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Magnetic Resonance Imaging / Formation image de résonance magnétique

Magnetic Resonance Imaging-guided Breast Biopsies: Tips and Tricks

Elissa R. Price, MD*, Elizabeth A. Morris, MD

Department of Radiology, Memorial Sloan-Kettering Cancer Center, New York, NY

As a robust imaging modality, magnetic resonance imaging (MRI) of the breast offers sensitivity that approaches 100% for invasive carcinoma and approaches 80%–90% for in situ carcinoma [1–4]. As with all breast imaging modalities, there is an overlap between benign and malignant features which necessitate biopsy [5,6]. Because many lesions identified on MRI will be occult on other imaging modalities, biopsy under MR (magnetic resonance) guidance is an integral part of any breast imaging program in today's imaging paradigm (Figure 1). The instrumentation and basic methodology for MRI-guided biopsies performed at Memorial Sloan-Kettering Cancer Center (MSKCC) was previously reviewed [7]. With this methodology as a foundation, and based on the institution's experience with over 2000 biopsies, we present 10 tips that we have found useful in performing this procedure safely, accurately, and efficiently.

Background

We perform MRI-guided biopsies by using a 1.5- or 3-Tesla magnet. As per the 2008 American College of Radiology (ACR) Practice Guideline [8], images should be acquired at a slice thickness of 3 mm or less, with the goal of approximately 1-mm in-plane resolution. A basic biopsy protocol should include fat-suppressed images (fat suppression is preferred over subtraction and is easily achievable on most current MRI systems); a bright fluid sequence (T2 or short-tau inversion recovery); pregadolinium T1-weighted, and several dynamic postgadolinium T1-weighted images [8].

We perform neither MRI-guided fine needle aspirations nor automated true-cut core needle biopsies, as both often yield an insufficient sample for diagnosis and may require extreme precision in targeting. In addition, these devices require removal of the needle from the breast after obtaining each sample. Vacuum-assisted devices allow a single probe insertion with directional sampling of small targets (smaller than 10 mm) and rapid collection of a significantly larger volume of tissue [9], both highly advantageous in the MR environment. While an average 14-gauge core needle biopsy device collects 17 mg of tissue, a 9-gauge vacuum-assisted device (that commonly used for MRI-guided biopsies) collects 200 mg [10].

Although handheld, multi-insertion MRI-compatible vacuum biopsy systems exist, we use a console system (ATEC; Hologic, Bedford, MA) in which the biopsy device is connected by tubing to a separate console, which remains outside the MRI suite. Console systems allow the biopsy device to be inserted a single time for continuous, rapid, vacuum-assisted sampling [11]. Local anesthetic can be continuously introduced through a side port, which leads to less patient discomfort [11]. The console system also provides stronger suction, which allows targeted tissue sampling, even when the accuracy of probe insertion is suboptimal or when, because of technical or patient-related limitations, the probe cannot be inserted precisely into the target. Stronger suction also facilitates improved hematoma evacuation [11].

Tip 1: "Position, Position, Position"

We perform breast biopsies under MR guidance with the patient prone in a dedicated breast coil. Proper positioning of the breast is key to a procedure that is both technically successful and is well tolerated by the patient (Figure 2). As much breast tissue as possible should be pulled into the coil and placed behind the grid, with particular attention paid to medial tissue and axillary tail tissue. This process allows adequate compression and thickness to accommodate the probe. Therefore, MRI technologists specifically trained in breast positioning are essential. If no trained MRI technologist is available, a mammographic technologist assists us in the MRI suite. The experience of these mammographic technologists in positioning the breast for stereotactic biopsy, in which the patient is also prone, makes them highly skilled at this task. They are particularly invaluable in positioning

* Address for correspondence: Elissa R. Price, MD, Department of Radiology, Memorial Sloan-Kettering Cancer Center, 1275 York Avenue, New York, NY 10065.

E-mail address: pricee@mskcc.org (E. R. Price).

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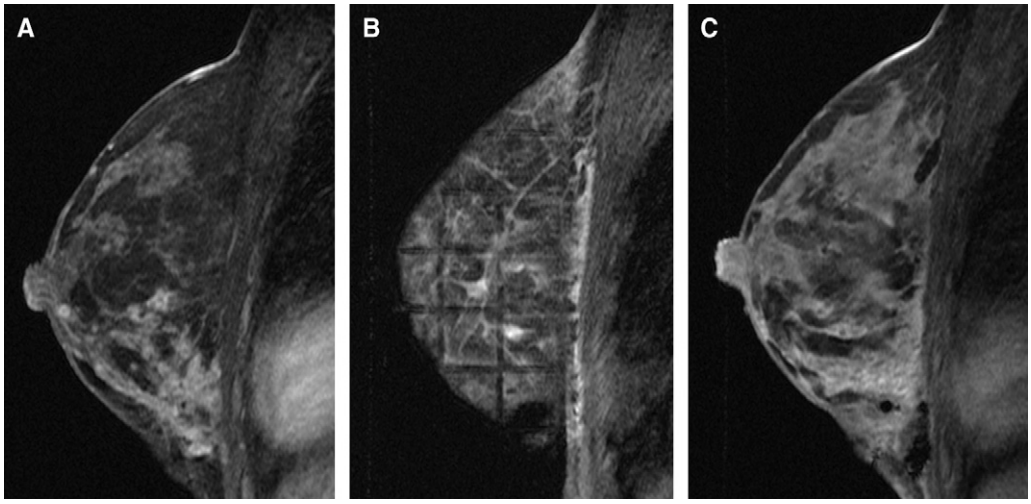

Figure 1. Segmental non-masslike enhancement in the lower breast seen on screening MRI in high-risk patient. (A) No abnormality was seen on mammography or ultrasound. Skin entry site of MRI-guided biopsy. (B) Obturator in good position within non-masslike enhancement. (C) Extensive non-calcified ductal carcinoma in situ was found on pathology.

the breast for difficult-to-access lesions, such as those in the posterior breast, upper inner quadrant, and subareolar regions. Before initiating patient positioning, the radiologist should review the diagnostic images with the technologist and illustrate where the grid should be placed. It is helpful for the radiologist to be in the MRI suite during patient positioning and grid placement, closely supervising if not actively participating in the process [12].

Although standard prone positioning is by far the most common, we and others have found that placing the patient in the prone oblique position facilitates access to the axillary tail and posterior breast tissue [13]. Lesions located posteromedially can be accessed by placing the affected breast in the contralateral coil (eg, for a posteromedial left breast lesion, place the left breast in the right breast coil, such that the medial left breast surface is easily accessible) (Figure 3). Minimizing padding on the coil is also useful to reduce elevation of posterior breast tissue [14].

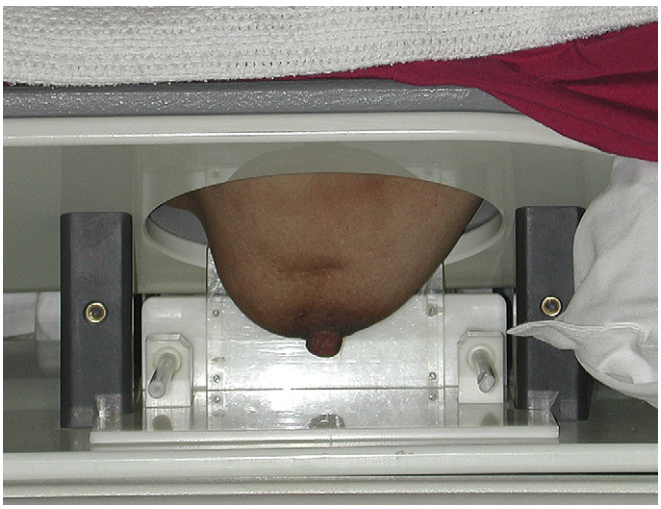

Figure 2. It is essential that the breast be properly positioned within the coil to facilitate easy, safe access for biopsy.

Tip 2: "Measure Twice, Cut Once" (Preparation)

This carpenter's axiom succinctly emphasizes the importance of meticulous preparation. Based on pre-procedure images, the shortest approach to the lesion is determined. If the lesion is central or if it is difficult to predict the shortest approach before patient positioning, we have a low threshold to grid the patient from both medial and lateral. This strategy prevents the need to change grid location after the initial noncontrast sequence. Once in place, the position of the lesion must be related to the overlying grid system. Vitamin E capsules are used as fiducial markers and are taped over the expected site of the lesion. If both medial and lateral grid plates are used, fiducials are placed on both. A grease pen is used to draw the position of the capsule onto a laminated sheet with a depiction of the grid (Figure 4A) This laminated replica of the grid is then taken from the MRI suite to the console, and this allows the site of skin access to be determined relative to the vitamin E capsule and lesion depth to be accurately calculated. The planned site of skin access is then also drawn onto the laminated sheet, which is taken back to the MRI suite to ensure that the proper location on the patient is cleansed and anesthetized (Figure 4B).

Speed and efficiency are of paramount importance during the biopsy procedure. Because of the transient nature of contrast enhancement on MRI, there is a limited window of time in which to perform the procedure and verify needle placement. Although contrast transit time will vary, a 15–20-minute time frame to accomplish the task is our general rule. The more prolonged the procedure, the more likely the contrast will wash out and the more likely the patient is to move, resulting in motion artifact and potentially leading to incorrect lesion targeting. To facilitate seamless progression, 2 technologists assist us: one inside the MRI suite, and the other operating the biopsy console just outside the suite and running the MRI sequence.

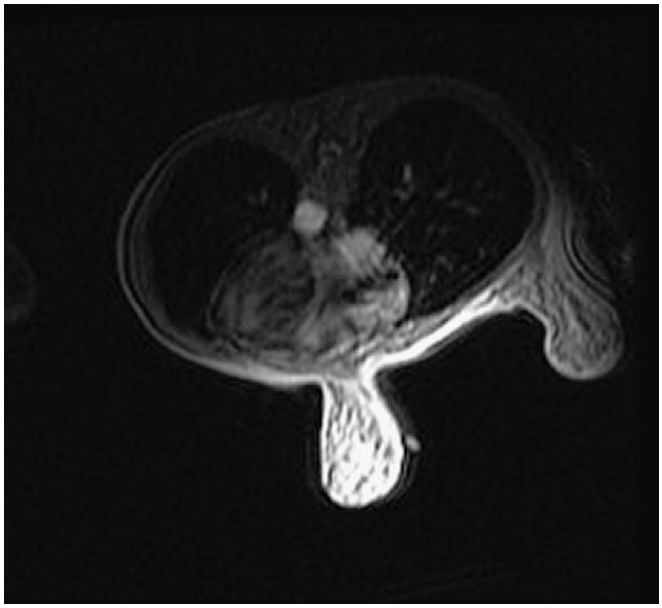

Figure 3. The left breast has been positioned in the right breast coil to facilitate access to a far posteromedial lesion. Vitamin E capsule was placed on the medial breast surface.

Readiness of both technologists is essential to help each step in the procedure flow smoothly [12]. The technologist in the MR suite needs to be acutely familiar with the procedure and the instruments. A dedicated breast biopsy tray that can be wheeled into the MR suite is prepared ahead of time. On this tray, all the necessary tools are arranged in an organized fashion so that once the procedure has been initiated, the radiologist has quick and easy access to all equipment. The technologist outside the MRI suite has an equally important role. We routinely obtain a pregadolinium image, and this technologist must ensure that fat saturation is adequate and uniform before injection. During lesion sampling, this technologist controls the biopsy console, changing between the biopsy, lavage, and aspiration modes as the radiologist requests.

Tip 3: Ensure Adequate Breast Thickness

The number of sagittal slices multiplied by the slice thickness determines total breast thickness. Lesion depth from the skin surface is calculated by counting the number of slices between the skin surface and the lesion on sagittal images, and by multiplying by the slice thickness (the skin surface is considered that slice on which the indentations of the grid in the skin are best seen). With these numbers in mind, the appropriate needle should be selected. We use an MRI-compatible, coaxial, 9-gauge, vacuum-assisted biopsy system (ATEC Breast Biopsy and Excision System; Hologic) and choose between handpieces with 20-mm (standard) or 12-mm (petite) sampling apertures (Suros Surgical Systems; Hologic). The radiologist must be cognizant that the smaller sampling aperture collects less tissue and necessitates more precise lesion targeting [9]. When we encounter thin breasts that cannot accommodate even the 12-mm aperture, we consider using the reverse compression paddle [7]. Although previously used to increase breast thickness for stereotactic biopsies in thin breasts, this tool has also been useful for MR-guided procedures. Again, we use the expertise of our mammographic technologists when employing this paddle.

Tip 4: Lidocaine with Epinephrine

For patients with no contraindications, we use a liberal volume of lidocaine with epinephrine (lidocaine HCL 1% and epinephrine 1:100,000) for deep anesthesia; 20–40 mL is prepared and injected in split doses, with 10–20 mL administered before insertion of the biopsy device, and 10–20 mL is administered by the device during sampling. Epinephrine may be helpful in minimizing parenchymal hematoma formation, which could potentially obscure the biopsy site. Initial subcutaneous anesthesia, however, is obtained by using lidocaine only. Epinephrine should not be administered into the skin. After drawing up the local anesthesia, we ensure that no air bubbles are present within the syringe or needle hub. Even small air bubbles can cause significant artifact on the MR image and obscure small lesions.

Tip 5: Target on the Target

When the infamous thief Willie Sutton was asked why he robbed banks, he replied, ‘‘Because that’s where the money is.’’ The principle underlying this quotation can be applied to MRI-guided breast biopsy. Obtain the first and most samples preferentially from the site where the bulk of the lesion is present [12]. If initial images demonstrate the localizing obturator to be eccentrically positioned within the lesion, only obtain samples on the side(s) of the needle where the lesion is located. This ability to sample in a designated direction is a major advantage to the vacuum-assisted biopsy device. Early rounds of sampling usually produce the highest yield. The more samples that are obtained, the more hematoma in the region and the farther the biopsy device is from the target lesion (because the closest tissue has already been removed). These constraints lead to diminishing returns of later sampling.

As breast imagers, we are often tempted to label lesions according to their position on a clock face. For MRI-guided biopsies, it is important to remember that the clock face is relative to the grid and not to the breast or to the patient. For example, if the bulk of a lesion is located anterior to the obturator on planning (sagittal) MRI sequences, then the majority of samples should be obtained with the sampling aperture directed towards the floor (6-o’clock axis relative to the grid). If the lesion is posterior to the obturator on planning sequences, then most samples are obtained with the aperture directed towards the patient’s chest wall (12-o’clock axis relative to the grid).

Based on the calculated lesion depth and by using the centimetre marker on the exterior of the introducer sheath, a plastic stopper is placed at the depth to which the biopsy device should be inserted. On many devices, this stopper does not lock in place, and therefore, does not prevent the device from being pushed farther into the breast during sampling. Therefore, while obtaining samples and rotating

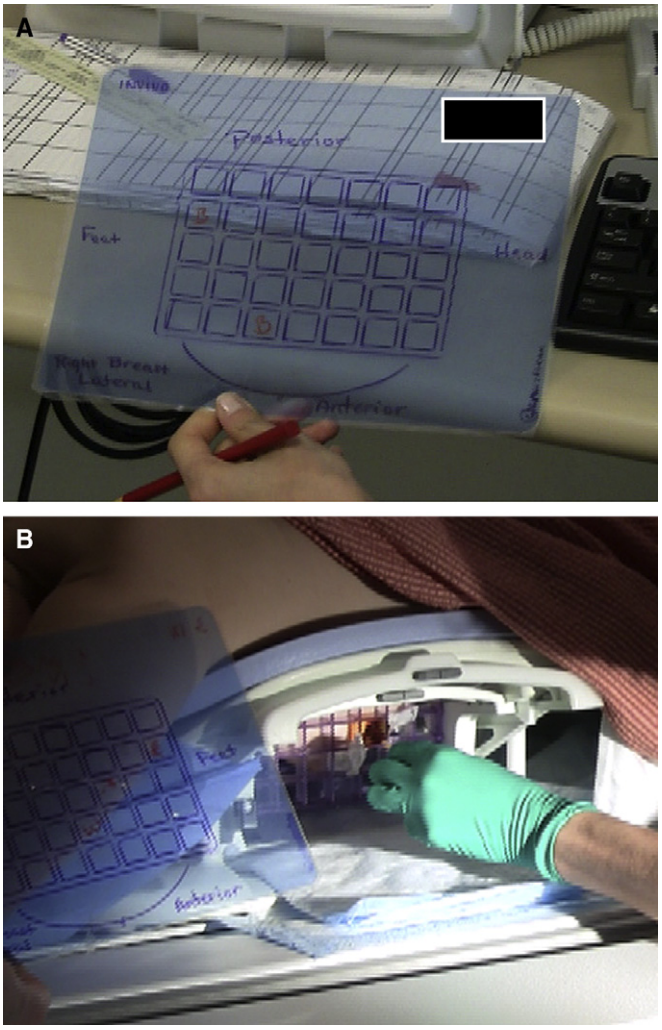

Figure 4. (A) A grease pen is used to document the position of the fiducials (as marked by the letter B) on a laminated depiction of the compression grid. (B) The laminated sheet is then taken back into the MRI suite to guide proper selection of the skin site to be cleaned and anaesthetized.

the biopsy device, carefully hold the device without applying pressure directed towards the breast and be continuously cognizant of the stopper position. Check the position of the stopper before sampling is initiated and after a round of sampling has been completed. For example, if a lesion is 5 slices from the skin surface, and slices are 3-mm thick, then the stopper would be placed at the 15-mm mark before sampling. If the stopper is at the 20-mm mark after sampling, then the radiologist has inadvertently advanced the needle 5 mm during the procedure and, therefore, may have been off target. In this case, the breast should be re-imaged to assess where the biopsy site changes are centred. If the changes are predominantly deep to the lesion and the lesion does not appear to have been adequately sampled, then the device should be repositioned and repeat sampling performed.

Tip 6: Flush Away

Some biopsy devices have the capability to lavage the biopsy cavity with saline solution and aspirate after sampling. Before deploying the marker and removing the device from the breast, the radiologist needs to compare gadolinium-enhanced pre- and postbiopsy images to ensure that the target has been adequately sampled. In minimizing residual high-signal blood at the biopsy site, lavage and aspiration facilitate this assessment (Figure 5). Furthermore, hematoma evacuation may help minimize postbiopsy marker displacement [12].

Tip 7: Postbiopsy Mammogram

After completion of sampling, we place an MRI-compatible marker (Suros Surgical Systems ATEC TriMark TD Biopsy Site Marker; Hologic) to demarcate the site of biopsy. Signal void from the marker is indistinguishable from signal void from air introduced during the procedure. Therefore, ensuring that the marker has deployed and assessing its position is extremely difficult (if not impossible) on MRI, and postbiopsy unilateral craniocaudal and mediolateral mammograms are always obtained. We carefully compare the position of the marker on the mammogram with the expected site of the lesion based on the diagnostic MR images. Any marker displacement (or suspicion thereof) needs to be clearly documented, particularly if future needle localization is planned (Figure 6).

Tip 8: When the Lesion Is Not Visualized

The suspicious enhancing mass or nonmass enhancement that warranted biopsy may not be seen at the time of the procedure. We explain this possibility to the patient during the informed consent process. If this is the case, we first ensure that contrast has been properly administered into the vasculature (ie, that there were no technical issues such as tube leakage or interstitial injection). If contrast was administered appropriately and the lesion cannot be identified, then compression is reduced. Excessive compression has been shown to interfere with lesion enhancement [15]. Delayed sequences are also occasionally obtained. In general, we have not found a second injection of gadolinium to be valuable in demonstrating the lesion if the first injection did not successfully do so. If neither compression reduction nor delayed sequences elucidate the lesion, then the procedure is canceled and the patient is scheduled for 6-month follow-up diagnostic MRI (Figure 7). At MSKCC, approximately 8% of MRI-guided biopsies are cancelled for such reasons (Brennan S, Sung J, Dershaw DD, et al, ‘‘Cancellation of MRI Biopsy Due to Breast Lesion Disappearance: Frequency and Follow-up,’’ presented at the 95th Scientific Assembly and Annual Meeting of the RSNA, December 1, 2009, Chicago, IL).

Tip 9: Multiple Lesions

A patient with multiple lesions intensifies the need for detailed advanced planning, with careful assessment of the location and accessibility of each lesion. With these issues in mind, and depending on patient cooperation level, we will

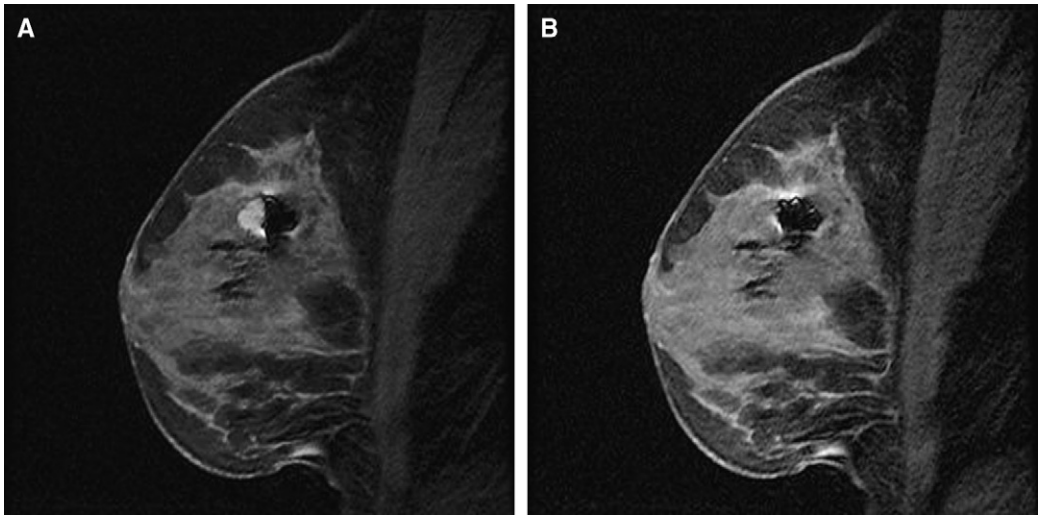

Figure 5. High-signal blood and gadolinium in the biopsy cavity (A) are removed by postbiopsy lavage and aspiration (B), thereby facilitating assessment of sampling adequacy.

biopsy 2–3 lesions in a single sitting. As with any biopsy procedure, the most suspicious lesion should undergo intervention first, in case the later sites are not visualized or the patient is unable to tolerate further imaging and/or intervention. When dealing with 2 lesions in the same breast, the primary consideration is the location of the lesions relative to each other. It is ideal if the lesions can be positioned beneath the grid surface simultaneously so that access to both sites can be obtained without the need to reposition. We try to grid both lesions, inject gadolinium, and then clean and anesthetize both sites. In rapid succession, both introducer stylets are inserted within coaxial introducer sheaths. The stylets are then replaced with localizing obturators. As necessary, postgadolinium sequences are then used to adjust the position of each obturator (the introducer stylet should be reinserted if advancement is necessary). With the localizing obturator in place at the second site, biopsy of the first site is performed to completion. Once the radiologist is satisfied with sampling at the first site, the obturator is replaced and attention is turned to the second site. Biopsy of this second site is then completed, and postbiopsy markers are deployed at both sites.

If multiple lesions within a single breast cannot be positioned beneath the grid at the same time, then the lesions need to be sampled sequentially. The patient should be positioned with the grid overlying the more suspicious lesion first and sampling at this site completed (including marker deployment). The patient should then be repositioned with the grid overlying the second site. If bilateral lesions are present, then we grid both sides, inject gadolinium, and clean and anesthetize both sides. Biopsy is then performed on the more suspicious side, including marker deployment, before moving to the contralateral breast. We generally do not find washout of a second lesion (be it in the same breast or in the contralateral breast) to impede biopsy. If washout does occur because of the time elapsed between the gadolinium injection and biopsy at the second site, then landmarks are usually adequate to guide the procedure successfully. Clearly, the

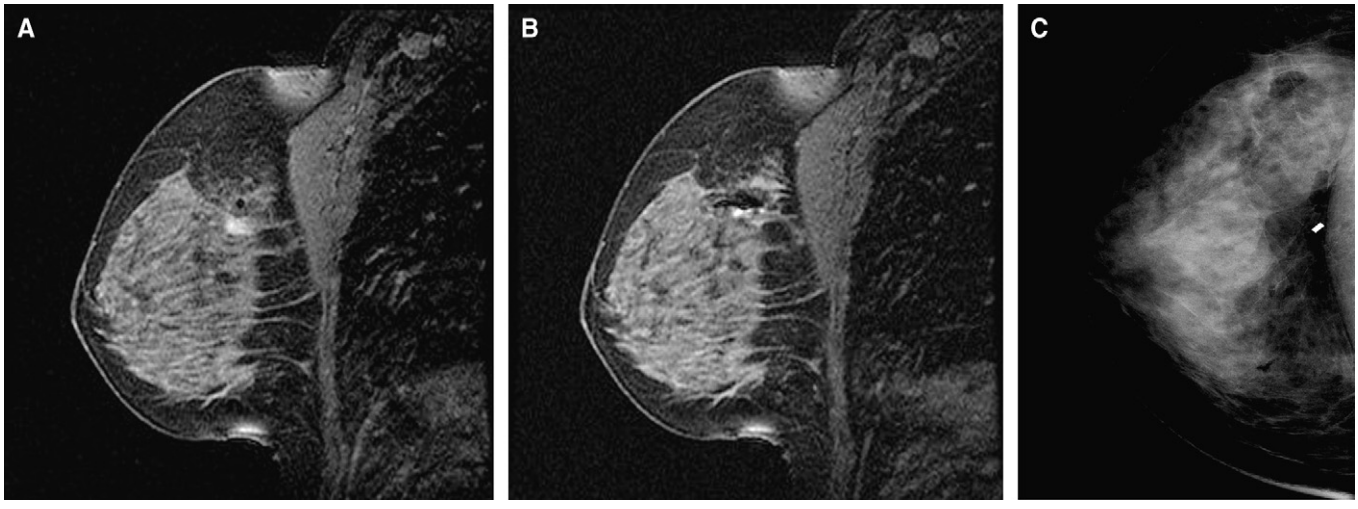

Figure 6. Postbiopsy mammogram is essential to document marker position. In this case, a lesion in the superolateral cone of tissue was biopsied (A and B). (C) Postbiopsy craniocaudal mammogram demonstrates the marker approximately 3 cm medial to the site of biopsy.

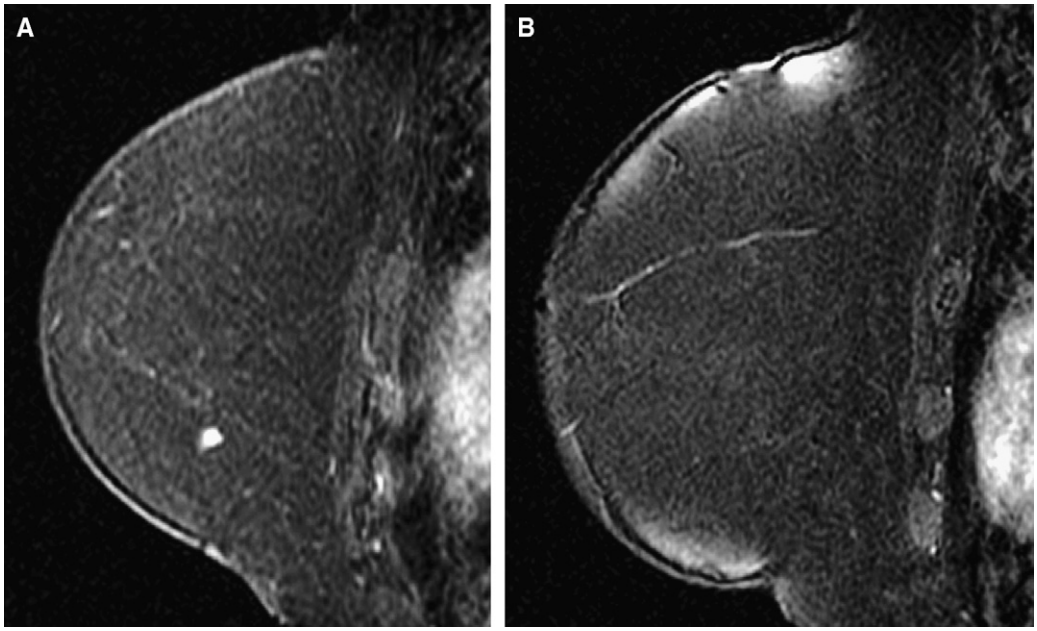

Figure 7. Small enhancing mass in the medial breast (A) was not visible on the day of biopsy (B). The biopsy was canceled and the patient scheduled for follow-up MRI in 6 months' time.

preparation and organization emphasized earlier become even more critical in expediting the biopsy of multiple lesions.

Tip 10: Procedure Limitations

Although MRI-guided breast biopsy has been a tremendous addition to the radiologist's armamentarium, not all lesions are amenable to this procedure. Lesions that are far posterior along the chest wall or deep in axillary tail may be inaccessible despite the best attempts at positioning. Similarly, superficial lesions and lesions near the nipple may be difficult for biopsy. These instances may necessitate MRI-guided needle localization and surgical excision.

As discussed earlier, other factors that may preclude MRI-guided biopsy include lesions not visualized on the day of the procedure and breasts too thin to accommodate the sampling aperture, even with the use of the reverse compression paddle. In addition, depending on the degree of suspicion from the diagnostic MRI, we may consider canceling the biopsy if a lesion demonstrates a clear decrease in size on the day of the procedure.

Histologic Considerations

Completion of the biopsy itself is not the final step in this procedure. Radiologic-histologic concordance is an essential component of percutaneous breast procedures in general, and is particularly crucial in MRI-guided biopsies in which postprocedural verification of lesion removal is impossible [16]. Imaging-histologic discordance occurs when the histologic findings do not provide adequate explanation for the observed imaging features [17]. Lee et al [16] found 7% of MRI-guided vacuum-assisted biopsy results to be discordant, and of the discordant lesions that were surgically removed, malignancy was identified in 30%. In a number of studies that assessed biopsy discordance under stereotactic and sonographic guidance, an average discordance rate of 3% (range, 1%–8%) was found. Among the discordant cases in those studies, malignancy was identified in 14% (range, 0%–100%) at re-biopsy [16–21]. The 30% malignancy found by Lee et al [16] demonstrates the importance of radiologic-histologic correlation and implies a small but significant number of false negative MRI-guided biopsies. The false negative rate on MRI biopsy may in part relate to the small size of many lesions seen on MRI that are occult on all other imaging modalities, the fact that the actual sampling of tissue is not performed under real-time direct visualization, and that lesion retrieval cannot be verified [17]. Perhaps the most important underlying issue, however, is the baseline risk underlying the patient population that generally undergoes breast MRI and MRI-guided biopsy. These are often high-risk patients who inherently have a higher pretest probability of malignancy [17].

For lesions that we believe to be histologically discordant and Breast Imaging Reporting and Data System (BI-RADS) 5 on imaging, we recommend surgical excision. Alternatively, if histology is concordant with imaging and a *specific* benign diagnosis is provided (eg. fibroadenoma or intramammary lymph node), then follow-up MRI is recommended to ensure that the lesion was adequately sampled to assess for growth. Some radiologists, however, believe a specific benign concordant diagnosis requires no further evaluation. Of 177 concordant, histologically benign lesions assessed at MSKCC, we found that none of the missed malignancies demonstrated growth before 6 months and thus the advantage of early diagnosis was not lost [22]. Therefore, we recommend follow-up at 6 months, and not earlier, for benign concordant histology

found at MRI-guided biopsy. Similarly, a *nonspecific* concordant benign diagnosis (eg, benign breast tissue) must undergo repeat MRI in 6 months' time.

Another important histologic phenomenon to consider is that of underestimation. Atypical ductal hyperplasia (ADH) underestimation occurs when a lesion that yields ADH at percutaneous biopsy proves to be cancer at surgery [23]. Ductal carcinoma in situ (DCIS) underestimation occurs when a lesion that yields DCIS at percutaneous biopsy proves to be invasive carcinoma at surgery [23]. Previous work at MSKCC by Lee et al [24] found that, among lesions that yield pure DCIS at 9-gauge MRI-guided vacuum-assisted biopsy, surgery revealed invasive carcinoma in 17%. This underestimation rate is higher than MSKCC's previously reported 14% for stereotactic 11-gauge vacuum-assisted biopsy [25]. Among lesions that yield ADH at MRI-guided vacuum-assisted biopsy, cancer was identified at surgery in 38% [26], higher than 20% underestimation rate with 11-gauge vacuum-assisted biopsy performed under stereotactic guidance [27]. These results are somewhat counterintuitive because larger tissue-acquisition devices, with which sampling error is reduced, would be expected to yield *lower* underestimation rates. Higher underestimation of both ADH and DCIS under MRI-guided biopsy may again reflect the high baseline risk of malignancy in this patient population [24]. This knowledge must be kept in mind when making further management recommendations after MRI-guided biopsy.

Conclusion

Performing MRI-guided breast biopsy in a precise, proficient manner is an important skill in the current imaging milieu. We strongly believe that extra effort in the planning and preparation phases will improve the efficiency of the procedure as a whole. Trained, knowledgeable technologists who are familiar with breast MRI and the nuances of positioning are essential. Targeted sampling, aimed specifically at the bulk of the lesion, will produce the highest yield with subsequent lavage and aspiration, which allows biopsy adequacy to be optimally assessed. Based upon our experience with this procedure, we have outlined a series of tips and tricks that have been useful in both routine and complex cases.

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