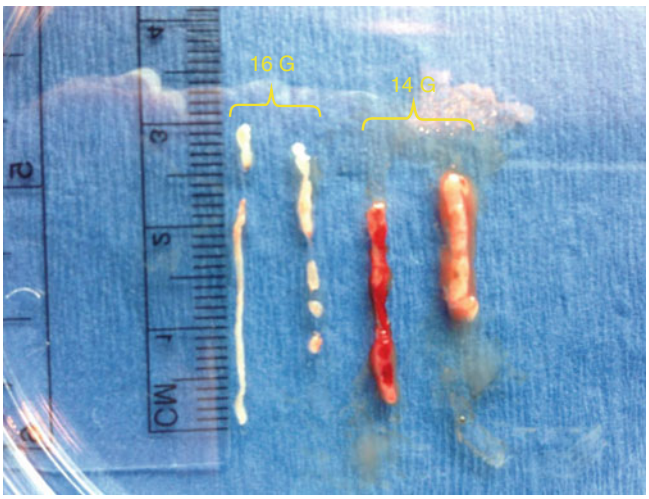

Fig. 12.3 Size of a 14-gauge samples versus 16-gauge samples obtained with an automated spring-loaded core device

US Approach and Positioning

The patient is placed supine on the table, with the ipsilateral arm elevated above the head. The physician then scans to confirm lesion location and determine the best approach to use. If needed the patient may be repositioned to an oblique angle for better access to a lateral lesion. Needles will pass more easily through fatty and glandular tissue than dense echogenic fibrous tissue. As such, finding an approach path with fatty tissue rather than dense tissue is preferred when possible (Fig. 12.4a, b). Use of Doppler may be helpful to avoid vessels. The subareolar region should be avoided if possible as this tends to be a very tender and sometime challenging area to anesthetize. If the mass is located in the subareolar region, a "nipple block" may be performed with topical lidocaine (such as EMLA®, AstraZeneca) with an occlusive dressing, followed by intradermal injection of lidocaine circumferentially around the nipple-areolar complex [18].

As a general rule, the shortest distance from the skin to the lesion should be used, keeping in mind the basic principles of ultrasound guidance. Although a vertical approach may be the shortest distance, a more lateral or oblique approach is required for ultrasound visualization. The intensity of the echoes produced by the needle increases as the angle of incidence

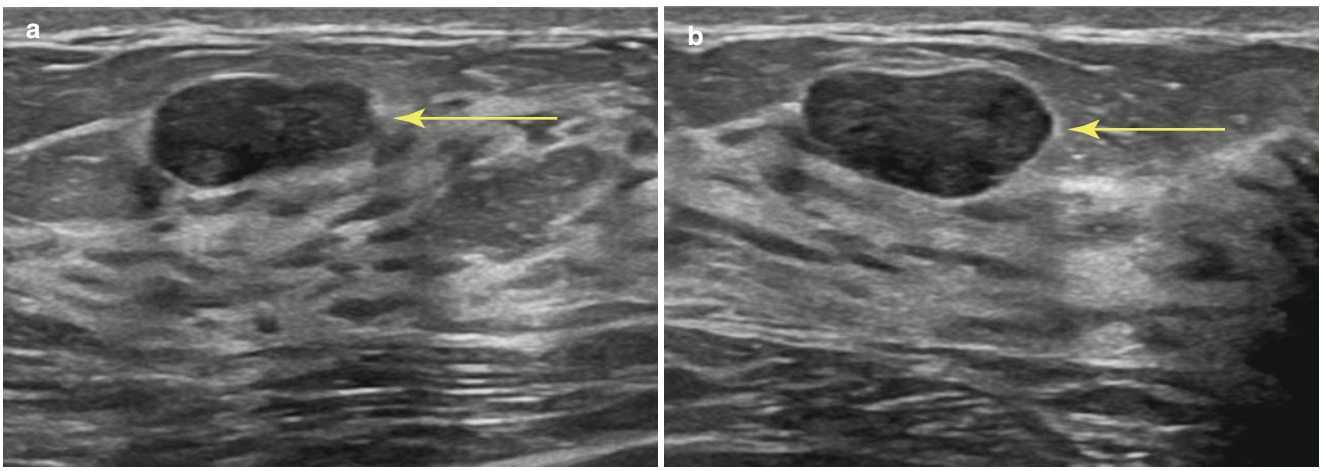

Fig. 12.4 (**a**, **b**) Planning your approach: the breast should be scanned from various angles to choose the optimal path of the needle (*arrow*). Transversing dense breast tissue with the needle (**a**) is more difficult than transversing fatty tissue (**b**)

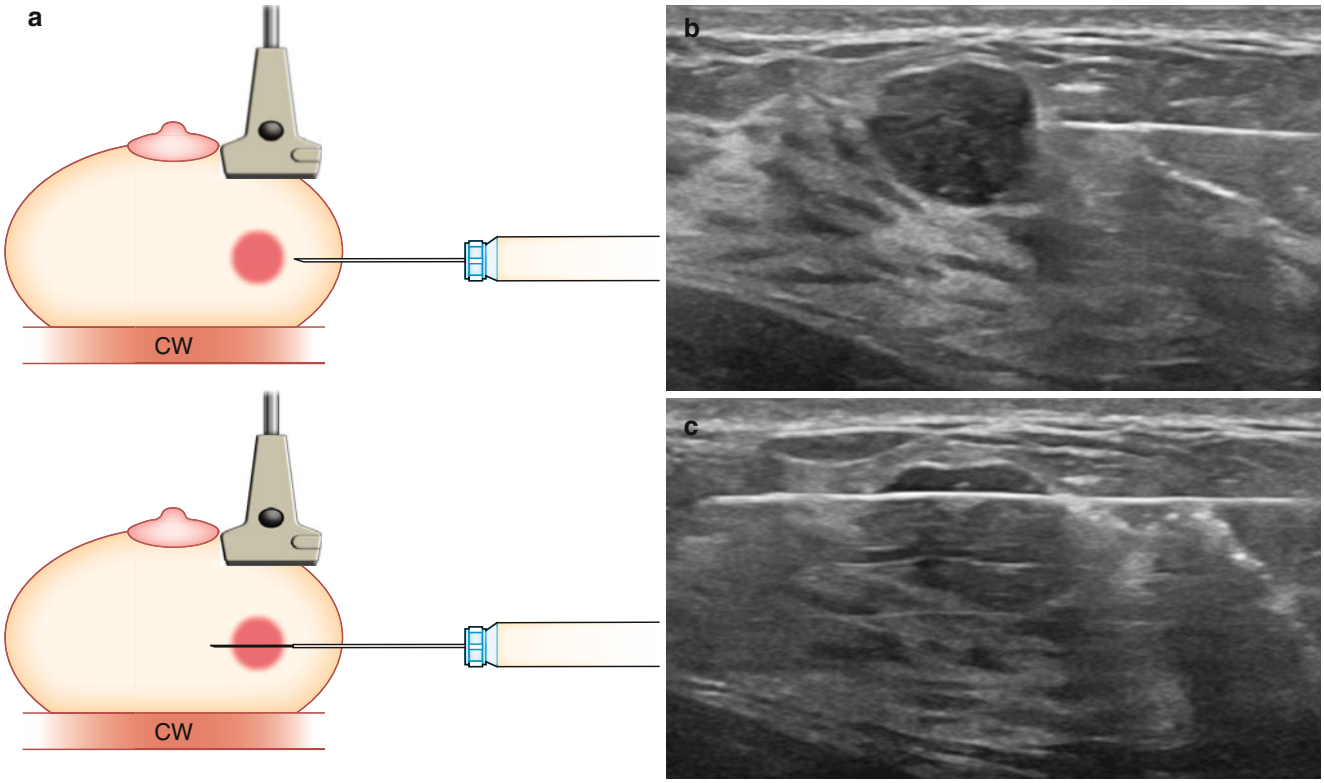

Fig. 12.5 (**a**) Transducer should be parallel to the needle to allow for maximum visualization of the needle and needle tip. Chest wall (*CW*). (**b**) Prefire location. (**c**) Postfire location

decreases, with the most useful specular reflections taking place when the ultrasound beam strikes the reflector at 90° to the surface of the needle. The needle must be parallel to the long axis of the transducer to produce the maximal number of reflected echoes for visualization. The needle should also be as parallel to the chest wall as possible (Fig. 12.5a–c).

Images should be obtained documenting lesion location, approach, and any pertinent findings (adjacent chest wall, skin, implant, etc.).

Biopsy Procedure: ASL

Skin Prep, Anesthesia, and Incision

After choosing the best approach, the biopsy tray is assembled as per physician preference. The tray and supplies should be positioned to ensure maximum accessibility and ease of use (Fig. 12.6). When setting up the tray, one should always be cognizant of accidental needle sticks or contamination. Examining your equipment prior to use to ensure no defects is always good practice. Many radiologists perform a test firing of the biopsy device to confirm proper function. This also provides an opportunity to warn the patient of the sound to avoid a startle reaction during the actual procedure. It should be noted, however, that some device manuals specifically precaution "never test the product by firing into the air" [19]. The breast is prepped and draped in the normal sterile fashion. Betadine solution is used to cleanse the skin and a sterile drape is placed. The transducer is routinely cleansed or a sterile probe cover can be used. One percent lidocaine (with or without epinephrine 1:100,000) is used for local anesthesia. Use of lidocaine with epinephrine can decrease bleeding and subsequent bruising. We prefer to buffer our lidocaine to decrease the pain associated with dermal injection. Ten milliliters of 1 % lidocaine (with or without epinephrine) is diluted with 1 mL of 8.4 % sodium bicarbonate [20, 21]. A 30-G needle is used for the initial superficial injection which also significantly reduces discomfort, with most patients reporting minimal to no pain with injection. This is followed by deeper injection with a 25-G 1 ½ needle. Ultrasound guidance should be used while giving anesthesia as this gives the radiologist a feel for the angle and approach that will be needed for the actual biopsy, a sort of trial run. Additionally any distortion (fluid pockets or hemorrhage) caused by the lidocaine can be seen real time so as not to confuse the subsequent biopsy. The lidocaine syringe should be well flushed before use to avoid introduction of air into the target field, which could obscure lesion visualization. The lidocaine placement can also be used to "move" the lesion as necessary, such as elevating a deep lesion off the chest wall by injecting the lidocaine deep to the lesion and "pushing" it more superiorly. Alternatively it can be used to make a shallow lesion "deeper."

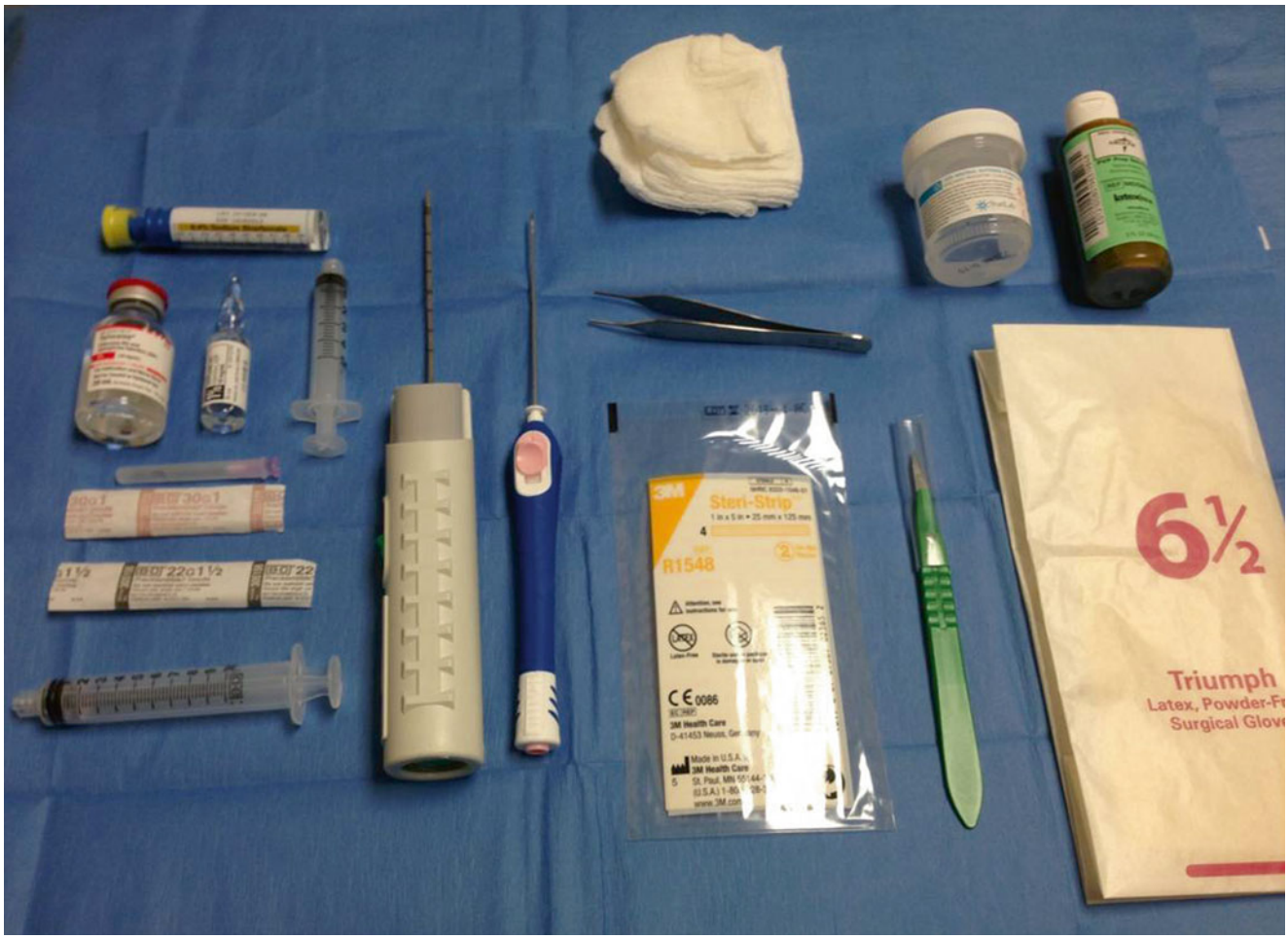

Fig. 12.6 Supplies for ultrasound-guided core needle biopsy

Insertion, Correct Positioning, and Firing of the Needle

A small skin nick is made with a #11 blade scalpel. Although targeting systems are available, the freehand method is preferred by most radiologists and is used at our institution. The physician holds the transducer in one hand (usually the nondominant hand) and the biopsy device in the other. Alternately, a well-trained technologist can hold the transducer allowing the physician to have both hands free for the biopsy. The skin entry point should be shallow, located 1–2 cm from the edge of the transducer to ensure a needle path that is parallel with the transducer (Figs. 12.7, 12.8a–e, 12.9a, b, and 12.10a, b). As such, the angle of incidence is zero, creating maximal specular reflection and allowing visualization of the entire needle and tip. Steep angles and short axis imaging can lead to inaccurate needle tip location and poor sampling.

The needle is inserted and advanced under the long axis of the transducer. The transducer hand should now be fixed and still. Your eyes should be in the habit of mostly looking at the breast, not the screen. With a "mental image" of where the mass is, the needle is moved to the transducer. Once in position, a prefire image is obtained for documentation. The needle should be positioned in or at the edge of the mass. Prefire positioning depends on several variables. First you must be aware of the penetration depth or "throw" of the needle. Most throws are ~2.2 cm, meaning the needle tip will be advanced 2.2 cm from the original prefire tip location. The length of the sample notch is ~1.9 cm. There is also a small ~6–7-mm dead space at the needle tip. It is important to be aware of the throw, dead space length, and notch size of whatever needle you are using (Fig. 12.11a, b). If sampling a large lesion, the prefire position may be just in front of the mass to sample both the edge (perilesional) and the center portion of the lesion (Fig. 12.12). Alternatively the tip can be placed within the lesion, especially if the mass moves and the needle "bounces off" the mass. In smaller lesions, the needle tip must be further away from the mass to ensure the mass lies within the sample notch postfire. Prior

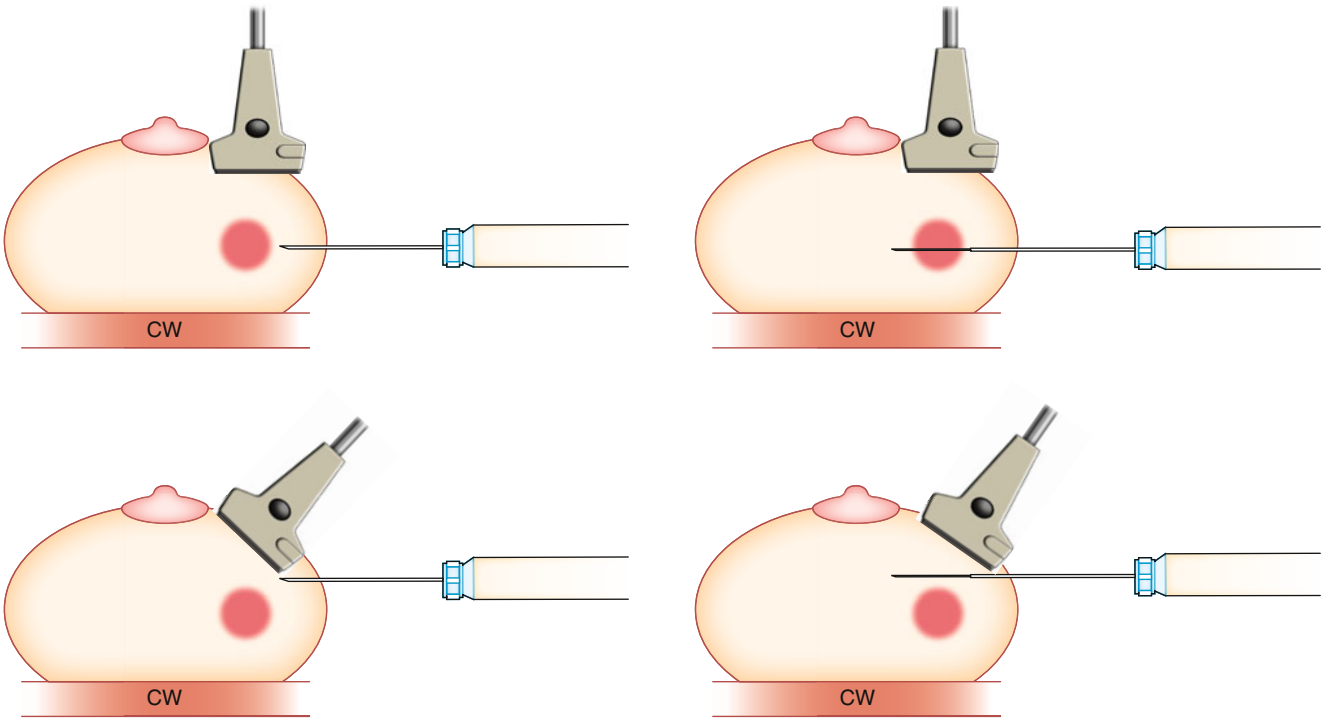

Fig. 12.7 It is important to keep the transducer parallel (*top*) to the needle to ensure proper targeting of the lesion. If the plane of the transducer is not parallel (*bottom*) to the needle, then although it may appear that the needle is in/in front of the lesion, errors in targeting will occur chest wall (*CW*)

to firing the needle, one must estimate the postfire needle position to insure no unwanted structures are in the expected path.

Obtaining a rim of normal perilesional tissue can aid the pathologist in making the correct diagnosis. Multiple areas of the lesion should be sampled to decrease sampling error and improve diagnosis (Fig. 12.13a, b). Another key point to remember is to use the spring to your advantage. Some lesions tend to be "pushed away" from the needle as it is advanced. The rapid forcefully fired spring mechanism can help combat this in many cases (Fig. 12.14a, b). Another useful trick in very dense tissue is using a 16 G instead of a 14 G. The smaller diameter will often pierce the tissue better and achieve nice specimens, especially of "hard" lesions.

A coaxial introducer may be used in conjunction with the biopsy gun. The introducer is placed similar to the needle placement described previously. Introducers are typically extremely sharp and do not usually require a skin incision. The trochar is then removed and the biopsy needle is placed through the introducer and into proper position to obtain a sample. This allows multiple samples to be obtained with only a single skin puncture. It decreases trauma to the surrounding tissue and can be very useful in dense, difficult to penetrate tissue.

In cases where automatic deployment is not safe, a device with a manual mode is advantageous. The Achieve® biopsy device (Cardinal Health, Dublin, OH) is available in several gauges, and the stylet can be deployed independently from the cutting cannula. An introducer must first be placed. The device, with the stylet prefired, is placed thru the cannula and the sample notch can be positioned as desired within the mass. The cutting cannula is then deployed directly over the stylet, with no additional needle tip forward advancement. This can be very useful in cases with masses very near implants or other sensitive structures.

Inspection of Specimen and Number of Cores

After obtaining a sample the needle is removed. Manual pressure should be applied over the incision by the technologist while the needle is out to aid in hemostasis and decrease bleeding. Care should be taken to maintain sterile technique. Tweezers or the tip of a needle can be used to remove the specimen from the sample notch and place it into formalin. Care should be taken not to crush or damage the specimen. A small amount of normal saline from a sterile syringe can also be used to "wash" the specimen out of the notch. The needle should not be placed directly into the formalin, as this would introduce a caustic substance into the patient. Some centers prefer to swish the needle tip in a small test tube of normal saline to remove the specimen. This can subsequently be transferred to a formalin container.

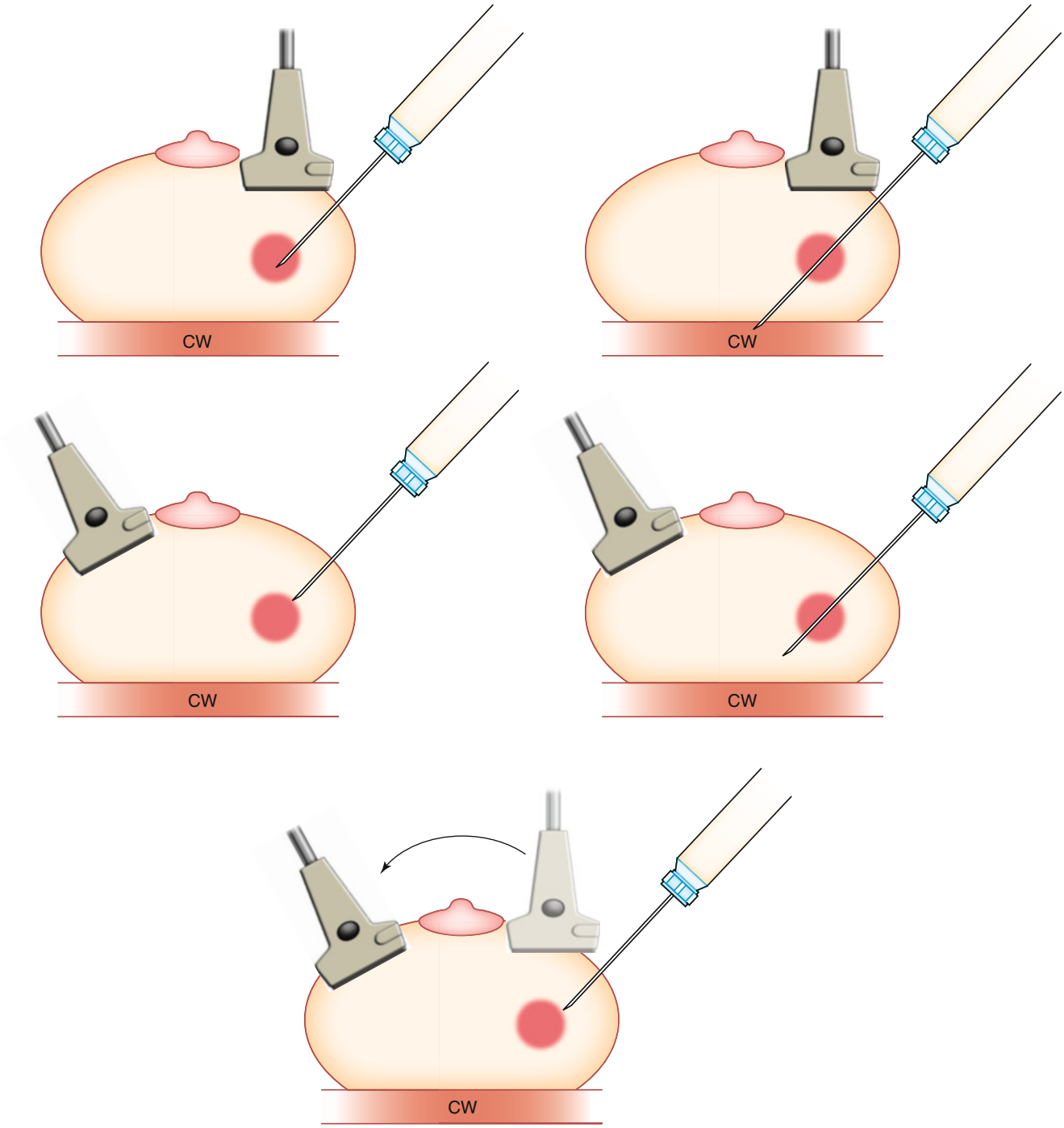

Fig. 12.8 (**a**–**e**) If a steep-angled approach is necessary, caution must be used to avoid piercing the chest wall (*CW*). Prefire (**a**) and postfire (**b**) show incorrect probe angle for a steep approach. The angle of the probe must be changed (**c**). Prefire (**d**) and postfire (**e**) correct angle and accurate biopsy

The macroscopic evaluation of the specimen can yield important information regarding quality. Intact, firm, white or dark red-brown cores that sink are favorable signs. Fragmented, yellow, floating oily cores are less likely to yield a conclusive diagnosis.

As per the ACR Guidelines, 3–6 core samples are generally recommended [15]. Several authors have advised not be "dogmatic" about the number of cores, with the exact number based on case-by-case assessment. Decisions regarding the optimal number of specimens should take into account

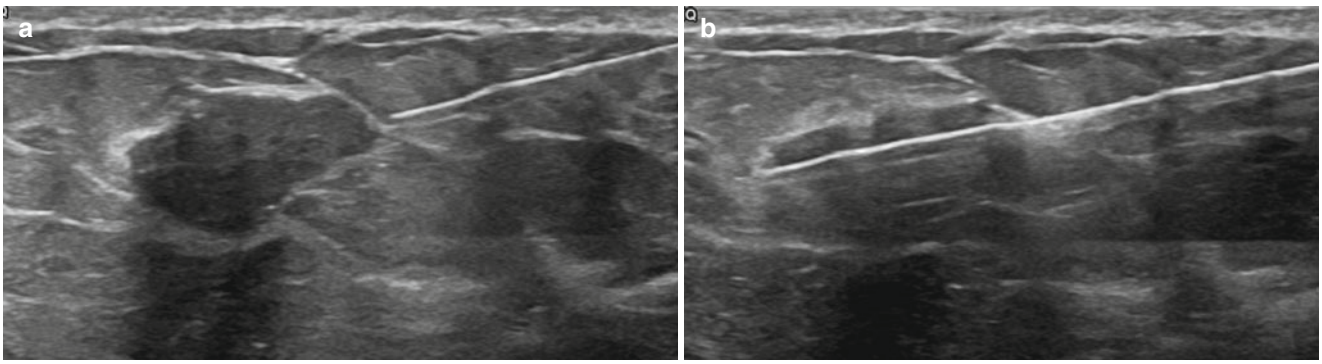

Fig. 12.9 (**a**, **b**) Pre- (**a**) and postfire (**b**) images demonstrating proper targeting

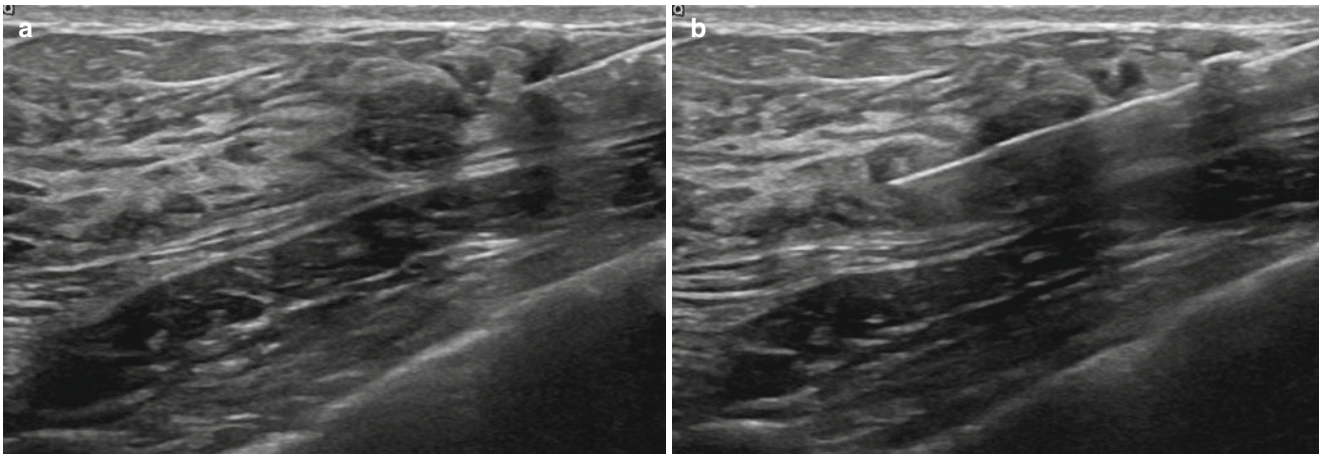

Fig. 12.10 (**a**, **b**) Pre- (**a**) and postfire (**b**) images demonstrating proper targeting

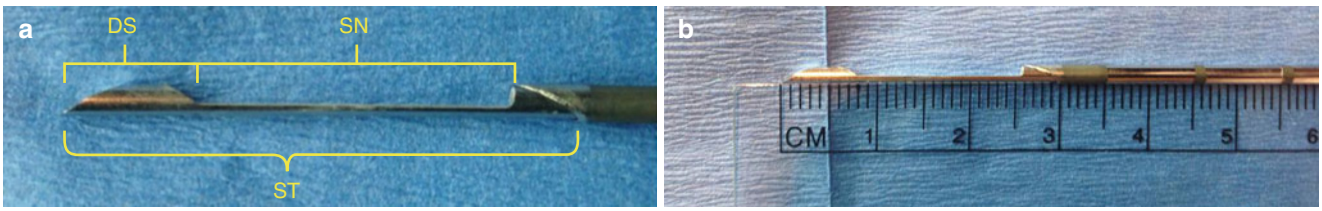

Fig. 12.11 (**a**, **b**) Close-up of the cutting notch. The stylet (ST) advances into the lesion and a sample falls into the notch (SN). A sheath is then closed over the notch, coring a sample of tissue in the notch. The dead space of the needle (DS) is also depicted

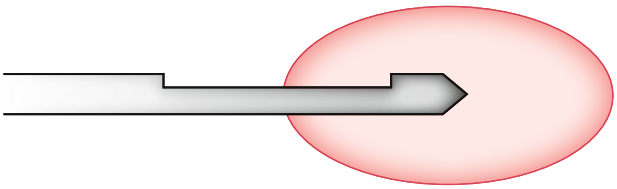

Fig. 12.12 Biopsy needle shown with the cutting notch encompassing both the lesion and the perilesional tissue

the radiologist overall confidence in the specimens. Factors to consider include how well the lesion was seen before and during the procedure, needle location pre- and postfire, and visual evaluation of the specimen [16, 22].

Biopsy Procedure: VAC

Vacuum-assisted core needle biopsy may also be performed. Ultrasound-guidance principles are the same as automated

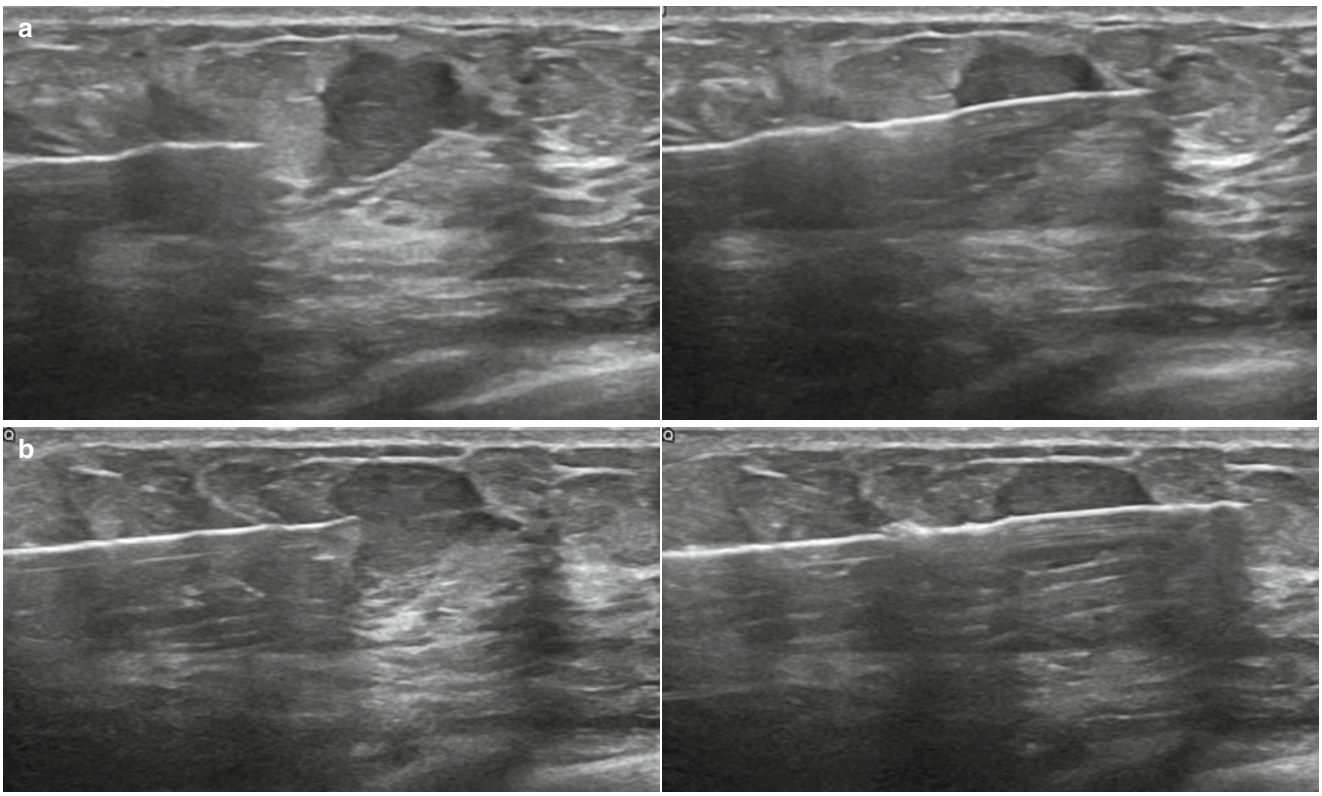

Fig. 12.13 (**a**, **b**) It is helpful to sample the edge of the lesion, including some the normal margin to aid the pathologist in diagnosis. (**a**) This can be accomplished by positioning the needle slightly away from the mass to ensure the notch captures some normal breast tissue before entering the mass. (**b**) If positioned close to the mass, the entire sample will likely arise within the mass

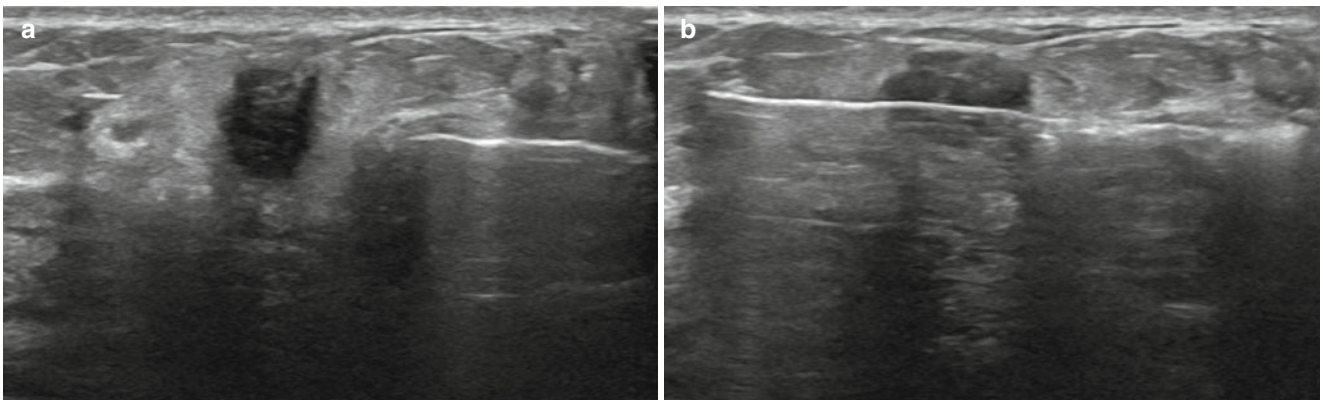

Fig. 12.14 (**a**) As seen on the image, the tissue can "bunch up" in front of the needle, as the lesion tries to move away from the advancing needle tip. (**b**) The spring action of the needle helps to eliminate this problem

spring-loaded devices. A range of needle sizes are available (7–14 gauge). The needle is usually positioned at the inferior margin of the lesion in the case of small lesions (Fig. 12.15). For larger lesions or non-mass-like areas, the needle may be centrally located within the mass. When the needle is in correct position, the vacuum is activated; the specimen is then pulled into the shaft and cut. The sample moves back down the needle to the container and the biopsy aperture is ready to obtain another specimen. Multiple samples can be obtained

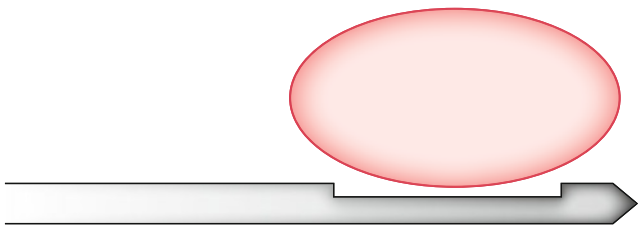

Fig. 12.15 The vacuum-assisted biopsy needle is usually placed along the undersurface of the lesion to be sampled

Fig. 12.16 Gross image of a sample of available breast markers

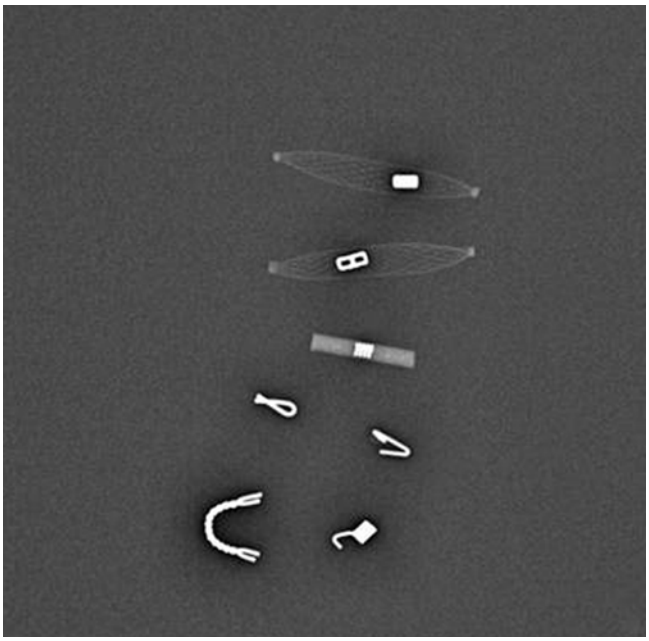

Fig. 12.17 Mammographic image of a sample of available breast markers

without moving the needle as the vacuum action continually sucks the lesion into the aperture. The shaft of the needle can also be rotated (directional control) to obtain specimens from various clock faces. Vacuum-assisted devices allow rapid acquisition of large volume specimens with a single insertion. An average of six cores is usually taken [6], although like spring-loaded cores numbers will vary. After the biopsy has been completed, lavage and aspiration of the biopsy cavity are performed to decrease bleeding and hematoma formation.

Marker Placement

Biopsy marker placement is essential for optimal patient management. Marker placement benefits [23]:

- Marking multiple lesions
- Insuring correlation across different imaging modalities
- Follow-up of benign lesions
- Monitoring neoadjuvant therapy
- Preoperative surgical localization and postoperative specimen evaluation

Multiple lesions often reveal varying pathological analysis and require different treatments/intervention. The vast array of marker shapes (Figs. 12.16 and 12.17) allow for easy identification of multiple lesions. Occasionally correlation across varying modalities may be in doubt prior to biopsy; marker placement can help verify. Marker placement aids in correlation on future exams as well. Marking of benign lesions facilitates short-term follow-up as well as helps to prevent unnecessary rebiopsy, particularly in patients who undergo follow-up at different institutions. Some patients undergoing neoadjuvant therapy may have such an excellent response that no radiographically visible tumor is present after treatment, making a marker essential to preoperative localization of the original tumor bed.

There are multiple commercially available markers on the market today. Some are designed to be deployed through the biopsy device (often the case in vacuum-assisted devices) others by freehand. Most markers are very small, 2–3 mm, and made of titanium or stainless steel. They may be imbedded with additional materials, such as collagen, PLA (polylactic acid), PGA (polyglycolic acid), interwoven polymer, or hydrogel to increase US visualization and decrease clip migration.

Choosing which marker to use is highly institution dependant. Different-shaped markers should be used when biopsying multiple areas with clear documentation in the report regarding which marker was placed into which lesion. Consideration may also be given to how one desires the marker to be visualized on subsequent exams. All commercial markers are seen well mammographically. However, some are better seen than others on US and MRI. US visualization can be increased with various embedding material such as woven polymer or hydrogel. MRI appearance depends on type (stainless steel creates a larger artifact than titanium), shape, and imaging parameters. Some marker material/shape combination will produce almost no MRI artifact with routine sequences, while others produce a fairly large MRI artifact. One that produces a clearly detectable but small artifact is usually best.

Marker placement utilizes the same basic ultrasound-guidance principles as described for CNB. In freehand placement, the tissue marker needle tip is advanced into the lesion/biopsy bed. A pre-deployment image is obtained. Under direct ultrasound visualization the marker is deployed.

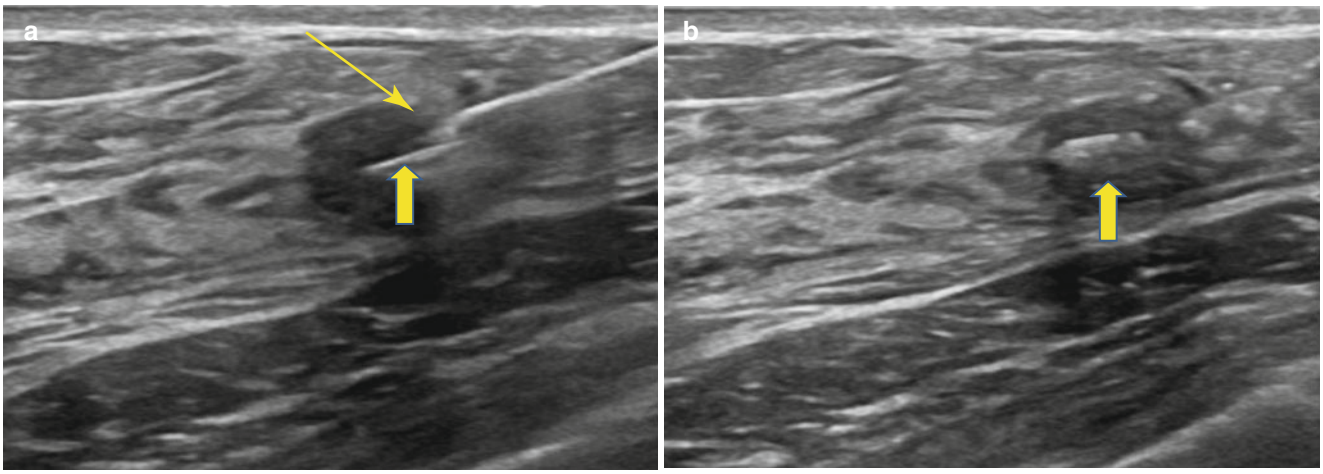

Fig. 12.18 (**a**, **b**) Clip deployment. (**a**) The breast tissue marker needle tip is inserted into the mass under direct ultrasound visualization. Clip (*thick arrow*) is deployed from the tip (*thin arrow*) or distal side port. (**b**) Clip (*thick arrow*) is well visualized within the mass following deployment

It should be seen extruding from the tip of the device (Fig. 12.18a). The needle is then removed and a post marker placement image is obtained (Fig. 12.18b). Care should be taken when removing the needle to ensure that it does not "drag" the marker back out, down the biopsy tract. It is good practice to inspect the deployment device after removal.

For vacuum-assisted devices, after the specimens have been obtained, the inner needle is usually removed and a compatible marker clip device is placed through the outer introducer sheath and deployed. Markers may also be placed freehand. As the marker is not anchored to the wall of the biopsy cavity, it can move within the breast tissue and result in clip migration. The marker should be within 1 cm of the lesion following placement. Causes of clip migration include the "accordion effect." This refers to clip migration along the *z* axis. It can occur during decompression of the breast with stereotactic or MRI biopsy. Hematoma formation and distortion caused by excess bleeding may also cause migration. Fatty breasts may have more migration than dense breasts. Larger-gauge needles and larger biopsy cavities have also been implicated in increased risk of clip migration.

A PubMed literature review demonstrated no definite documented cases of breast marker allergic reaction. Two case reports show a possible exacerbation of preexisting atopic dermatitis with titanium breast clips. There are rare reports of titanium allergy with pacemaker contact sensitivity and some orthopedic implants [23, 24]. Markers may be removed under stereotactic guidance if needed [25].

Hemostasis, Post-biopsy Mammograms, and Post-Biopsy Care

Following marker placement, direct manual pressure is applied to the biopsy site for approximately 10 min to achieve hemostasis. The skin is then cleaned and a Steri-Strip™ (3 M) bandage is applied. The patient undergoes immediate postbiopsy mammogram. Craniocaudal and 90° lateral views are routinely obtained (Fig. 12.19a, b). Additional views may occasionally be required to visualize the marker. Marker placement and mammographic correlation are confirmed. A small ice pack is placed over the biopsy site. The patient is instructed on routine postbiopsy care and provided with written information. This includes keeping the wound clean and dry. Strenuous activity should be avoided for 24 h, and PRN ice packs (first 24 h) and heating pads (after 24 h) may be used. The patient is instructed to keep the wound dry for 24 h and avoid swimming pools and hot tubes for 1 week following the biopsy to allow for complete wound closure. OTC medications (acetaminophen) are advised for postbiopsy discomfort, which should be minimal. Aspirin and NSAIDs should be avoided for 48 h.

Follow-Up

Imaging/pathology concordance is critical to assure appropriate patient care. The pathology report should be reviewed by the radiologist for concordance. (Please see Chap. 13 for discussion.) The patient and/or referring physician should be notified of the pathology and recommended follow-up. Concordant malignant findings should be referred to appropriate surgical/oncological consultation, as should discordance.

No BI-RADS recommendations exist regarding imaging surveillance for benign concordant core needle biopsy. Since CNB involves sampling, not removing lesions, imaging is required to demonstrate stability. However, there is no consensus regarding the timing of follow-up, with recommendations ranging from 6 months to 1 year. Salkowski et al. [26] found that rebiopsy recommendation rates and PPVs did not

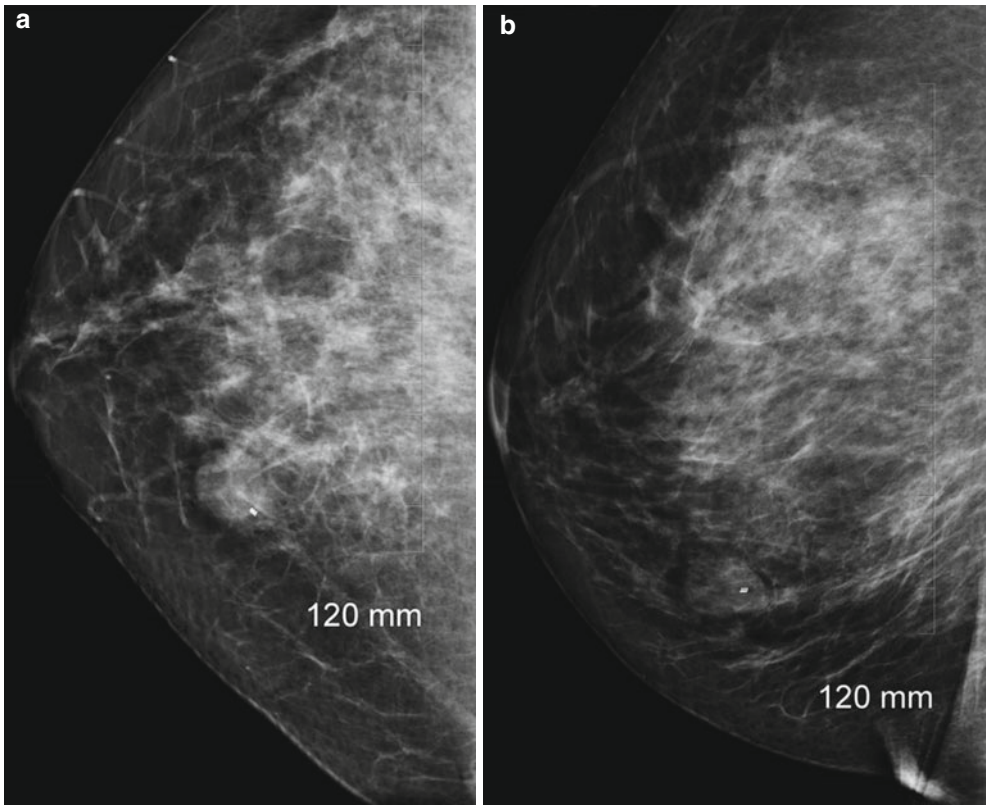

Fig. 12.19 (**a**, **b**) Post-biopsy mammogram (**a**, CC; **b**, LM) showing marker within the breast mass

differ in the 6- and 12-month groups. They suggest yearly follow-up may be more appropriate, lower costs, decrease patient anxiety, and lower radiation dose. Practice at our institution varies between 6 months and 1 year. Several factors are taken into account, including but not limited to specific pathology, image findings, and patient/physician preference.

Biopsy Report

As per ACR guidelines, the radiologist report should include the following [15]:

1. Procedure performed
2. Left and/or right breast
3. Description and location of the lesion with standard lexicon
4. Type and amount of local anesthesia
5. Gauge of needle and type of device
6. Complications and treatment, if any
7. Specimen radiographs or ultrasounds, if any
8. Marker placement, if performed
9. Postprocedure mammogram/ultrasound documenting marker placement and location of marker relative to sampled lesion
10. Recommendations based on tissue sampling results, imaging information, and concordance
11. Record of communication with the patient and/or referring physician

Complications of US CNB

The risk of complications in ultrasound-guided core needle biopsy is minimal. The reported risk of complications for automated spring-loaded CNB has been reported as less than 1 % [4, 27]. Complications with vacuum-assisted biopsy are reported as higher, ranging from 0 to 10 %, with a mean of 2.5 % [11, 27, 28]. The risk of severe complications (requiring surgical intervention) is lower with CNB (automated spring loaded or vacuum assisted) than with open surgical procedures, <1 % versus 2–10 % [1]. The most common complications include pain, bleeding, hematoma formation, and infection. Rare complications include pneumothorax, implant rupture/damage to implanted devices, and milk fistula/galactocele formation.

Pain

A study by Szynglarewicz [29] found a median pain rate of 4 (on an 11-point visual analogue scale of pain; 0 = none 10 = extreme) in women undergoing US-guided core biopsy. Specifically they compared pain experienced by patients undergoing US-guided biopsy with either a 14-gauge automated core needle or an 11-gauge vacuum-assisted CNB. Despite the larger gauge, the study found that less pain was experienced in the VA biopsy group. The authors believe this is due to contiguous collection of tissue without removing the needle. They reference similar findings in other studies.

They also point out that while some studies indicate more pain with an 11-G VA needle biopsy than with a 14-G ASL needle biopsy, these studies were comparing 11 stereotactic procedures with 14-G US-guided procedures. The findings may be related to inherent differences in stereotactic guidance versus US guidance (longer procedure time, prone positioning, compression, etc.).

Hematoma/Bleeding

Most studies indicate hematoma formation and bleeding are more common in VA biopsies than in ASL biopsies [1, 5, 27, 30]. The fairly straightforward argument holds that a larger biopsy cavity creates more bleeding. A few studies demonstrate that hematoma/bleeding is less common (or equal) in VA biopsies compared to ASL biopsies [29, 31]. These authors argue that although more tissue is removed, the single insertion with subsequent decreased tissue trauma and the ability to evacuate the biopsy cavity with vacuum actually decreases hematoma formation.

Implant Injury

Although implant rupture is a risk, it is very low given the real-time imaging capability. In addition, manual devices such as the previously mentioned, Achieve®, and VA devices that do not require a "throw" can be helpful in challenging cases. Both stereotactic and US-guided biopsies are safe and accurate in augmented breasts [32].

Tumor Cell Displacement

Seeding of biopsy needle track with viable malignant cells was an initial concern with all diagnostic breast needle procedures. Tissue seeding has been reported in 37 % ultrasound-guided ASL biopsy and in 23 % of the cases following VA biopsy [16]. In a prospective study from the Netherlands [33], seeding was not felt to be clinically significant, as radiotherapy is performed and conclusions were that tumor cells do not survive displacement.

Size and Type Argument: VA Biopsy Versus ALS CNB

The volume of tissue removed with vacuum-assisted core (VAC) devices is significantly greater than the volume obtained with automated spring-loaded core devices (ASLC). (See Tables 12.1 and 12.2.) Although this has proved invaluable in stereotactic biopsy of calcifications, overall utility in ultrasound lesions is not as clear.

When choosing between the use of a 14-gauge automated spring-loaded core needle biopsy and a vacuum-assisted core needle biopsy (usually 9–11 gauge), many things should be considered [34, 35]. While the accuracy of biopsy is increased with VAC [1], there is also a significant increase in cost and complications (although increased complication rate seems to be under debate) [4, 11, 27, 28]. Increased accuracy may not justify the routine use of VAC. VAC may not be as accessible as ASLC. In the diagnosis of high-risk lesions (such as ADH, radial scar, papillomas), ASLCN is more likely to underestimate the presence of DCIS than VAC. Invasive carcinoma is more likely to be underestimated in DCIS specimens with ASLCN than VAC. However, as standard of care is to send these lesions to surgical excision, no carcinomas are missed. Verifying concordance also ensures carcinomas are not missed. In larger lesions where the overall outcome is very unlikely to be different; the increased cost, resources, and patient discomfort of VAC would argue against its routine use.

However, others argue that with increased large volume samples, select high-risk lesions may not require surgical excision when appropriately reviewed in a multidisciplinary setting. If so, this may justify the increased use of vacuum-assisted biopsy. There is also a fairly strong argument for using VAC in small (less than 1.5–1 cm) lesions [29]. As there is inherently increased risk for sampling error in smaller lesions, the use of VAC may beneficial. As detailed in the complications section of this chapter, there are a few studies that demonstrate decreased pain and complications with VAC compared to ASLC [29, 36]. Overall, VAC shows significant improved accuracy with calcifications, non-mass-like areas, and small masses (not larger masses) and cost more than ASLC. Results of pain and complication rates between the

Table 12.1 Needle gauge comparison chart

Needle gauge	Nominal outer diameter (mm)
8	4.2
9	3.8
10	3.4
11	3.1
12	2.8
13	2.4
14	2.1
15	1.9
16	1.7
17	1.5
18	1.3

Adapted from http://Wikipedia.org/wiki/needle_gauge_comparison_chart. http://creativecommon.org/licenses/by-sa/3.0/

Table 12.2 Volume of tissue obtained with various CNB devices

Gauge	Core needle biopsy (CNB) device type	Volume of tissue obtained (mg)
16	ASL	5.3
14	ASL	12.7–17
14	VA	34–40
11	VA	94–100
7	VA	250

Data from Lai et al. [14], Liberman [4], and O'Flynn et al. [6]
ASL automated spring loaded, *VA* vacuum assisted

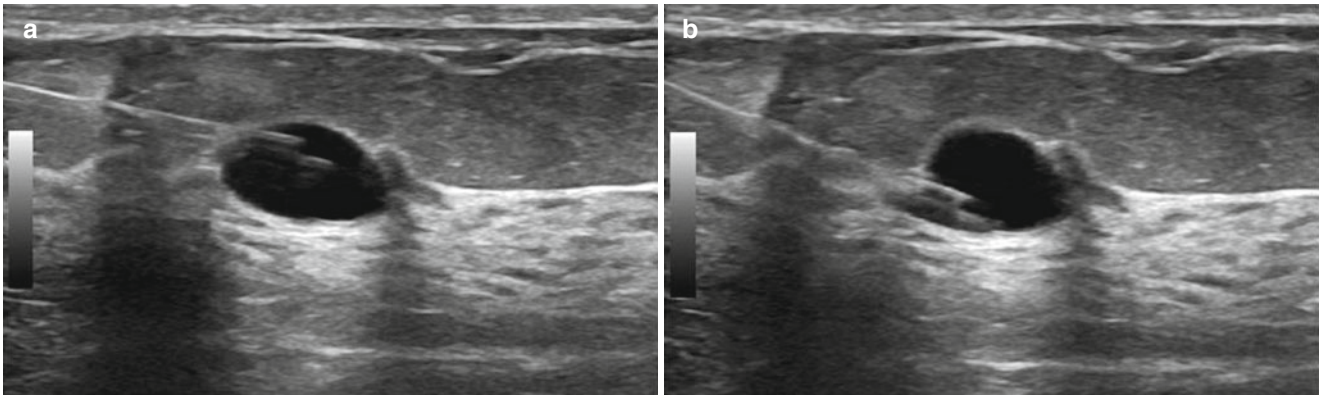

Fig. 12.20 (**a**, **b**) "Rocking" the needle tip. The needle tip can be moved up (**a**) and down (**b**) within the cyst. If this were a solid mass, rocking the needle up or down would move the entire mass up and down and the needle would remain in the same location within the mass

two procedures show varying results. More studies should be performed in addressing the optimum choice in various clinical scenarios.

Cyst Aspiration

Although aspiration of a simple cyst is not necessary for diagnostic purposes, tender or painful cysts may be aspirated for symptomatic relief. For a suspected but not definitive simple cyst by ultrasound criteria, cyst aspiration may be performed to confirm the cystic nature of the lesion. If such lesions prove solid, then the procedure can easily be converted to a core needle biopsy. Complex cysts with mural nodules or irregular septations should not be aspirated as cytology from such is often falsely negative even in the presence of intracystic carcinoma. In dealing with such lesions, vacuum-assisted CNB or surgical excision is advised. Cyst aspiration may also be performed to help improve clinical exam or help clarify imaging findings.

Preparation, local anesthesia, and guidance principles are the same for cyst aspiration as they are for the previously described ultrasound-guided core needle biopsy. Under direct ultrasound guidance an 18-G needle with an attached syringe is advanced into the cyst. You should usually be able to "feel" the needle enter the cyst, which is confirmed with images and documented. Being able to "freely rock" the needle tip within the lesion is very good indicator of a cystic or fluid component (Fig. 12.20a, b). The contents are then aspirated and inspected (Fig. 12.21a, b). Complete or near-complete resolution of the cyst should be confirmed with real-time imaging. *Tip: It is often possible to aspirate a simple small cyst with the lidocaine needle/syringe, sparing the patient an additional stick.* Occasionally when an aspirate is unable to be obtained, despite strong suspicion of a cystic nature, an attempt can be made with a 16-G needle. If this fails, we will usually proceed to core needle biopsy.

Fine-Needle Aspiration (FNA) of Lymph Nodes

Ultrasound is increasingly being used in the evaluation of lymph nodes in the breast. Documenting lymph node metastasis is an important step in breast cancer management. Sentinel node biopsy is often performed to asses for metastatic disease of the axilla. Ultrasound and FNA can help select patients avoid the time, cost, and stress of sentinel lymph node biopsy. Fine-needle aspiration cytology involves collecting cells from a suspicious lymph node with a small hypodermic needle. FNA is fast, inexpensive, and minimally invasive. It can easily be performed when the patient undergoes CNB of their primary breast lesion. A screening ultrasound is performed of the axilla and the most suspicious lymph node is chosen for biopsy.

For evaluation of metastatic or suspected metastatic disease of the axilla, most studies describe the use of FNA. There have been reports of core needle biopsy as well, although much fewer in number. Ultrasound combined with CNB or FNA has specificity reported to be as high as 100 %. FNA sensitivities range from 21 to 95 %, and CNB have reported similar results, 40–91 % [37]. Preparation, local anesthesia, and guidance principles are the same for fine-needle aspiration as they are for the previously described ultrasound-guided core needle biopsy. Using ultrasound guidance, a small hypodermic needle (usually 21–25 gauge) can be used to obtain aspiration cytology. Larger 18-gauge needles are also sometimes used. The needle tip is advanced into the lymph node under ultrasound guidance. Once confirmed and documented in place, negative pressure is applied to the needle with an attached syringe as the tip is moved around in the mass to collect cells (Fig. 12.22a–d). No aspiration should be applied when removing the needle. This may add nonlesional material and increases track seeding [38]. Others prefer to use the capillary action of the needle, where cells are detached by the cutting edge of the needle and are conducted into the lumen by capillary force rather

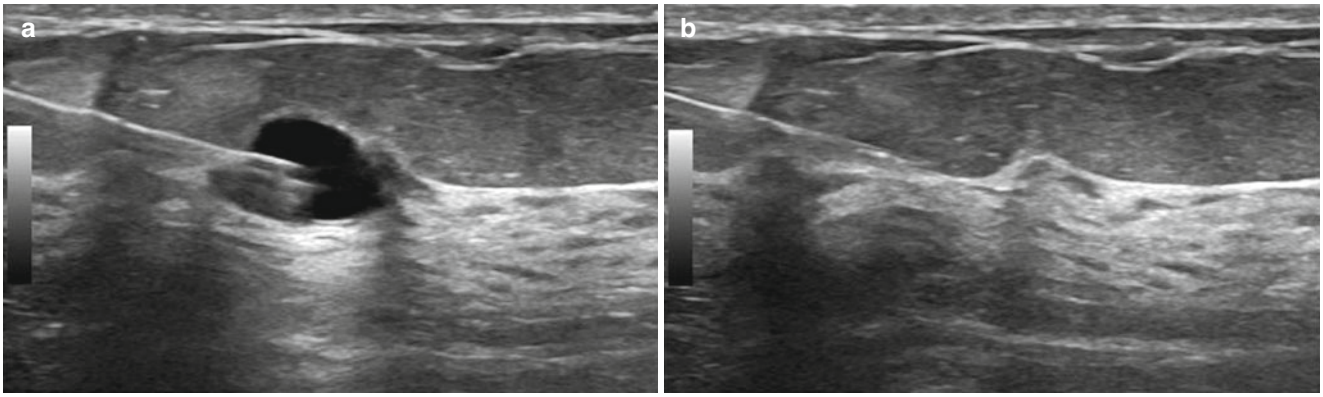

Fig. 12.21 (**a**, **b**) Cyst aspiration. (**a**) The needle tip is inserted into the cyst. (**b**) The cyst is then completely aspirated

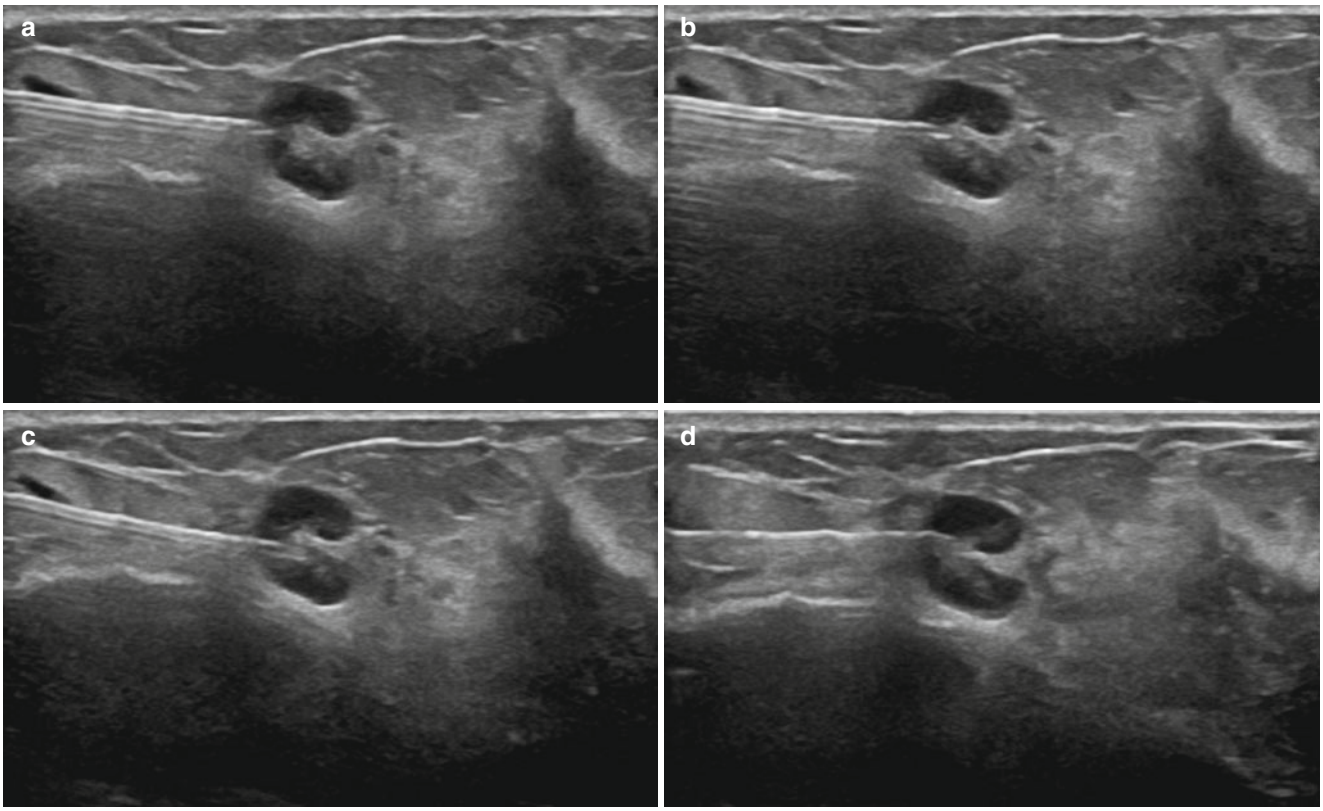

Fig. 12.22 (**a**–**d**) The needle is advanced into the lymph node and gently moved to and fro within the node to obtain cells from various locations

than aspiration. Typically between two and five needle passes are performed per suspicious lymph node. However, studies have shown that after four passes, the gain is minimal [39]. Having a cytologist immediately available to inspect the specimens for adequacy is very helpful in obtaining optimum FNAs.

Abscess Drainage

Abscess drainage is most often performed surgically as percutaneous drainage does not offer the amount of complete drainage possible with a surgical incision. However, there are times when percutaneous abscess drainage may

be helpful; when surgery is not feasible or samples are needed for culture. A large bore 16- or 18-gauge hypodermic needle attached to a syringe is used to aspirate pus or fluid form the abscess.

MRI-Guided Breast Biopsy

A lesion may be seen on MRI and not visualized by mammography, ultrasound, or clinical examination. In this case, MRI-guided biopsy may be the only option for tissue diagnosis. A second-look ultrasound and possible diagnostic mammogram are recommended to check if lesions are amendable to biopsy using other methods, particularly when the lesion is greater than 1 cm. Ultrasound-guided biopsy is generally more comfortable from the patient standpoint, more rapid, and more cost effective. However, per Morris, an ultrasound correlate was found in only 23 % of cases [40].

Percutaneous biopsy is advantageous over surgical excisional biopsy with decreased morbidity, faster recovery, improved cosmetic result, and decreased scarring on subsequent mammograms. Percutaneous biopsy has decreased the number of benign findings from surgical excision. If cancer is diagnosed by percutaneous biopsy, better surgical planning with fewer surgeries result. Additionally, monitoring a patient's response to neoadjuvant treatment is also possible. The accuracy of percutaneous biopsy approaches that of surgical biopsy [41, 42].

Indications

Indications for percutaneous MRI-guided biopsy per the American College of Radiology include MRI lesions with no correlate on mammogram or ultrasound. This includes suspicious lesions or lesions highly suggestive of malignancy (BI-RADS® Category 4 or 5 in the Breast Imaging Reporting and Data System). Probably benign lesions (BI-RADS® Category 3) may be biopsied if there are valid clinical indications or if short-term interval imaging follow-up would be difficult. A repeat MRI-guided biopsy may also be performed in nondiagnostic or discordant cases [42].

Contraindications

Contraindications include lesion nonvisualization following contrast injection. Allergies to gadolinium are rare but also are a contraindication. The continued use of aspirin, anticoagulants, or other agents affecting bleeding times or bleeding diatheses is also discouraged. Basic MRI safety precautions and gadolinium risk assessments should be followed. Also, patient size should also be considered. Patients should also be able to tolerate prolonged, still positioning [42].

Prebiopsy Considerations

Ideally, breast MRI biopsy should be performed in the same location as the initial MRI imaging. The use of identical protocols decreases the need for repeat MRI imaging which might occur when comparing images from different centers. If different centers must be used, the protocols and technical factors should be replicated to avoid duplicated examinations. Additionally, the physicians MRI interpretive ability is improved when the pathology correlate is known. Before an MRI-guided biopsy is performed, the lesion should be correlated with prior imaging such as mammography or ultrasound to insure this is not a stable, benign mass. If prior imaging is not available, diagnostic mammography and focused breast ultrasound may further characterize the finding. If the lesion is amendable to ultrasound-guided biopsy, this will be more rapid, comfortable, and less costly. Of note, masses are usually easier to demonstrate versus non-mass-like enhancement. Of note, second-look ultrasound may fail to visualize a correlate up to 77 % of cases [40, 43]. When comparing different modalities, the lesion distance from the nipple may vary due to differing positions in mammography, ultrasound, and MRI. It might be more helpful to describe the findings as anterior, middle, or posterior in position. Landmarks may also prove useful when correlating different modalities [44].

Consent

Informed consent should be documented and include risks, benefits, limitations, and alternatives. Complications can occur in less than 5 % of cases. These include bleeding which might require compression, suture placement, surgical drainage, large hematoma, infection, and damage to surrounding tissue and organs and vasovagal reactions [40].

The Joint Commission's Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery is also required. The biopsy site should be marked and confirmed and a time-out performed [42].

Equipment Needed

A 1.5 T MRI machine is typically utilized with a breast coil and several commercial options are available. A guidance method is used which includes a grid and pillar and post. Some clinicians utilize CAD or a worksheet system.

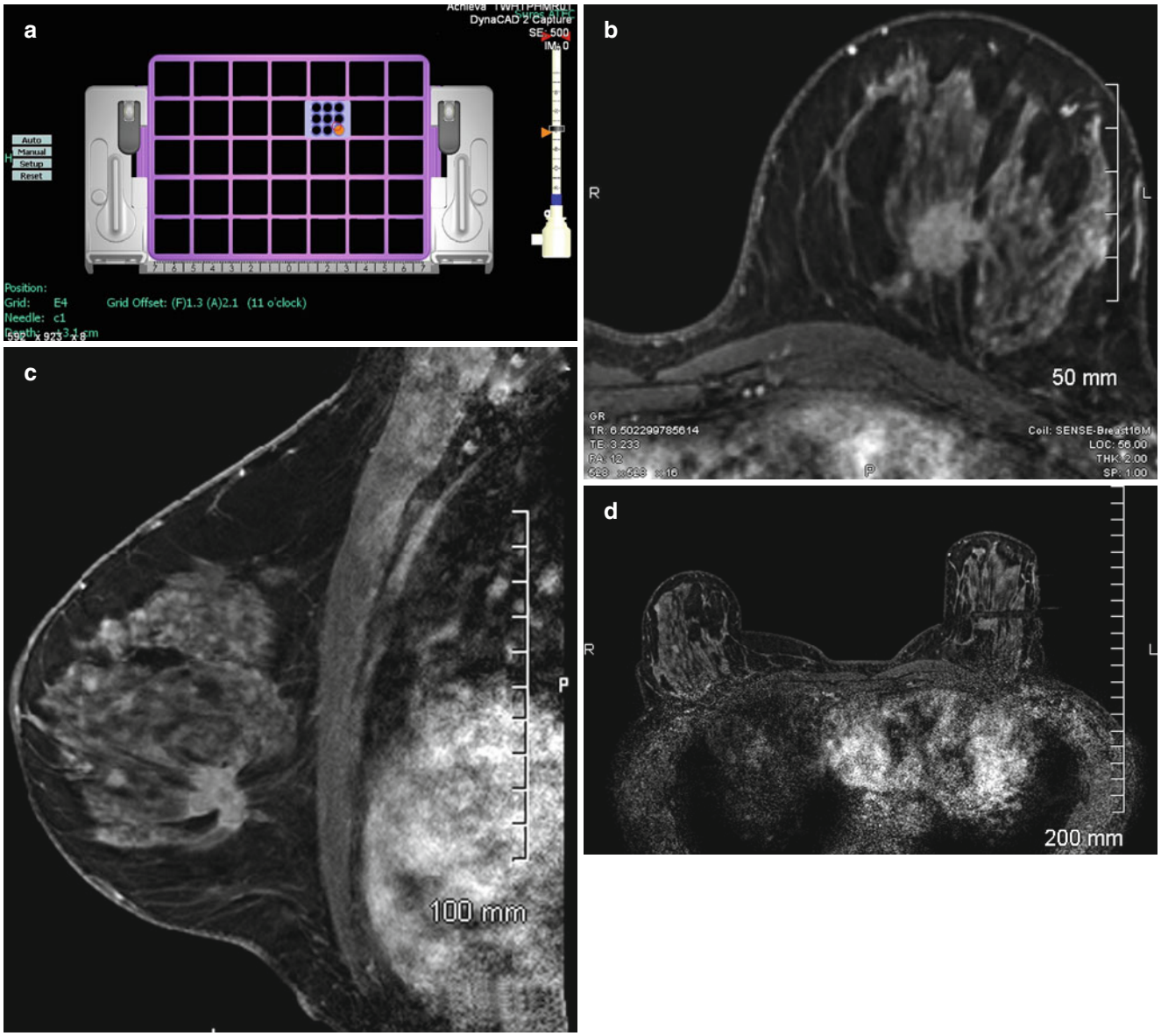

Fig. 12.23 (**a**–**d**) MR-guided biopsy of a lesion in the left breast. Histological diagnosis: invasive ductal cancer. (**a**) Pre-biopsy localization of the lesion using a CAD system that displays a lateral grid on the monitor identifying the location of the lesion to be biopsied and its depth. (**b**) T1-weighted axial image following gadolinium injection shows a spiculated mass in the left breast. (**c**) T1-weighted axial image following gadolinium injection shows a spiculated mass in the left breast. (**d**) Subtraction image demonstrates the biopsy needle in satisfactory position within the mass to be biopsied

A coaxial system comprised of an introducer sheath, trochar, obturator, and biopsy needle helps minimizes needle deflection and decreases repeated trauma to the breast parenchyma. A vacuum-assisted core biopsy device is used to obtain the sample. The MRI compatible biopsy kit contains a white introducer with 5-mm markings to adjust the depth. The trochar is placed through the introducer which will be inserted in to the breast. The obturator replaces the trochar during imaging to confirm placement with a black dot at the intended biopsy location. The vacuum-assisted biopsy needle has a sampling notch, and the samples are collected in a specimen collecting cup. Tubing connects the hand piece to the control module which remains outside the MRI room. A biopsy clip must also be available and is placed through the introducer after the biopsy is complete (Fig. 12.23a–d).

Pretreatment

Generally, we do not pretreat the patient unless the patient is unable to tolerate the procedure. With proper explanation prior to the procedure, we find most patients tolerate it well.

If pretreatment is required, oral benzodiazepines may be used. This includes diazepam (Valium®, Roche), 5 mg oral, 1–2 doses, or lorazepam (Ativan™, Baxter), 0.5 mg oral, 1–2 doses prior to the procedure [40].

Medication

Prior to scheduling the procedure, the patient should be asked about anticoagulants.

The risks and benefits of stopping Coumadin should be discussed with the patient and her referring clinician. Coumadin® (Bristol-Myers Squibb) may be discontinued approximately 4 days prior to biopsy and INR (international normalization ratio) checked prior to biopsy. Coumadin therapy can resume after the biopsy. If patient is high risk, patient may transition to a low-molecular-weight heparin which may be discontinued prior to biopsy [40]. Anticoagulant management should be performed under the direction of the patient's referring clinician. Other anticoagulants include aspirin which should be discontinued 1 week prior to the examination. NSAIDS should be discontinued 48 h prior to the examination.

Patient Positioning

Patient is placed in the prone position with the breast in an open breast coil. The biopsy is usually performed from the lateral or medial position depending on the MRI biopsy system used. Typically the lateral approach is more accessible. The breast is placed between a grid device. Compression should be adequate for visualization. Over compression should be avoided which can effect contrast enhancement.

Lesion Localization

The MRI should be high resolution and replicate the initial MRI examination as closely as possible. The grid contains a fiduciary marker. The marker should be visualized on the localization images. The lesion should be also included in the field of view. Initial localizer sequences are performed in the sagittal and axial positions. If positioning is satisfactory, Pre- and postcontrast T1-weighted fat-saturated images are performed using axial and sagittal images. Fat saturation images may assist finding the lesion in the event the patient moves between examinations causing misregistration in the subtraction images. The standard gadolinium contrast bolus is 0.1 mmol/L/kg of body weight. It is administered as a rapid bolus with a subsequent 10 cc saline flush. Images are obtained rapidly before the contrast washes out of the lesion. The scan time should not exceed 4 min. The presence and location of the lesion is confirmed in two planes. If the lesion is not seen, please refer to the troubleshooting section. Adjacent landmarks may also be utilized to confirm the region of interest is visualized. The *X*, *Y*, and *Z* coordinates are then calculated.

MR Guidance Methods

MR-guided biopsy was first attempted in the freehand manner. Cutaneous markers such a vitamin E capsule was placed on the skin surface. The lesion's location was then estimated [45]. Current methods involve guidance through a grid. A square insert is placed in the grid and the software will calculate the square fenestration the needle should pass through [46].

Procedure

The biopsy area is prepared in the normal fashion using betadine solution, provided the patient is not allergic. If patient is sensitive to betadine, chlorhexidine solution is substituted.

The superficial and deep area is anesthetized using approximately 10 mL sterile 1 % lidocaine (Xylocaine). Some practitioners prefer 10 mL 1 % lidocaine 10 mg/mL with epinephrine 1:100,000. The skin entry site is nicked with a scalpel. While cutting trochars are available which do not require a skin nick, we have had better results using an initial nick .The introducer and trochar are passed as a unit to the calculated depth through the needle guide using a twisting motion. The trochar is replaced with the obturator. The breasts are subsequently scanned to confirm that the introducer/obturator placement corresponds to the lesion. This can be visualized as a black dot. Axial and sagittal T1-weighted fat-saturated images without contrast are performed. If adjustments are needed, additional T1-weighted fat-saturated sequences without contrast may be performed at this time to confirm placement.

If placement is satisfactory, the obturator is removed and a 9- or 11-gauge vacuum-assisted biopsy needle is carefully placed through the introducer. When the biopsy needle is placed at the hub of the introducer, the biopsy needle tip will protrude through the introducer tip at the site of the lesion. Vacuum-assisted biopsy is more accurate than fine-needle aspiration and offers more tissue sample compared to core biopsy. The samples are obtained in a 360° (12 sample) or 180° (6 sample) configuration, depending on the biopsy needle position relative to the lesion. The biopsy needle is rotated one clock face step each time a beep is heard while stepping on the foot pedal. Approximately 100–150 mg of tissue is obtained depending on the biopsy needle used [47].

The biopsy samples are removed and placed in a prelabeled vial containing formalin solution, per pathology specifications. The biopsy site is then flushed with saline. The biopsy needle is replaced with the obturator and a noncontrast fat-saturated T1 image is performed.

A clip is placed to assist with future localization techniques or monitoring, depending on the pathology results. The clip device is placed through the introducer to its hub and deployed. The clip introducer is rotated, removed, and inspected to ensure deployment [40].

An additional postbiopsy sequence is performed. There can be difficulty in distinguishing the clip and postbiopsy air. For this reason, craniocaudal and lateral mammogram projections help confirm the clip position in the event wire localization is needed in the future. In the event of clip migration, mammographic landmarks may assist future wire localization.

Post-biopsy Care

Direct compression is applied for 10 min along the biopsy tract. Antibiotic ointment, Steri-Strips, and overlying gauze bandages are applied. The patient is offered an icepack and compression netting. Post-procedural care instructions are provided which include keeping the wound dry for 48 h and no heavy lifting. Signs and symptoms of infection are explained to the patient. It is also helpful for the patient to be aware that some bruising is expected. The radiologist's contact information is provided should concerns develop.

A postbiopsy visit may be scheduled to inspect the incision site and relay biopsy results to the patient. If this is not possible, the results must be conveyed to the patient and documented and patient referred for follow-up as appropriate. Follow-up recommendations may assist the referring clinicians, particularly if they are not breast surgeon specialists.

Follow-Up Pathology Concordance

If the results are benign and concordant with the imaging findings, the patient may return to screening mammography. If there is any concern of biopsy accuracy, follow-up MRI is recommended in 6 months. If the lesion is considered high risk or discordant, breast surgeon consultation is recommended to discuss excisional biopsy. Medical audits should also document false-negative and false-positive results [42].

Troubleshooting

Lesion Is Not Visualized at Time of Biopsy

If a lesion is not visualized at time of percutaneous MRI biopsy, the MRI images should be evaluated for evidence of contrast opacification of the heart and internal mammary arteries. Other sources of nonvisualization include breast overcompression which hinders contrast enhancement. Additionally, if the images were obtained too soon, a delayed image may show contrast enhancement. If the lesion is still not visualized, this might be due to hormonal effects and should be correlated with the menstrual cycle. Landmarks may also be helpful in evaluating the region of concern. Some clinicians may administer additional contrast but we typically reschedule the biopsy on another day. If the lesion is still not able to be visualized, MRI follow-up in 6 months is recommended to confirm that the lesion is not visualized.

Lesion Appears Not to Have Been Sampled

The MRI images performed after the biopsy may indicate that the area of concern was not sampled. In this case, the introducer unit may be repositioned. If the lesion is superficial, the introducer and trochar are advanced to the appropriate position. If the introducer is too deep, the introducer and obturator unit are pulled back to the appropriate depth. The new position is confirmed on MRI and additional tissue is obtained and placed in a separate formalin vial [40].

Posterior Lesion

Some lesions may be located far posteriorly. In these cases, patient positioning with a technologist experienced in stereotactic biopsy may be invaluable. Decreased cushioning might be considered if the patient is amendable to this. The needle may be placed either in the posterior grid or posterior to the grid [40]. In the event of a nondiagnostic biopsy, the biopsy clip may be useful to help guide an excisional biopsy. The lesion position relative to the clip should be documented and conveyed to the breast surgeon. The patient should be made aware of the possibility of a nondiagnostic biopsy in these cases.

Medial Lesion

If a medial approach is not permitted by the MRI biopsy system, the sample is obtained from the lateral approach. Alternatively, the breast may be positioned in the contralateral opening in a thin patient. The medial breast will now abut the lateral aspect of the contralateral coil. This may also assist accessing a posterior lesion in the medal breast [48]. A slight oblique position may also be helpful. The MRI technologist should be informed of the patient's positioning in this case so appropriate image annotations may be performed.

Dense Tissue

It is important to be aware that a snowplow effect may occur when the dense tissue and possibly skin are pushed by the needle rather than cutting through the breast parenchyma. Stereotactic biopsy can overcome this using a firing system

to advance the needle into place. MRI-guided systems do not have this feature and appropriate pressure needs to be used to advance the introducer and trochar [48].

Thin Breasts

Similar to stereotactic-guided biopsy, thin breasts may pose a challenge. Care must be taken to ensure that the full thickness of the needle biopsy chamber is well within the parenchyma and clear of the skin. Recommendations are similar to stereotactic biopsy. Minimal compression and a generous wheal of anesthetic may be helpful. A grid on the opposite side might allow for enough skin and subcutaneous displacement to enable the procedure to be performed [40].

Multiple Lesions in the Same Breast

If there are multiple lesions in the same breast, the needles are placed consecutively after a single IV contrast bolus [48]. If patient will not tolerate multiple biopsies, the more suspicious lesion might be biopsied first and hopefully help guide management of the other lesions.

Bilateral Breast Lesions

Bilateral breast lesions may be biopsied in the same session. The breasts may be distinguished by using one fiducial marker on the right grid and two fiducial markers on the left grid [48].

Patient Motion

Clear instructions to the patient are critical prior to the procedures start. Oftentimes, the patient is unaware that even slight shoulder movement may affect the biopsy procedure. It is sometimes helpful to mark the skin at the grid border to confirm the patient has not moved mid-procedure. In the event of motion after the skin nick, the obturator may be left in place and another attempt to confirm the biopsy site may be performed using adjacent landmarks. If the lesion is close to the obturator (within 5 mm), the biopsy needle may be oriented to sample in the direction of the lesion [48]. If there is question of an inadequate sample, the biopsy clip may assist mammographic-guided needle localization if surgical excision is indicated. Alternatively, if the skin is intact and there are no reliable landmarks, the patient may be rescheduled on another day when contrast can be administered. If patient has difficulty tolerating the procedure, premedication might be considered to decrease motion.

Implants

It is our practice to diligently confirm whether the lesion is amendable to ultrasound-guided biopsy under direct visualization or whether mammographic-guided wire localization and excision are more safely performed. There are reports of stereotactic-guided biopsies in the literature [49].

Presurgical Localization of Breast Lesions

Presurgical localization of breast lesions was initially performed to obtain histological diagnosis of mammographic screen-detected nonpalpable abnormalities of the breast. Over the last two decades, there has been a dramatic drop in the number of these procedures due to widespread use of minimally invasive percutaneous biopsy procedures performed under ultrasound or stereotactic mammographic guidance. Apart from the morbidity factor, the cost benefit of performing imaging-guided percutaneous procedures has been shown by multiple studies [50–53]. Preoperative diagnosis of cancer decreases or eliminates positive operative margins and need to re-excise tissue. Stereotactic percutaneous biopsy has been recommended as the procedure of choice for mammographically detected abnormalities [50].

Presurgical localization is now performed for selected indications, such as in those patients with a biopsy-proven cancer, in those who have imaging pathological discordance at core needle biopsy, in those with high-risk lesions diagnosed at percutaneous biopsy, or in those where core needle biopsy is not an option or fails to provide a definitive histological diagnosis. It has been reported that with selective use of excisional biopsy for indications noted previously, missed diagnosis of breast cancer is rare [50]. Compared with surgical excisional biopsy, preoperative diagnosis by core needle biopsy allows for wider margins of excision, fewer positive margins, and fewer surgical procedures to achieve adequate treatment than diagnosis by surgical excisional biopsy alone would permit [50]. A study testing the cost-effectiveness of stereotactic biopsy versus needle-localized open surgical biopsy reported that there was no difference in cost benefit in cases where there are lesions highly suggestive of breast cancer (BI-RADS 5) or those cases suspicious for ductal carcinoma in situ [53]. However, in cases of intermediate risk lesions classified as BI-RADS 4, these investigators noted significant cost savings when stereotactic percutaneous biopsy was performed instead of needle-localized breast biopsy [53].

Mammographic-Guided Needle Wire Localization

Mammographic guidance is used for lesions that are seen well only on mammography. In this method there are three variables to be considered, the type of needle wire, the length of the needle, and the type of approach. A modified hook wire system with a reinforced 2-cm segment 1.2 cm from its hook is commonly used for all procedures regardless of whether localization was performed under mammographic or sonographic guidance. A 5-, 7-, or 9-cm needle length is

used depending on the depth of the abnormality being localized in the breast. All procedures are performed using the parallel-to-the-chest-wall approach; a freehand approach has been described [54].

Two kinds compression paddles can be used; the alphanumeric grid is the one that is most commonly used. The alternate Swiss cheese paddle is a smaller paddle with multiple holes and is useful in women with small breasts, for lesions in the subareolar region, those high up in the axilla or close to the chest wall, where the small size of the paddle allows for easier access and optimal immobilization.

Informed consent is obtained routinely following explanation of the procedure and a description of the potential complications including informing the patient of the possibility of failure to adequately excise the abnormality localized. Local anesthesia is not administered at our institution for mammographic-guided localization procedures but is used in most instances for an ultrasound-guided localization. The decision to use local anesthesia for sonographic-guided localization procedure is dependent on both physician and patient preference.

For the parallel-to-the-chest-wall approach, the breast is positioned such that the lesion to be localized is closest to the skin surface through which the needle wire combination is to be introduced. For a lesion at the 12 o'clock position in the upper breast, for instance, the approach is superior with the breast placed in the craniocaudal position, and a lesion at the 3 o'clock position of the right breast is best approached medially with the breast in compression in the mediolateral position. The length of the needle selected depended on the depth of the lesion, keeping in mind that the final wire placement should be such that the tip of the wire extends beyond the lesion and is ideally with 0.5 cm from the abnormality. Once the approach and length of the needle is decided, the breast is placed under compression. The lesion coordinates are obtained from this initial mammogram based on its location within the alphanumeric grid (Fig. 12.24a). Using the collimator cross hairs, the point of entry is determined and the needle wire is advanced to the predetermined depth, satisfactory placement of the needle wire is determined by obtaining two views in the orthogonal plane, and needle position is adjusted based on these two views as needed (Fig. 12.24b, c). Once this is satisfactory, the wire is advanced so that the hook wire anchors to the tissue and the needle is gently withdrawn. A final two-view mammogram is obtained to confirm that the wire tip is located within 5 mm of the lesion (Fig. 12.24d–f). The patient is then transported to the operating suite with the films showing the position of the localizing wire so that the surgeon can see review prior to performing the excisional biopsy. Similar procedure is followed for masses that are localized under mammographic guidance (Fig. 12.25a–f).

Ultrasound-Guided Localization

When an abnormality is seen well on ultrasound and concordance with mammographic finding has been proven for those abnormalities that are seen on mammograms, sonographic localization is the preferred modality for localization. These lesions are usually solid masses. The same needle wire utilized for mammographic localization is used when localizing abnormalities under ultrasound guidance. The needle wire is introduced through a point on the skin determined to be the shortest to the lesion. Under real-time guidance, the needle wire is advanced 1 cm beyond the lesion, and once position is determined to be satisfactory, the wire is advanced over the wire and the needle is withdrawn gently taking care not to withdraw the wire with the needle. An image with wire in satisfactory position is obtained and sent with the patient for the surgeon. In both types of presurgical localization procedures, the wire is taped firmly in position, and the patient is advised not to move the arm in question to avoid movement of the wire during transportation to the operating room. All surgical excisional procedures were performed under general anesthesia.

Presurgical localization is performed generally for nonpalpable abnormalities considered suspicious for breast cancer based on mammographic and or sonographic workup of screen-detected breast abnormalities. Mammographic abnormalities localized for excisional biopsy may include microcalcifications, solid or complex cystic masses, areas of architectural distortions, or focal asymmetry. In some instances a surgeon may request imaging guidance prior to surgical excision of palpable abnormalities to ensure optimal correlation between clinical and mammographic or sonographic findings [54]. The hook wire technique using the parallel-to-the-chest-wall approach that we use at our institution for needle localization is the most commonly used method and is described in the materials and methods section of this article. An alternate approach using the hook wire is the freehand technique or an anterior approach. In this method the radiologist extrapolates the location of the abnormality from the mammograms to a decompressed breast and advances the needle blindly towards the chest wall. Two-view mammograms are obtained and repeated as needed after repositioning until the wire is seen to be within 1 cm of the lesion being localized. This technique requires more time and tends to have a higher complication rate [54]. Other techniques have been described that have also been used to localize breast abnormalities under mammographic guidance. When an abnormality is located within 1 cm of the skin surface, placing a BB on the skin overlying the abnormality may be adequate to perform localization. The position of the BB is then be confirmed by a two-view mammogram. Skin localization is, however, not recommended for lesions at a depth greater than 1 cm and may lead to excision of unacceptably

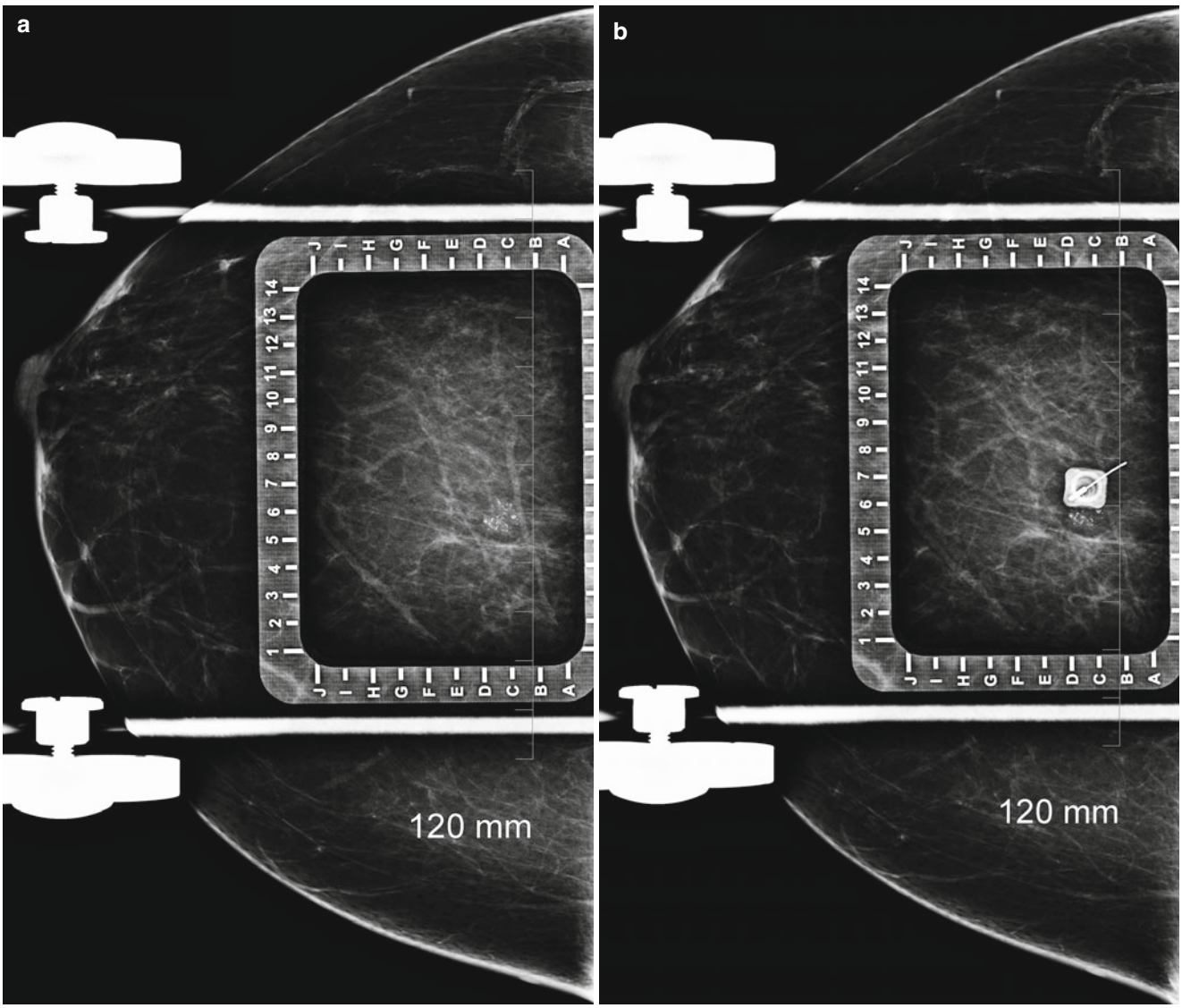

Fig. 12.24 (**a**–**f**) Mammographic presurgical localization for clustered microcalcifications that were histologically proven to be DCIS. (**a**) Craniocaudal view with breast under compression with an alphanumeric grid showing microcalcifications at 6D coordinate. (**b**) Craniocaudal view with breast under compression with an alphanumeric grid and needle wire in satisfactory position. (**c**) Mediolateral view confirming satisfactory placement of the needle wire. (**d**) Mediolateral view following showing satisfactory deployment of the wire. (**e**) Craniocaudal view showing satisfactory position of the wire. (**f**) Specimen radiograph showing the wire adjacent to the localized microcalcifications

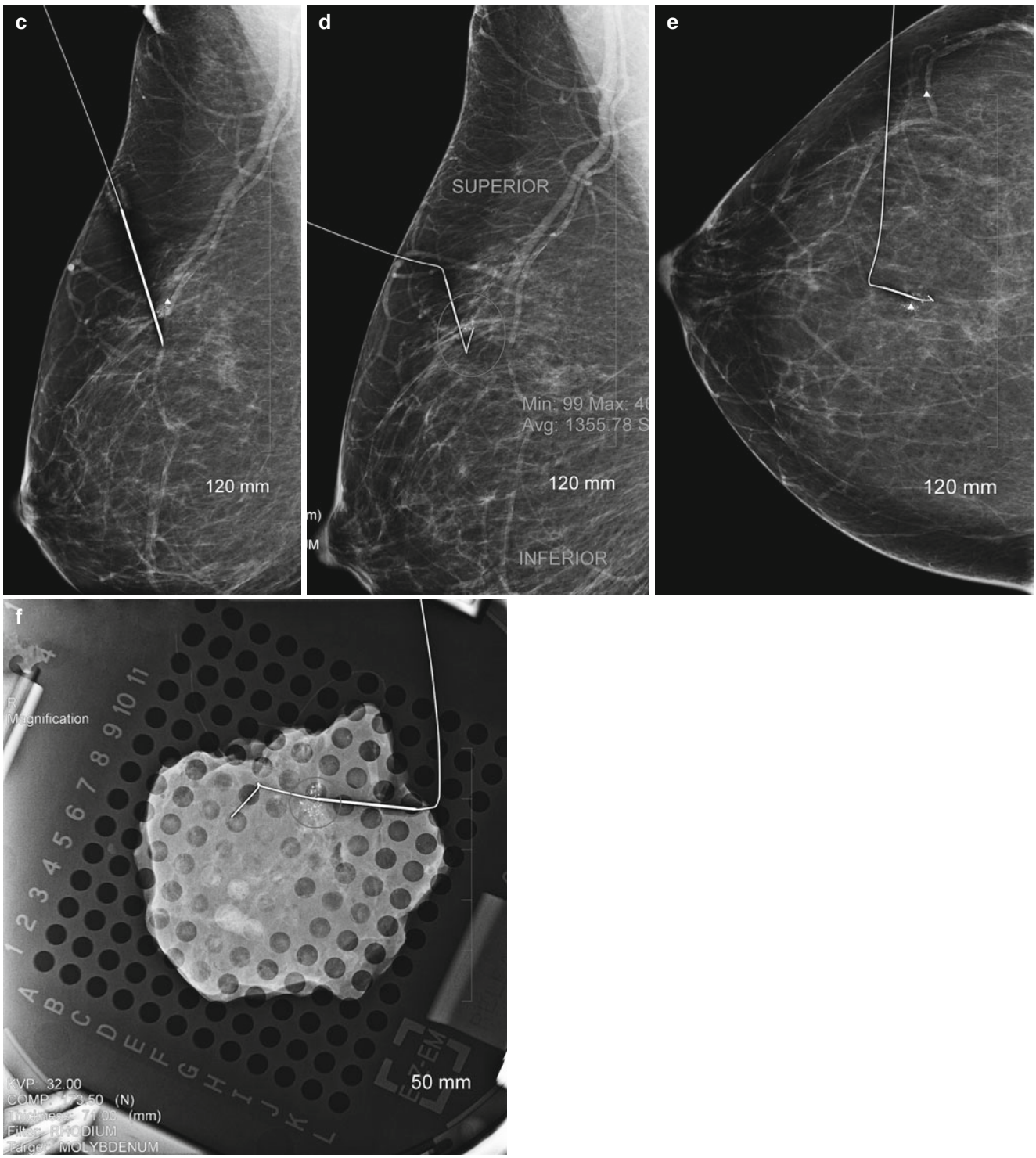

Fig. 12.24 (continued)

large volume of tissue. The dye method of localization involves injection of 0.2 mL of dye through a needle positioned under mammographic guidance near the abnormality localized. As the needle is withdrawn, a dye outlined track is left behind which the surgeon uses as a guide to find the abnormality. Methylene blue dye or alcian blue dye can be used; care should be taken to inject not more than 0.2 mL to avoid dye diffusion. The advantage of this method is that there is no need to leave a wire in the breast and hence avoids the problem of potential wire displacement or migration

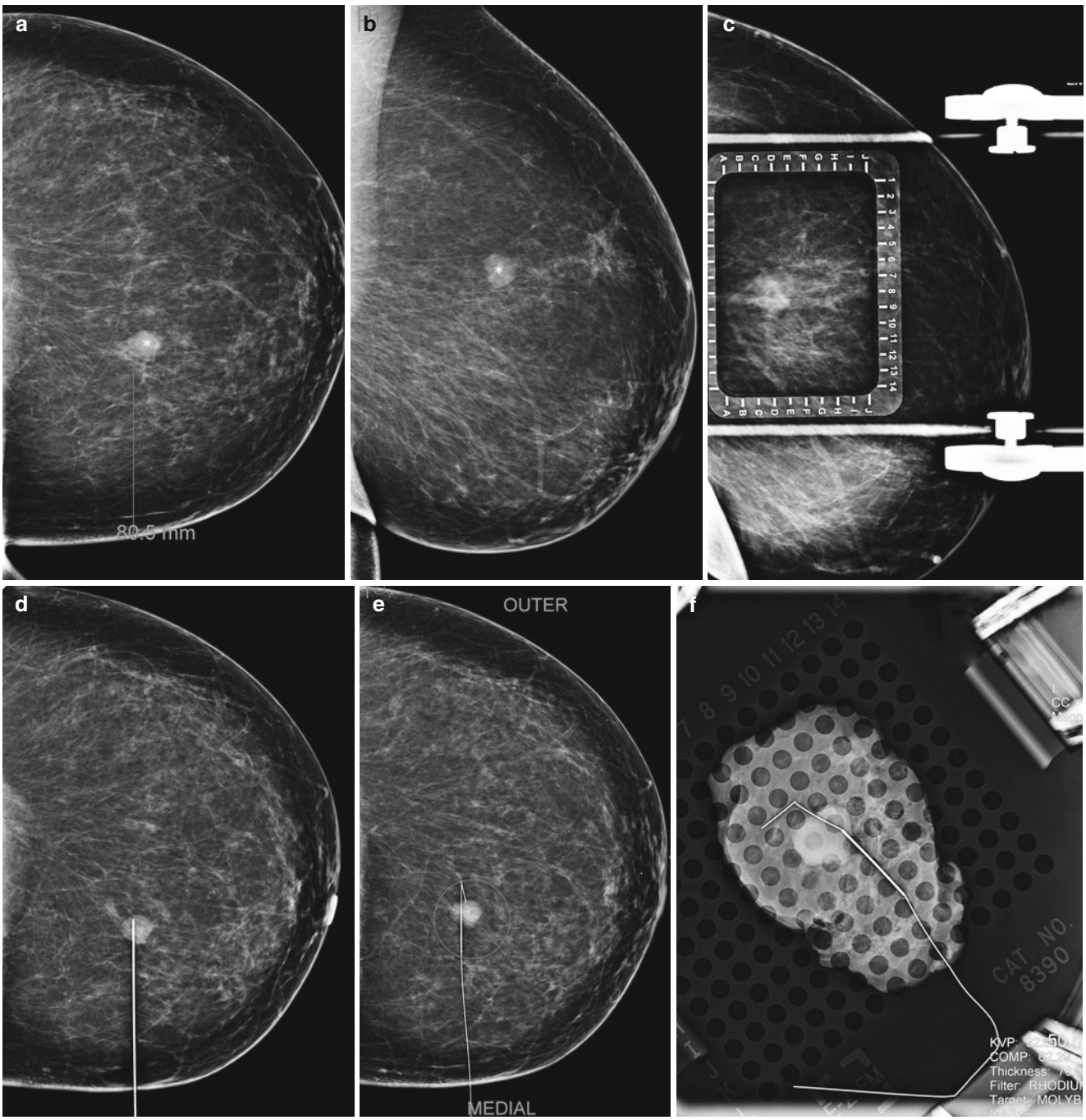

Fig. 12.25 (**a**–**f**) Mammographic presurgical localization for a mass that was histologically proven to be a fibroadenoma. (**a**). Craniocaudal view showing the mass. (**b**) Mediolateral view showing the mass. (**c**) Mediolateral view with breast under compression in a fenestrated paddle with an alphanumeric grid. (**d**) Craniocaudal view with satisfactory placement of the needle wire. (**e**) Craniocaudal view showing satisfactory position of the wire. (**f**) Specimen radiograph showing the wire adjacent to the localized mass

during transfer to the operating suite [54]. The practice of using local anesthetic prior to introduction of the needle wire is variable. At our institution we do not use local anesthetic during mammographic localizations and often do for sonographic-guided procedures. The value of local anesthetic has been questioned. In a study of 89 patients undergoing mammographic localized excisional biopsy, 46 patients received local anesthetic and 43 did not. Patients who did not receive the local anesthetic reported a lower mean pain score than those who did [55].

Complications of the presurgical imaging-guided localization procedures may involve failure to excise the localized

abnormality or procedure-related complications. A failure to excise the localized mammographic abnormality has been reported in 2.5–6.7 % of cases. Jackman and Marzoni looked at a series of 280 lesions undergoing presurgical localization [56]. Failure to localize occurred in 7 (2.5 %), 21 lesions that were not initially excised were done so on repeat excision of more than one tissue specimen in 14 of 21 cases where specimen radiography did not demonstrate the abnormality [56]. These authors concluded that failure was more likely with two lesions, small breast, for microcalcifications, small specimen, and small lesions [56]. In another study Abrahamson and others reported a success rate of 93.3 % (254 of 272 lesions) and concluded that placement of the localization wire within 5 mm was a significant predictor of successful removal of the localized lesion and that failure rate was higher when wire was greater than 5 mm from the lesion, in small breasts and in small specimen [57]. Potential reasons for failure to excise include placement of the wire greater than 1 cm from the lesion, placing the wire short of the lesion or advancing the wire significantly beyond the lesion, wire movement during patient transfer to the operating suite, and bleeding leading to hematoma formation.

Procedure-related complications are relatively rare. Of the known complications, the most common ones are vasovagal reactions and bleeding, both of which are self-limited and easy to manage and almost never lead to cancellation or failure of the procedure. Migration of the wire, fragmentation of the wire, and pneumothorax are very rare complications [58, 59]. There has been a report of a hook wire causing delayed cardiac injury by penetrating the pericardium and myocardium and lodging in the aorta with patient presenting with chest pain. Following an echocardiogram and CT scan, the wire was surgically removed [58]. We did not encounter any procedure-related complications during the 1-year study period,

Specimen radiography following imaging-guided localization is performed for several reasons. Primarily it verifies that the entire lesion has been removed. It provides a guide for the pathologist to the location of the lesion in the specimen. It verifies that the wire has been removed from the breast. Other advantages include detecting additional abnormalities that may not have been suspected and is a good learning tool to correlate lesion morphology with histology [54]. At our institution we routinely perform specimen radiography on almost all cases undergoing mammographic localizations, and less commonly so when ultrasound is used to localize masses, the decision is surgeon driven. The benefit of specimen radiography has been questioned, in one study only 3 of 165 patients (1.8 %) benefited from performance of specimen radiography [60]. A technique of immersion ultrasonography of excised specimens has been reported for lesions localized under ultrasound guidance and those that are not mammographically visible [61]. The diagnostic accuracy of the procedure is excellent and reported to be 100 % when the localized lesion is seen on the specimen radiograph and available for histopathology evaluation. A study looking at the diagnostic accuracy of needle-localized open breast biopsy reported 96 % accuracy at 5-year follow-up. A review of the cases of missed breast cancer revealed that six of the seven that were missed were in fact failure to excise the localized abnormalities and in one instance the cancer was noted to have developed after the surgical excision [62].

Imaging-guided presurgical localization of non-palpable mammographic screen-detected abnormalities of the breast is a simple, safe, and accurate way of diagnosing early-stage breast cancers. Over the last two decades, a rapid decrease in the number of these procedures has been noted due to advent of minimally invasive percutaneous biopsy procedures performed under mammographic or sonographic guidance. Nevertheless it still remains a useful method and is now indicated in selected cases where a cancer diagnosis has been made based on a needle biopsy, when there is imaging pathological discordance following needle biopsy or in those patients where imaging-guided biopsy is not an option due to patient related factors.

Stereotactic Breast Biopsy

Since its description in the 1970s, image-guided breast biopsy has become increasingly utilized for the diagnosis of breast lesions. Stereotactic biopsy can be performed on suspicious calcifications as well as masses and areas of parenchymal distortion not visualized by ultrasound. Most women undergoing breast biopsies do not have cancer; therefore methods for diagnosis should be minimally invasive. Stereotactic biopsy has been shown to be safe, accurate, and cost effective [63]. Successful biopsy is dependent on proper patient selection and understanding of the equipment and procedure by those performing the biopsies.

Advantages of Stereotactic Biopsy

Stereotactic biopsy is a less invasive procedure which can be performed quickly at less cost than open biopsy. It causes minimal or no scarring and recovery is quicker. Few significant complications occur. Accuracy is comparable to open biopsy [63]. With the introduction of large-gauge vacuum-assisted biopsy devices, more accurate diagnoses can be made with fewer false-negative results. For benign lesions there is no need for excisional biopsy and malignant lesions can undergo a single surgery.

Indications

Lesions amenable to stereotactic biopsy are ACR BI-RADS Category 4 and 5 calcifications, masses, and areas of architectural distortion. ACR BI-RADS Category 3 lesions should

undergo short-term follow-up unless the patient is considered to be at high risk for breast cancer, cannot comply with follow-up recommendations, or has undue anxiety.

Contraindications

Patients must be able to lie still during the procedure. Any medical, physical, or mental condition that would interfere is a contraindication. Prone table also have a weight limit, while upright units do not. Anticoagulant therapy is a relative contraindication especially if the medication cannot be temporarily withheld. Consultation with referring physicians should be made on a case-by-case basis.

Patient Selection

The lesion must be able to be properly targeted to perform the procedure. Beware of patients referred for stereotactic biopsy who have not been thoroughly evaluated. Lesions visible by ultrasound should undergo ultrasound-guided biopsy. As already noted prone tables have a weight restriction and adherence to its limits will prevent unsuccessful procedures.

For biopsies on a prone table, the patient must be able to lie without moving for the length of the procedure. A history of congestive heart failure, severe gastroesophageal reflux, arthritis, shoulder or spine injury, or psychiatric illness may preclude the patient's cooperation.

Prior to the procedure a history should be obtained and if necessary a "trial run" to position the patient on the table to determine if the patient can cooperate. Patient educational material such as brochures or videos can be helpful in reducing anxiety.

Qualifications for Performing the Procedure

The American College of Radiologists have set forth the qualifications for performing stereotactic biopsies for physicians, medical physicists, radiologist assistants, and radiologic technologists [64].

Stereotaxis

The ability to determine the position in space of a fixed point can be calculated by the apparent shift of that point on stereotactic image pairs. The stereotactic table compresses the breast between a compression plate and the image detector. The stereotactic image pairs are taken by convention at +15° and −15° around the x axis of a Cartesian coordinate system. The z axis or depth is then calculated by the computer. The principle of stereotaxis and errors and problems that can be encountered have been described in depth.

The Equipment

Most stereotactic biopsies are now performed on dedicated prone table or upright systems that can be used with mammographic units. These upright "add-on" units now have the capability for the patient to lie in the lateral decubitus position reducing the likelihood of vasovagal reactions.

Each of the available systems has proscribed procedures for localizing breast lesions. Before performance of a stereotactic biopsy, one must become familiar with the specific equipment and its requirements to ensure a successful biopsy. Core needle biopsy devices may be spring loaded or vacuum assisted and come in sizes ranging from 16 to 8 gauge.

Patient Preparation

Educational material such as brochures or videos may help relieve anxiety for the patient. At our institution we ask the patient to come in for a consultation at which time the patient is shown the stereotactic room and table. We also make sure the patient understands that a biopsy tissue marker will be placed at the time of the procedure. Any questions the patent has can be answered. We also take the opportunity to assess the patient by asking pertinent medical history, reviewing medications, and obtaining vital signs as indicated. Patients are instructed to take medications (except for anticoagulants) the day of the procedure. If the patient desires anxiolytics (diazepam 5–10 mg), arrangements are made for the patient to pick the medication up at her pharmacy and bring it the day of the procedure. We instruct the patients to make arrangements to have someone be available to take them home.

Informed consent should be obtained prior to the procedure. Antianxiety medications can be taken by the patient after informed consent has been obtained. Ensuring the patient has voided, is in comfortable clothing, and is comfortable on the table will help the patient remain still during the procedure. Patients do not have to be NPO and are encouraged having a light meal a few hours prior to the procedure.

The Procedure

The patient is positioned on the table with the breast containing the area of interest positioned through the opening. The technologist positions the area of interest in the open field of view. It is important to place the area of interest in the center

of the field especially in the *x* axis to ensure the target remains visible on the stereotactic pairs. A scout image is obtained. The stereotactic pairs are obtained and the lesion is targeted. It is important at this step to ensure the area targeted in the two images is the same. If different points are targeted, there is a greater likelihood of a failed procedure. The computer calculates the depth and the coordinated are transferred to the table. One staff member reads the coordinates from the computer and a second staff member verbally confirms the coordinates. As the physician performing the biopsy, it is well worth your time to "double-check" these coordinates.

At this point prior to anesthesia instillation, it is important to determine that there will be adequate tissue between the tip of the needle and the back of the breast after the needle is fully deployed. This is noted as the stroke margin and is the compressed breast thickness minus the calculated *z* depth – 6 (a safety margin). The stroke margin must be positive or the needle will exit the breast and enter the back breast support. Newer equipment has an audible signal if the needle is placed in the prefire position that will result in a negative stroke margin.

The breast is prepped with a skin antiseptic; the most common is an iodine-based solution. A skin weal is made with buffered lidocaine. Deeper anesthesia is given centrally then in four sites around the center of the area of interest (i.e., 12, 3, 6, and 9 o'clock) in equal amounts so as not to move the underlying target. Repeat stereotactic images can be obtained to ensure the target has not been displaced by the anesthetic. A small skin incision is then made at the expected entrance of the biopsy needle. The needle is then manually advanced into the breast. Quite often there is tenting of the breast, and it is important to have the needle through the breast and for the skin to return to its normal configuration. The needle is then positioned in the prefire position. Repeat stereotactic pairs are obtained. It is at this time the final assessment can be made before placing the biopsy needle at the target. The needle is placed, and "postfire" position of the target is determined by repeat images before samples are obtained.

The number of samples obtained is determined by the needle gauge, size of the lesion, and patient tolerance. Vacuum-assisted devices can be rotated to obtain samples from multiple directions. The samples are then placed in a container suitable for specimen imaging to confirm presence of calcifications. Specimen x-ray obtained for masses or areas of distortion can be made on a case-by-case preference. At our institution the specimens containing the calcifications are sent separately from those without calcifications.

Marker Placement

A tissue marker is deployed and confirmation with one image is made prior to removal of the biopsy needle. Marker placement is vital for further patient management. If a lesion is benign, the markers can be used for follow-up of the area and to mark the area as biopsied if the patient is seen at another institution in the future. If the lesions are one such as atypical ductal hyperplasia that should be further evaluated or is malignant, the marker can be used for preoperative localization or as follow-up to neoadjuvant therapy. Different markers are available and should be compatible with the biopsy system. These markers are small (2–3 mm) and made of titanium or stainless steel. Since some patients have multiple lesions or may have had previous biopsies with marker placement, it is important to ensure the marker is unique to each procedure. Marker migration can occur, and it is important to denote with measurements and location the length and direction of any movement.

Post-biopsy

After the biopsy marker is deployed and confirmed by typically a single image, the introducer is removed and manual compression is held for 20 min to ensure hemostasis. A visual inspection of the breast is made and further compression is performed if indicated. The breast is then cleaned and a Steri-Strip™ is applied and the area is bandaged. A two-view mammogram (cranial caudal and 90° lateral) with minimal compression is obtained for confirmation of the tissue marker position and to assess the postbiopsy appearance of the targeted area.

Post-biopsy Instructions/Care

A cold pack is given to the patient for the trip home. Patients are asked not to soak in a bath, swim in either a pool or ocean or submerge the biopsied breast in a hot tub/spa for 5–7 days. Other postbiopsy instructions include how to recognize early signs of infections, and the patients are given contact numbers as well as written instructions. For pain, over-the-counter pain relievers are recommended such as acetaminophen. Use of aspirin and nonsteroidal antiinflammatory drugs are discouraged because of the potential for bleeding. The patient is asked to avoid strenuous activity for 24 h and then resume activities as tolerated.

Complications

Report of the Procedure

Per ACR guidelines permanent retrievable images documenting the procedure should be obtained with the normal identification. The report of the procedure per the guidelines includes very specific items and which should be included. A template within a reporting system is very helpful to ensure all items are reported. At our institution, a workflow sheet is kept by one of the staff during the procedure and includes time medication such as diazepam is taken, time patient is

placed on table, approach used, amount of anesthesia used, number and clock face of core sample obtained, time specimens are placed in formalin, type of biopsy tissue marker placed, time of deployment of the marker, and length of time the breast is compressed for hemostasis. The staff also records any immediate complications and the time and to whom the patient is discharged [63].

Postprocedure Follow-Up

Any complication (significant hematoma, infections, etc.) should be documented. The radiologist is also required to report on the concordance of the pathology with the imaging finding. These reports should be in compliance with the ACR Practice guidelines for reporting and communication of diagnostic imaging findings [65]. Further management of the patient should be based on concordance of findings and pathology results. The findings are then communicated to the referring physician and patient.

Concordance/Discordance of Pathology

It is incumbent upon the radiologist to determine whether the pathology is concordant or discordant with the mammographic/biopsied area.

A benign concordant biopsy is followed up short term (6–12 months) to ensure sampling error has not occurred. At our institution 6 months is the typical time frame.

For a discordant result the patient may undergo a second biopsy or surgical excision.

Concordant malignant results should be referred for further surgical/oncological management.

Elsewhere in this book are discussions on imaging pathological correlation (Chap. 13).

Reasons for Failed Biopsy

Proper maintenance of the equipment as well as daily calibration is important to ensure successful biopsies.

Failure to bring the target area into the field of view can happen if it is near the chest wall or in the extreme outer breast.

During the targeting on the stereotactic pairs, it is possible to target different calcifications on each image causing the needle not be ideally placed. If there are many calcifications scattered in the breast beside the target group, one may select a calcification outside of the target group.

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